



## Why consider the lighthouse a public good?

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### ABSTRACT

Was the lighthouse ever a public good? The lighthouse is presented as the quintessential public good as it was inherently non-excludable and non-rivalrous. Since the work of Ronald Coase (1974) on the lighthouse, economists have debated the extent to which the private provision of public goods is possible. We argue that there is no *a priori* basis to consider lighthouses are a public good, being both rivalrous and excludable. We highlight recent findings in the history of lighting services (especially private provision of said services) to illustrate why it may be incorrect to consider the lighthouse as a public good for two reasons. First, lighthouses are complements to other maritime services (e.g. pilotage, docking, ballastage). The lighthouse could have been bundled with these complements, which were excludable and rivalrous, in ways that would have permitted its provision. Second, organizations in charge of providing lighthouses were aware of this bundling possibility and lobbied hard to monopolize these other aspects of the trade in ways that limited entrepreneurial opportunities.

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Or as to seamen o'er the wave is borne  
The watchfire's light, which, high among the hills  
Some shepherd kindles in his lonely fold  
- Homer's Iliad (Earl of Derby, 1876, p. 128)

### 1. Introduction

In economics, lighthouses are presented as the quintessential public good. It made its entry in the literature through the work of John Stuart Mill ([1848] 2004)<sup>1</sup> and has continued to feature, notably in the work of Paul Samuelson (1961) where the example is still featured in the latest edition of Paul Samuelson's *Principles of Economics* (Samuelson and Nordhaus, 2009). Its place in "economic lore" can be well assessed by the litany of articles on the question of its provision (Coase, 1974; Van Zandt, 1993; Taylor, 2001; Bertrand, 2006, 2009; Krause, 2015; Lai et al., 2008a, 2008b;

Lindberg, 2013, 2015; Barnett and Block, 2007; Block and Barnett, 2009; Carnis, 2013, 2014; Candela and Geloso, 2018a,b,c, 2019; Mixon and Bridges, 2018; Saito, 2019).

What this literature has in common is that it begins, from an analytic starting point, that lighthouses *are* public goods, and then either reinforces or challenges this claim with empirical evidence, or lack thereof, to support whether or not lighthouses are in fact public goods. In the present paper, we argue why there is no *a priori* basis in economic theory for economists to begin from the premise that lighthouses are a public good. We base our claim, following Cowen (1985), that non-excludability and non-rivalry are not exogenous features of any good, but are endogenous to their institutional context, lighthouses being no different from other economic goods. We stress this point in order to ask the following question: why has the lighthouse been considered a public good in the first place?

Since the publication of Ronald Coase's article (1974) on the ability of private entrepreneurs to build and operate lighthouses in Britain between the 16th and 19th centuries, a consensus has formed around the idea that the provision of the lighthouse there existed with some form of state intervention beyond the mere enforcement of property rights (Van Zandt, 1993; Taylor, 2001; Bertrand, 2006, 2009; Barnett and Block, 2007; Block and Barnett, 2009; Carnis, 2013, 2014). In this literature, the focus has been exclusively on the lighthouse rather than the broader market for

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<sup>1</sup> Though as Taylor (2001, p. 752) mentions, J.R. McCulloch (1835) had preceded Mill in assuming that the provision of lighthouses were the proper responsibility of government. However, this is relatively unknown to economists, and it was Mill's analysis of lighthouses that has been the primary basis from which other economists had followed in assuming it is a public good.

maritime safety provided by other means. The two exceptions are Carnis (2013, 2014) and Candela and Geloso (2018a,b,c). Both exceptions argue for the need to look beyond the market for lighthouses in order to include substitutes and complements relevant to maritime safety that open the door to bundling opportunities and reduce the amplitude of the free-rider problem. We believe that this is an underexploited insight.

Historically, maritime safety was provided through a plethora of different services meant to reduce the likelihood of being shipwrecked (or beached). This included services like ballastage (filling the bottom of an empty ship with sand to give it stability) or pilotage (local experts boarding at safe points to guide foreign ships to ports). These services were purely private goods – they were excludable and rivalrous. They were also complements to lighthouses. For example, a pilot's efficiency would be superior if he had access to a lighthouse. This opens the door the possibility for firms to bundle the production of private goods and public goods in ways that can price in free-riders (Bakos and Brynjolfsson, 1999). As Cornes and Sandler (1984, 1986) pointed out, once joint production of private and public goods is possible, most of the conditions behind the conventional wisdom regarding the provision of pure public goods no longer hold. More importantly, the complementarity between the goods brings out a capacity to privatize the whole bundle even if one of its components is a public good. The complements to the lighthouse have never, to the best of our knowledge, been considered in the economics literature.

The contribution of this paper is twofold. First, we look beyond the original case study that Coase analyzed and illustrate the variety of mechanisms across time and place by which entrepreneurs were able to exclude and price lighting services, and is currently overlooked by economists. Such excludability and pricing operated through bundling, which often occurred with services such as pilotage and ballastage. Maritime historians have long been aware that such bundling occurred frequently (see notably McKenzie, 2003, 2006; Clancy, 1984; Adams and Woodman, 2013; Finger, 2010; Leclerc, 1989, 2003). This differs slightly from Coase (1974) and others (Bertrand, 2006; Barnett and Block, 2007) who emphasized bundling through harbors (whose provision of docking services permits exclusion). We argue that this bundling channel, which is not mutually exclusive to that of bundling with docking services, has been historically more important and far more adopted by economic actors on the ground. The fact that this bundling mechanism has been overlooked has been due to its monopolization through rent-seeking.

This sets the stage for our second contribution, which is to explain why the lighthouse has been the textbook example of a public good. The actors who were aware of the ability to bundle frequently pushed for legal enshrinement of monopoly rights over services complementary to the lighthouse and, as such, they crowded-out most bundling mechanisms. Beginning in the 13th century, rulers and associations of pilots frequently engaged in political exchanges (Buchanan and Tullock, 1962) in which the rulers exchanged legal monopoly (and the rents they produced) to pilots in exchange for a share of the rent and the purposes of reducing the odds of invasion by other foreign rulers. Gradually, the association of pilots also began to monopolize other complementary services such as ballastage. In the process, this political exchange meant that monopolization prevented the emergence of market solutions that tied pilotage to lighthouses. We also highlight that it was in the Americas (Canada and the United States) during the colonial era, when and where pilotage monopolies were weak or nonexistent, that we find most evidence for this bundling and that it was only *after* entry in the pilotage trade was restrained that lighthouses became publicly provided.

By monopolizing the most efficient mechanisms that would have allowed private provision of lighthouses, pilotage guilds and

associations left only limited options for private provision notably relying on pre-provision exclusion (e.g. subscriptions and lotteries), ostracism of free-riders and innovation to reduce the amplitude of the free-rider problem to overcome. In so doing, it appeared to economists who first studied the lighthouse in the 19<sup>th</sup> century that it could not be a private good. In other words, the perception of market failure made by economists was endogenous to a government failure in earlier rounds that went unstudied.

## 2. Lighthouses, rivalry, and pricing

While it may seem obvious to begin from the premise that lighthouses are a public good, a review of basic price theory illustrates why this is not the case. According to the definition of a public good, non-rivalry implies that the marginal cost of adding an additional consumer to a public good is zero. However, once we take into account *the costliness of price discrimination*, lighthouses cannot be regarded as a public good. The fact that pricing lighthouse services across different markets requires scarce resources makes the provision of lighthouses inherently rivalrous, the absence of which would eliminate the incentives and information necessary to exclude non-payers. Though it has become a well-recognized idea that pricing is itself a costly activity (Coase, 1937, 1946; Demsetz, 1964), and, specifically, price discrimination is a costly activity (Leeson and Sobel, 2008), its application has been overlooked with respect to lighthouses.

To illustrate our point, for sake of argument, let us begin from the premise that lighthouses are indeed a public good. Without the ability to exclude non-payers, a decentralized pricing system cannot emerge to determine the optimal level of collective consumption (Samuelson, 1954, p. 388). Suppose, then, government intervenes to exclude non-payers of lighthouse services, namely through taxation. In a zero-transaction cost world, government provision of lighthouse services would supply the optimal level of the public good according to the summation of the marginal benefits of the relevant individuals consuming the good. If lighthouse services are a public good, then price discrimination is consistent with competitive equilibrium (Demsetz, 1970). Since price discrimination is inconsistent with a set of price-takers, or stated differently, a set perfectly competitive firms, government provision is analogous to supply by a monopolistic, price discriminating firm.

According to Samuelson, this is an irrelevant point, since charging positive prices for a non-rivalrous good would be economically inefficient, since there are no extra costs of adding a marginal consumer, such as ships utilizing light from a lighthouse (Samuelson, 1964, p. 151). *Implicit to this conclusion is that the relevant marginal consumers are known ex-ante*. Non-rivalry assumes away the very problem that government provision is presuming to solve, which is the cost of discovering who in fact are the relevant buyers of lighthouse services across different markets. In the market process a “consumer does not only have to decide whether to consume additional units of a product; he also has to decide whether it is worth his while to consume the product at all rather than spend his money in some other direction” (Coase, 1946, p. 173). Prices serve as a competitive mechanism by which to deliver information, but such a competitive process is costly in the sense that resources, which have alternative uses, must be utilized to discover who the relevant buyers are, for example in advertising. Without the price mechanism, government officials will have to utilize another form of competition, which will still require scarce resources and effort, ascertaining who the relevant buyers are in different markets in order to deliver the optimal amount of a public good. It may be the case that, *after* a lighthouse has been produced, the cost of adding an additional consumer, such as a ship utilizing its light, may be

zero.<sup>2</sup> However, this point avoids a more fundamental question – that is, whether, on the margin, there are individuals who value the production of a lighthouse *in the first place*, at what quantity and quality, as well as their intensity of demand. Therefore, the degree to which a good is rivalrous after its production is endogenous to the degree to which its production accurately reflects the quantity and quality demanded across relevant markets *ex-ante*.

Candela and Geloso (2018a) illustrate this point with respect to lightships, also known as floating lighthouses. In 1731, two entrepreneurs, David Avery and Robert Hamblin, moored the world's first modern lightship in the Thames River. The particular importance of the Nore lightship was that it was introduced precisely at a time when traffic at the Port of London was increasing rapidly. During the 18<sup>th</sup> century merchant traffic entering the Port of London stood increased nearly fourfold, from 157,035 tons in 1702 to 620, 845 tons by 1794 (House of Commons, 1796, p. V). The production of the lightship was strategically placed at the shallow mouth of the Nore bank, at the confluence of the Thames and Medway rivers, where lighthouses could not be constructed and the risk of shipwreck was highest. The willingness of entrepreneurs, such as Avery and Hamblin, to supply a lightship, rather than constructing another navigational aid, such as buoy or beacon, emerged only when the profitability of accommodating additional commercial ships rose. Therefore, the consumption of lighting services grew more rivalrous as commerce increased, as well as the cost of shipwreck. It was the rivalrousness of lighting services that incentivized Avery and Hamblin to advertise their product, price discriminate based on tonnage, and therefore craft ingenious way to exclude non-payers. This included the use of subscription payments by which they were able to overcome free-riding. The fact that the lighthouse (and lightship) has been treated as a public good, and therefore as non-rivalrous, has directed economists' attention away from the various ways in which lighting services were provided, and how excludability was an endogenous feature of such rivalrousness.

### 3. Ill-defined market, complements and bundling

In order to understand whether the services of a lighthouse are in fact excludable, it is necessary first to understand the actual service that is being provided, that of maritime security. While the difference may at first sight appear to be purely semantic, phrasing it as such opens the door to the possibility that there are private goods that are substitutes to lighthouses which can also act as complements to them. Generally, the literature on public goods has portrayed the private goods alternatives to public goods as imperfect substitutes. For example, private citizens can substitute locks, guns, and watchdogs for public police protection even if the latter can be produced at lower collective cost if provided publicly. However, the question that has never been asked is whether or not the attributes of the lighthouse constituted the superior alternative in terms of providing maritime security. Moreover, the attributes of the lighthouse – when jointly produced with other substitutes – could amplify the attributes of the other substitutes. For example, a lighthouse's attributes enhance the attributes of the local pilot boarding a foreign ship to take the helm waters unfamiliar to the vessel's crew. Most importantly, if these private goods substitutes

to the public goods are complements, they suggest the possibility that through joint production there can be optimal provision of the public good. For example, a pilot may bundle the fee of the lighthouse into the fees he asks for pilotage before he boards a ship. This pilot, as he possesses the ability to refuse to board, can exclude shipowners from *both* using his pilotage services and the lighthouse. Another example is that of a port which can also bundle fees for the lighthouse with those for docking at a particular wharf. The port, as it possesses to refuse docking, can exclude shipowners from *both* using the wharves and the lighthouse. In the literature, none of these points have been considered.

#### 3.1. Complements

Only the relation between ports and lighthouse has been considered in detail. Coase (1974, p. 364), Van Zandt (1993); Bertrand (2006, p. 394) and Barnett and Block (2007, p. 713) place important emphasis on how exclusions could be accomplished in ports which allowed, even in the instance of public provision, the application of user fees (as opposed to financing out of general taxation).<sup>3</sup> However, while historians such as Talbot (1913); Putnam (1917); Meade (1949); Stevenson (1959); Nicholson (1983), and Dolin (2016) do emphasize an important role for ports, they also highlight the complementary nature of the lighthouse to the task of pilots who often bundled their services with those of the lighthouse. For example, the frequently referenced Stevenson noted that from the 15<sup>th</sup> century, the pilotage guilds in England were proactive in lobbying for the desirability of certain seamarks which they deemed necessary to their trade (1959, p. 393). He also notes that pilots near Liverpool had established lamps at their base of operation to help them in their piloting duties (1959, p. 241). In their history of Trinity House, the guild which was mandated with a legal monopoly for providing seamarks in England, Adams and Woodman (2013, p. 13) highlight that as early as the late middle ages, the Company of Mariners in the College of Deptford (an ancestor to Trinity House they seem to believe) was proactive in bringing to court individuals who willfully destroyed the “seamarks used by pilots”. Others, such as Cunliffe (2010, p. 69), highlight that the Dungeness (close to Dover) had early on a lighthouse that was “close enough (...) to be readily serviced with fresh pilots and cutters and, if a cutter were not in the offing, a ship might well signal for and secure a pilot who would board directly from the shore”. Cunliffe (2010, p. 90) also notes that, throughout the 19<sup>th</sup> century, pilots on the English Channel Island of Guernsey lobbied for the construction of a lighthouse as it was crucial to their trade in the rough choppy waters round the southwest corner of the Island (the authorities had refused the expense). This is why historians often highlight that the two services were interdependent. In his popular history of American lighthouses, Dolin (2016, p. 25 in e-book) relates that a lighthouse near Boston during the colonial era operated as a pilotage station from which the lighthouse keeper would leave to offer his pilotage services. Putnam (1917, p. 211) notes that prior to 1840, the pilots of New York and Chesapeake were paid to take care of the mooring of floating lights. In Wales, Hague (1994, p. 34) highlights that during the 19<sup>th</sup> century, the lodgings of pilots were in close proximity to lighthouses. This is because the lighthouse allowed not only for safer navigation but also for more efficient identification of ships requiring pilotage services.

<sup>2</sup> Demsetz, however, points out other reasons why it be beneficial to charge a positive price for such a good, even though its marginal cost of adding an additional consumer might be zero. As he illustrates in the case of operating a bridge, depreciation over time, rather than through traffic, is still costly, even if the marginal cost of use is zero. Moreover, the use of relative prices can also direct the construction of new bridges at other locations in the future (1964, p. 20). These two points apply no less to lighthouses, and illustrate another aspect of rivalry.

<sup>3</sup> This is well illustrated in basic economics textbooks. In the Australian adaption of Parkin's textbook, the exclusionary mechanism is described as such: “A ship that refused to pay the lighthouse toll was excluded from using the port” (McTaggart et al., 2013, p. 175). Given the work of Bertrand (2006), it seems that this is not exactly accurate. Customs officials would fine transgressors and they would be liable for other penalties.

Contemporary sources also make clear this complementary nature of pilotage and lighthouses. [Stevenson \(1831, p. 10\)](#) noted that the Lynn Regis harbor light in Norfolk was erected on the “Pilot-House of Lynn” and was inhabited by the pilots servicing the port. He also points to the same complementary nature for the Linis Point Light near Liverpool (1831, p. 47). The Hydrographic Office of the Admiralty in Britain reported in 1879 that some lighthouses in Australia also operated as pilotage stations ([Hydrographic Office of the Admiralty, 1879, p. 73](#)). Contemporary publications also seamlessly blended pilotage and lighthouses, which points out the complementary nature of the two services. For example, in the United States during the 19<sup>th</sup> century there was a frequently re-edited and updated volume, titled the *American Coast Pilot*, which provided mariners and pilots with maps and details about the area around ports and detailed accounts of the local lighthouses.<sup>4</sup> In the 1833 edition of the volume, for example, pilots are provided with detailed accounts of safe distances from shores and sand banks using the neighboring lighthouses as a reference point ([Blunt, 1833, pp. 177, 201, 210, 241](#)).<sup>5</sup> In England, such practical publications existed at much earlier time. For example, the *Seaman’s Guide and New Coaster’s Companion* ([Chandler et al., 1788](#)) was a common find for 18th century local mariners in England and was written by pilots who included tide-tables and distances that tended to use the lighthouses as reference points. The earliest and most consistent treatise to do the same was the *English Pilot* ([Seller, 1671](#)). In France, the treatises published by [Michelot \(1805\)](#) and [Coulier \(1829\)](#) also provided the same service.

Ballast providers also saw their activity as complemented by a lighthouse. [Stevenson \(1831, pp. 109, 111, 112\)](#) reported that it was the Irish Ballast Office (which had received the mandate for managing both ballast and lights) which resolved to build lighthouses at Sline Head, Eagle Island, St John’s Cape and Tory Island in the counties of Galway, Mayo and Donnegal. In England and as early as 1493, Trinity House, the guild that operated lighthouses, also operated a ballast office on which it relied heavily for its revenues ([Cotton, 1818](#); [Arrow, 1868, p. 35](#); [Adams and Woodman, 2013](#)).

### 3.2. Bundling

The fact that contemporaries involved in maritime trade and modern maritime historians appreciate the complementary nature of the lighthouse with other services is of great relevance for economics in general. If one good has features that make it a private good in the sense that its consumption is both rivalrous and excludable, but that it is complementary to a public good, then bundling becomes an option. The key value of the complementarity is that the utility generated by two services – e.g. pilotage and lighthouses – separately is inferior to the utility generated when combined. As such, consumers are provided with greater value. For producers, this implies that more demand can be served and the pricing of the bundle covers the fixed costs of the public goods ([Cornes and Sandler, 1984, 1986](#); [Coates, 1998](#); [Bakos and Brynjolfsson, 1999](#); [Liebowitz et al., 2011](#)). The private good in the bundle allows for the exclusion of free-riders of the public goods, especially if the private good is valued more importantly than the public good. As such, because they are buying the whole bundle of services which, when produced as complements, are worth more, the issue of a public goods problem is virtually irrelevant.<sup>6</sup>

<sup>4</sup> The first edition appeared in 1796 under the aegis of Edmund March Blunt. It was frequently re-edited until 1867 when the Blunt family sold the rights to United States Coast Survey.

<sup>5</sup> It is also worth noting that the *American Coast Pilot* had competitors such as the *New American Practical Navigator* ([Bowditch, 1817](#)).

<sup>6</sup> As [Liebowitz et al., 2011](#) point out, this mechanism is further reinforced if there can be competition between bundlers. The problem being that, when bundled, the

value of the different components cannot be easily observed. Pointing to Tiebout models, they can argue that preferences about bundles can be revealed when options exist to defect to another bundle (with different features) altogether. This further reinforces the possibility of privately solving the problem.

For lighthouses, pilotage, and ballastage, did such bundling occur? The answer to this seems to be in the affirmative. First, it must be understood that pilotage was probably the most valued of the two services. For example, we know that pilotage preceded lighthouses in the French and British colonies of North America – sometimes by more than a century in the case of the French colonies ([Baker, 1968](#); [Clancy, 1984, p. 47](#); [Leclerc, 1989, 2003](#)). In the French settlements along the Saint-Lawrence River<sup>7</sup>, we possess data on the number of ships wrecked ([Bosher, 1992](#)) as well as on total ships clearing the only port city – that of Québec City ([Pritchard, 1976](#)) – which allows the computation of the shipwreck rate.<sup>8</sup> This is relevant because these colonies did not benefit from a lighthouse until 1809 (Journal of the House of Assembly of Lower Canada, 1809). The rate of ships lost at sea and shipwrecked from 1713 to 1760 (the last year of French rule in Canada) is averaged annually at 6%, which appears in line with other existing estimates for other countries at the same time ([Wilkinson, 1766, p. IV](#)).<sup>9</sup> However, that proportion is probably too high as it includes ships lost in the high seas well before they would have been in need of pilots and lighthouses. Focusing only the ships that Bosher identifies as “wrecked” in the St-Lawrence River and its estuary, we arrive at the shipwreck rate of 3.3%. Further focusing on those that were wrecked in the areas of the Saint-Lawrence River where pilotage services would have been available, the proportion falls to 2.0%. Moreover, this proportion is probably overstating the level because the denominator of the shipwreck rate is subject to debate but everyone agrees that it understates the total number of ships that entered the Saint-Lawrence River ([Vallières et al., 2008, p. 2248](#)). This is meant to suggest that pilotage was the most valued by ship owners.<sup>10</sup>

It was also heavily valued by pilots because it helped do their work in two ways. The first is that it allowed pilots to guide ships better. The second is that it allowed the pilots to find their clients. For example, in Canada, we know that the pilots which operated on the Saint-Lawrence River – while they did not provide sophisticated lighthouses – knew the key spots to occupy in order to highlight their presence to passing ships and their availability as pilots ([Leclerc, 2003, pp. 57, 103](#)). The quote at the beginning of this article from Homer’s *Iliad* suggests that in Ancient Greece, shepherds also guided navigators by kindling fires on the shore. Given that historians often point out that local populations, which often included local farmers, often moonlighted as pilots, this adds to our contention of bundling services. Later, when entry into the pilotage trade became regulated and a state-mandated monopoly on lighthouses was created, pilots also bundled their activities by

value of the different components cannot be easily observed. Pointing to Tiebout models, they can argue that preferences about bundles can be revealed when options exist to defect to another bundle (with different features) altogether. This further reinforces the possibility of privately solving the problem.

<sup>7</sup> The term “river” is misleading. The Saint-Lawrence is one of the widest waterways in the world and is connected to the Great Lakes. It is also sometimes referred as a seaway. In French, there is also a distinction between *rivière* and *fleuve*. A *rivière* would apply as a term for the Delaware river, the Seine, the Thames or the Elbe. However, the Saint-Lawrence River is known in French as “le fleuve Saint-Laurent” which linguistically denotes a wider estuary.

<sup>8</sup> [Bosher \(1992\)](#) provides the list of ships involved in the trade between France and Canada under French rule as well as the fate of the different vessels (e.g. taken as prize, shipwrecked, beached, lost at sea etc.). Using each ship’s biographical details, we annualized values of ship lost for non-military reasons. We used Pritchard’s (1976) work as the denominator to obtain the ratio.

<sup>9</sup> Wilkinson reports 4,200 deaths in the 1750s for Britain. Given the lowest ratio of 8.6 tons per men estimated by [Davis \(1962, p. 56\)](#) and a merchant fleet of 473,328 tons circa 1750 ([Usher, 1928, p. 467](#)), Wilkinson’s figure entails a loss figure roughly equal to that from Quebec. Any higher figures for tons per men would make Quebec look better.

<sup>10</sup> [Smith \(1911, pp. 36–37\)](#), in his history of the Boston Harbor Light, also points to the fact that the word “pilot” carried more social prestige than the word “keeper” for the lighthouse.

waiting at the lighthouses. The lighthouses would provide incoming ships with the knowledge of the positioning of the shore and the presence of a pilotage station. We also know that light signals of different types were meant to communicate between pilots, lighthouse keepers and ship operators (Russell, 1883, p. 103). Moreover, the quote from the *Iliad* also serves to point that this complement did not need to be a very sophisticated building – all it needed to do was signal. As such, rudimentary lighthouses (lost to history because they are harder to find in archaeological surveys and thus harder for us to observe) were sufficient for pilots.

For the United States, the evidence is clearer as it is very well documented that the first lighthouse in Boston was operated by a pilot who often sought to go at sea to find clients. When, in 1716, the first lighthouse was erected lighthouse keepers also operated as harbor pilots (Putnam, 1917, pp. 7–8). Clancy (1984, p. 47) argues that “inevitably, pilots became lighthouse keepers and lighthouse keepers became pilots”. This arrangement continued until 1733 when the light keeper and pilot Robert Ball complained that other pilots were stealing much of his business while he was operating the lighthouse (McKenzie, 2003, McKenzie, 2003, pp. 98–99; Clancy, 1984, pp. 47–48). According to Fitz-Henry Smith (1911, p. 19), other lighthouses in New England worked on a similar bundling set. There too, a similar story to that of Quebec is found. The keepers would use the light to signal their presence to inbound ships who then signal for the services of a pilot (who would take a Cutter-sail ship to the incoming ship in order to board it). Evidence of bundling also exists on other fronts notably for 18th century Germany where Pietkiewicz and Komorowski (2013, p. 280) note that German lightships in the Baltic served as mobile pilotage stations.

The same is also seen in Great Britain. Stevenson (1959, p. 249) highlights the case of the lighthouse at Cloch (Scotland) in 1796 whose keeper competed with other pilots in his free time. The pilots complained to authorities who replied that since he did not neglect his duties as keeper, they were unconcerned. One way for pilots to find clients was to scour the waters for long periods of time until a ship signaled its presence and requested assistance. This seems to have been the preferred option when the coastline limited the ability of establishing rudimentary docks. However, when a pilotage station could be established, a complementary lighthouse would signal to incoming vessels that there was a service provider in proximity which could be of assistance. In so doing, risks to pilots would be limited as they could limit their time at sea. The East Anglian coast of England provides an illustration of this. In the area, there long existed “beach-companies” which historians have deemed as “very competitive” (Adams and Woodman, 2013, p. 164). These companies, in which the pilots were shareholders, scour the waters to find clients between key pilotage stations such as those at Yarmouth, Lowestoft, Southwold, Aldeburgh, Orford and Harwich. Most of these pilotage stations were also turned into sites for lighthouses and many of these lighthouses were the ones that remained in private hands until the very end of private lighthouses in England (Adams and Woodman, 2013, pp. 164–165; House of Commons, 1834). In his work, Cunliffe (2010, pp. 126–132) highlights that “beachmen” (as the workers of “beach-companies” were known) waited on beaches which happened to be close to lighthouses such as the ones at Orfordness, Caistor (two miles north of Yarmouth), Lowestoft, and Harwich.<sup>11</sup> In addition to this, sources such as Adams (1870, p. 64) also highlight that it improved the efficiency of the pilots.

<sup>11</sup> Cunliffe (2010, p. 132) points out that examinations for pilots in England included questions regarding the description of buoys and beacons in order to give bearings from one to another as well as cross-bearings throughout an area. That distances could be memorized in this manner confirms the complementary nature of the two services.

There were also other bundling mechanisms, but the evidence is more limited on those fronts than on that of pilotage. The one that appears most important relates to ballastage. Ballastage, the act of filling the hull of an empty vessel with sand to give it more stability, was a prized sector of activity of Trinity House in England (Adams and Woodman, 2013). The organization fiercely defended its legally-sanctioned monopoly against potential intruders and reforms, arguing that the revenues provided by ballastage served to finance the provision of the lighthouses and constituted 35% of the Society's revenues in 1760 (Trinity House, 1732a, 1732b; Convertito-Farrar and Cozens, 2009, p. 14; Adams and Woodman, 2013).

#### 4. Preventing bundling

If bundling the complementary services was so evident to contemporaries (and historians), why did it not catch on and, as a corollary, why did it end in the places where this private provision occurred? The answer we contend lies in the fact that pilotage and ballastage were subject to intense political logrolling between private providers and rulers from the early middle ages onwards.

A logrolling process boils down to a political exchange. One party in the exchange can be, as is the case here, a private entity seeking to extract a rent. To protect its rent-extraction, this party must engage with a political agent with whom it will offer either a part of the rent or secure the political agent's own rent (Buchanan and Tullock, 1962; Tullock, 1967; Krueger, 1974). Applied to the case of the lighthouse and bundling, if rent-seeking and logrolling occurred with regards to the private good – which is crucial to permitting bundling – then the rent-seeking process eliminated the most efficient channel for private provision, leaving only “second-bests” to be used. In our case, pilotage and ballastage are sectors subjected to intense rent-seeking. Historical evidence from Britain, Canada and the United States confirms this. One key unifying feature of all three examples is that entry into the pilotage market preceded monopolization or nationalization of the lighthouse by state-mandated actors.

##### 4.1. Logrolling the origins of state intervention in pilotage

The origin of state involvement in pilotage for Western countries can be found in the Rôles d'Oléron. The island of Oléron in the Guyenne region of France was a possession of Queen Eleanor of Aquitaine who eventually married king Henry II of England thus making the island a British possession. It was Queen Eleanor who introduced a new set of codified customs to regulate maritime trade, known as the Rôles d'Oléron,<sup>12</sup> which were adopted in England and its French holdings at first and later in Holland (Runyan, 1975; Clancy, 1984, pp. 9–13; Frankot, 2007).<sup>13</sup> Soon after, they had spread to the Hanseatic league (Frankot, 2007). Out of the 47 articles in the Rôles, 3 dealt exclusively with pilotage (Clancy, 1984, p. 11). They specified punishment for incompetence and malice on the part of pilots (Clancy, 1984, pp. 11–13): “pilots, undertaking to convey ships into harbor, were sometimes in league with the lord territories which they passed, to shipwreck the vessel for the sake of the plunder which would ensue” (Manning, 1839, p. 14). Little

<sup>12</sup> We will not venture a date for the Rôles because we have seen a number of conflicting dates. This is why some historians like Timothy Runyan writes that “the original version of the laws was probably drawn up in Anglo-Norman in about 1200” (1975, p. 98).

<sup>13</sup> It seems that the Rôles were, prior to Eleanor's codification, customs that emerged gradually out of practice (Pineus, 1955, p. 85). Eleanor was prompted to codify them after the Second Crusade where she observed derivatives of Rhodian Laws in the form of the Maritime Assizes of the Kingdom of Jerusalem. It was King Richard I who later further reinforced the application of the Rôles.

evidence exists to back this proposed motivation for the codification. However, in his outline of pilotage history, Hignett (1978, pp. 454–456) ties the Rôles d'Oléron with the emergence of shipmen's guilds in England such as the Shipman's Guild of Great Yarmouth<sup>14</sup> in a transition away from "casual employment of fishermen and boatmen" (1978, p. 454). Hignett added that guilds initially "may have attempted to control pilotage by ensuring that pilots were sufficiently competent for their respective ports" (1978, p. 456) but the evidence for the 13<sup>th</sup> century is somewhat limited. In later work, Hignett (in a book for a pilot's association) added there was "no direct evidence" for quality control as a motivation for the guilds (2012, p. 7).

However, what is clear that the codification of customs via the Rôles opened a breach that favored rent-seeking and that by the late Middle Ages, the ports of England and Scotland "each had a guild, society, combination<sup>15</sup> or club of mariners" and "all sought to regulate the professions of ship-masters and pilots, maintaining acceptable standards on the model of the medieval craft-guild" (Adams and Woodman, 2013, p. 11). Gradually, these associations would become known under the loose aegis of the Trinity Houses system.<sup>16</sup>

#### 4.2. The case of pilotage under Trinity House

The most discussed of these Houses in the economics literature on lighthouses is the one at Deptford Strond which affected most of England.<sup>17</sup> According to Allen, Trinity House "started as a guild of mariners with the purpose to look after aged seamen, widows, and their orphans" (2012, p. 176; see also Clarke, 2016, p. 28; Hardy, 1895, p. 40; Meade, 1949, p. 2; Taylor, 2001, p. 753). Emerging from the Company of Mariners in the College of Deptford, it seems that it was the first to be able to properly limit entry in the pilotage trade.<sup>18</sup> Candela and Geloso (2018b) provide an account of the circumstances under which Trinity House first obtained a monopoly privilege on pilotage. They illustrate how the ultimate nationalization of lighthouse market in 1836 was a politically efficient response to prevent the dissipation of rents between competing interest groups. For the House of Commons, nationalization was a means to redistribute rents in the form of lower light dues from one interest group to another, from lighthouse owners to shipowners, who had complained against excessive light dues<sup>19</sup>, yet preserve

<sup>14</sup> Hignett points to 1207 as the date for this society. However, there is little on the details of those guilds and conflicting dates appear. For example, Adams and Woodman (2013, p. 11) place the founding of this society in 1299. Its also why they consider the origins of Trinity House – the penultimate guild

<sup>15</sup> The word combination here must be understood in the sense of the legal concept of "combines" which acted as a restraint of trade.

<sup>16</sup> The term Trinity House is meant to refer to the religious aspect of the society. As Gary Richardson (2005) points out, most guilds had patron saints and religious activities because it allowed to supervise the involvement in the society of its members thus preventing free-riding.

<sup>17</sup> There were others such as Cinque Ports, Hull and Newcastle. While we concentrate here on the Trinity House at Deptford Strond, the historiography regarding the other Houses is clear that they were acting in the same way to restrict entry (see notably Tran, 2003; Hignett, 1978, p. 457). East (1931) also provides rich details regarding how the Trinity House in Hull (regulating trade near the Humber River in the areas around York) gradually attempted to tighten its grip on maritime affairs.

<sup>18</sup> Hignett (1978, p. 457) points to the House in Hull passing an Ordinance in 1512, one year before the petition in London, preventing non-members from being pilots but he points to evidence suggesting it was ignored. Barrett and Booth (1893, p. 1) places the origins of Trinity House early in the 1400s suggesting that its monopoly power was either weaker at that point or that it was granted by local administrations such as in the case of Scotland discussed by Frankot (2007).

<sup>19</sup> The House of Commons also justified nationalization as a means to reduce light dues charged to ship owners. According the 1834 report of the Select Committee of the House of Commons, formed to investigate the lighthouse system, it stated that the committee "strongly recommend that the Light Dues should in every case be reduced to the smallest sums requisite to maintain the existing Lighthouses and

the regulatory authority of Trinity House. Though economically inefficient compared to a lighthouse market with open entry and exit, such a political outcome made sense given the dynamics of interventionism. Rent-seeking for a monopoly privilege on pilotage systematically created a set of profit opportunities to circumvent such regulation, unleashing a set of market processes that not could not be anticipated by Trinity House<sup>20</sup>. As a result, Trinity House would lobby for additional regulation to regulate entry into the entire seamarks market, particularly lighthouses, in order to preserve their rents accrued from pilotage.

On March 19, 1513, the Company of Mariners in the College of Deptford presented a petition to the King in which they articulated their misgivings over the state of the market for pilotage (Ruddock, 1950, 460). In the petition, they argued that the existing system was producing "inefficient, unqualified pilots" which endangered vessels and their cargoes (Adams and Woodman, 2013, p. 15). The official historians of Trinity House, Andrew Adams and Richard Woodman, suggest that the initial petitioners saw their role as that of maintaining "the quality and quantity of that important pool of expertise – the master-mariners, mates and seamen – that the state would reserve to call upon through levies, impressments and conscription" (2013, pp. 15–16). Complementing this argument was that the regulation of pilotage would help guard the secrets of navigation within English waters and also prevent foreigners from become familiar with them (Adams and Woodman, 2013, p. 16).

What did monarchs gain from granting this guild power? First, the granting of a charter for a guild came was something that the latter organization had to pay for. In some instances, the ruler did not have to pay the costs of collecting taxes (he was relinquishing this right to guilds indirectly) and obtained revenues by sharing a part of the rent earned by the guild. This increased net revenues. Second, it actually allowed a monarch to secure a certain power base (Ogilvie, 2011, pp. 162–163). Members of Trinity House (and the Canadian and American equivalents as we will see below) were very close to political power and often provided political support to ruling coalitions. Third, Adams and Woodman (2013, pp. 15–16) believe that one of the most potent arguments on the part of the initial petitioners was that of the dearth of "skilled mariners". When naval warfare occurred, rulers relied on private ship-owners and mariners to staff their fleets for the duration of the war. In essence, rulers could commandeer ships and their crews for the purposes of defending their realms. The better trained the mariners on those ships, the more effective was a ruler's navy. The claim was made by petitioners from Trinity House that Henry VIII's war with France (1512–1514) had drawn most skilled seaman into service with the Royal Navy, resulting in a lack of trained seaman to pilot the Thames River. A lack of regulatory oversight for untrained seaman, they argued, would not only imperil the lives of other mariners, but also create an opportunity for "foreigners to learn the secrets of the channels and approaches to the Port of London" (Harris, 1969, 19; see also Adams and Woodman, 2013, 15). The allegedly unsafe conditions of navigating the Thames River created a justificatory basis for the regulation of pilotage. Adams and Woodman write that "the increasing importance of London's river to the security of English traders and the economy of the country, with its potential to

Floating Lights, or to establish and maintain such new Establishments as shall be required for the benefit of the Commerce and Shipping of the country" (House of Commons, 1834, iv).

<sup>20</sup> The basis for this is what Boettke et al. (2007) refer to this as "structural ignorance." While proponents of intervention may seek regulation for their own private interests, the contextual knowledge required to anticipate the consequences of such regulation are precluded to them, since outside the institutional context of private property rights and market prices, such beneficiaries are not full residual claimants of profit and loss signals available only in the entrepreneurial market process.

**Table 1**  
Major Episodes and Key Events of the English Pilotage and Lighthouse Markets (12<sup>th</sup> century).

Dates	Decrees and Other Events
1000 to 1200	Little state control over pilotage and competitive market of fishermen and boatmen producers
1200 to 1450	Rôles of Oléron adopted, emergence of shipmen's guild and port-level regulation on entry in pilotage market
1450 to 1550	Emergence of the Trinity House System
March 19 <sup>th</sup> 1513	Trinity House agents petition Henry VIII for authority to regulate pilotage along the Thames River
May 20 <sup>th</sup> 1514	Letters Patent were granted to Trinity House for regulating pilotage by King Henry VIII
1514 to 1670	Trinity House attempts to assert its regulating powers on the competitive East Anglian pilotage market
1550 to 1750	Gradual tightening of the Trinity Houses with regards to lighthouses, pilotage and ballastage
1566	An Act of Parliament grants Trinity House the authority to erect seamarks
1593	The omission of buoys from the Act of 1566 is rectified and buoys fall under Trinity House's purview
June 11 <sup>th</sup> 1594	Letters Patent were granted to Trinity House for monopoly privilege of providing ballastage
1604	King James I issues a new charter for Trinity House reinforcing its authority
1679	Trinity House adopts a policy of renting letters patent to private operators. After 1679, all new patents are obtained by Trinity House
1685	King James II issues a new charter for Trinity House reinforcing its authority
1717	Pilotage Act of 1717 is passed which made it a criminal offense to be an unlicensed pilot and penalties were specified for offenders.
1732	Pilotage Act of 1732 is passed, tightening aspects of the Pilotage Act of 1717
1732	Ballast Act of 1732 is passed, tightening the legal status of Trinity House's monopoly on the market
1765	Liverpool Pilotage of 1765 stipulates compulsory pilotage in the region surrounding the city
1808	Maritime Pilotage Act of 1808 is passed, other Trinity Houses fall under purview of the Trinity House at Deptford Strond, compulsory pilotage is enacted
1822	An enabling act permitting Trinity House to buy back leases before their term expire is passed
1836	Act of Parliament passed authorizing the nationalization of lighthouses and their placement under Trinity House as the sole lighthouse authority in England and Wales

Sources: (Coase, 1974, p. 367; Harris, 1969, p. 131; House of Commons, 1834; Price, 1906, p. 144; Ruddock, 1950, pp. 460, 463; Raithby, 1823, p. 33; Stevenson, 1959, pp. 139, 257; Redman, 1843, p. 35; Bertrand, 2006, p. 400; Adams and Woodman, 2013, pp. 160–169; Tran, 2003; Hignett, 1978, pp. 454, 457–460).

enrich those engaged therein, were the reasons why (...) expanding the powers of their [the Company of Mariners in the College of Deptford] brotherhood was timely" (2013, pp. 16–18).

From there, Trinity House would gradually increase its hold on the pilotage market. As testified by Table 1, it managed to acquire legal monopoly over seamarks in 1566 and ballastage in 1594. Later, during the 18th century, several Acts of Parliament were passed that tightened the House's legal status while also making pilotage a compulsory service (Bederman, 1989; Tran, 2003). A telling example of this is the aforementioned market for pilotage on the East Anglian coast of England. When Trinity House received its regulating powers, pilots in East Anglia "reacted with anger and alarm" since the House "sought not only to judge their fitness for work (...) but to mulct a part of their earnings for doing so" (Adams and Woodman, 2013, p. 165). From then on, there were always a large number of illegally operating pilots since the East Anglian coast, while the geographic sphere of authority of Trinity House, was beyond the practical enforcement abilities of the House (Adams and Woodman, 2013, p. 165). Gradually, notably through the Pilotage Act of 1717 (see Table 1), Trinity House convinced state actors to enforce its authority notably by imposing penalties on unlicensed pilots. The act of making pilotage compulsory further expanded the size of the rent extracted by Trinity House.

It would seem that if all vessels are compelled to use Trinity House pilots and to pay the monopoly fee, Trinity House would have all the right incentives to finance and maintain lighthouses because they benefit from the complementary nature of lighthouse provision. Though Trinity House was a private organization, it was also non-profit, and therefore lacked a defined residual claimant in its decision-making (Candela and Geloso, 2018b). Trinity House members did not acquire shares of ownership that could be directly bought or sold to other individuals as private property (Alchian, 1965), and therefore, none of the members directly accrued monetary profits from directing the allocation of pilots, ballasts, or seamarks according to consumer preferences. Rather, any profits were to be expended within the organization, ostensibly for monitoring the quality and maintenance of seamarks (Alchian and Demsetz, 1972). However, as Harris points out, the "provision of new seamarks cost money, and the Brethren had to meet the cost out of their own resources" (Harris, 1969, p. 160). The point here is that lacking residual claimancy over profits directly

accrued from seamarks, Trinity House regulators were disincentivized from financing and maintaining lighthouses, specifically by denying petitions brought forth by individuals for the construction of lighthouses (Stevenson, 1959, p. 259). According to Harris, "there were very few lighthouses on the English coast in the sixteenth century, and they did not exist in significant numbers until after 1700" (1969, p. 153). By 1609, only four lighthouses had been built by Trinity House (Clarke, 2016, 30), and none between 1610 and 1675 (Stevenson, 1959, 259; Coase, 1974, 364; Bertrand, 2006, 394). All the other lighthouses were built by private actors who could not rely on the bundling of pilotage, ballastage and lighthouse services.

Rent-seeking for control of the conditions of entry and exit in the lighthouse market was an efficient response by Trinity House to not only prevent rent dissipation from pilotage, but also a means by which to effectively preserve and monetize their rents accrued from controlling entry into the lighthouse market. Such a response, and the entire nationalization of the lighthouse market under Trinity House, emerged as an unintended consequence of Trinity House originally trying to secure its monopoly privilege against rent dissipation, and resulted in Trinity House preventing entrepreneurs from bundling services together.

Under this institutional context, what could have been complementary services, such as pilotage and lighthouses, ballastage and lighthouses, or a combination of the three, became substitute services that competed against each other. Lighthouses provided jointly (the best available option) with ballastage and pilotage was monopolized by Trinity House. Those who built lighthouses outside the Trinity House system had to rely on other mechanisms (which we describe in Section 5). Since Trinity House was disincentivized to finance and maintain lighthouses, it unintendedly created a profit opportunity for entrepreneurs to circumvent its monopoly privilege over pilotage (see Section 5).

To illustrate how Trinity House unintendedly created profit opportunities<sup>21</sup> for those who successfully circumvented the

<sup>21</sup> These profit opportunities are well observed in the recurrent complaints from shipowners against high light dues, pilotage fees and ballastage fees (see notably Adams and Woodman, 2013; Clarke, 2016). They can also be observed in the case of the lightship which, when implemented in 1731, had been floating around for some six decades against the wishes of Trinity House. The entrepreneurs who opened

monopoly right over pilotage, it is relevant to look at the patent system that existed in the 17<sup>th</sup> and 18<sup>th</sup> centuries. Private entrepreneurs alert to the demands of ship owners and mariners would apply for a patent directly from the Crown, empowering them to construct lighthouses and levy light dues on ships, which were collected at ports (Coase, 1974, 364). In exchange for such patents or leases, private individuals paid rents to the King for the privilege (Bertrand, 2006, 395; Meade, 1949, 114–115; Taylor, 2001, 752). Critics of Coase's analysis of the English and Welsh lighthouse system have taken this patent system as an example of market failure in the form of monopoly power, which later justified nationalization due to high light dues. However, as Candela and Geloso (2018b) have shown, this was actually an efficient response by entrepreneurs to enter the lighthouse market and increase the supply of lighthouses given the institutional context that Trinity House "tried to prevent private individuals from building lighthouses by attempting to have the exclusive nature of its building right recognized"<sup>22</sup> (Bertrand, 2006, 394). By not being able to bundle, private operators would have had to create their own collection and enforcement solutions. This would have been prohibitively costly unless the state enforced payment. However, this only became an efficient option because Trinity House has established a monopoly over bundling mechanisms, which forced entrepreneurs into costlier production options.

It is quite telling regarding our bundling contention that Trinity House first attempted to limit entry in the pilotage market and then, some five decades later, attempted to monopolize the lighthouse market. In fact, this explains why bundling of pilotage and lighthouses – while ubiquitous – did not act as a manner to permit private production. The limitation of competition in pilotage meant a reduction in the supply of pilots and *in the process* it also reduced the supply of lighthouses through a bundle of both services.<sup>23</sup> Since competition for lighthouses could have emerged through competition between different bundles, limiting entry into pilotage meant limiting the ability for private provision and competition for lighthouses.

Trinity House also recognized this implicitly. After 1679, Trinity House subsequently shifted its policy away from direct competition with private entrepreneurs to cooperation with lighthouse owners, so as to control the distribution of lighthouse patents and therefore effectively control the conditions of entry and exit (Stevenson, 1959, 257). Trinity House sought to consolidate its monopoly privilege – derived from the Act of 1566 – namely by applying itself for a patent from the King to operate a lighthouse. Such patents, held by Trinity House, would then be leased to individuals seeking to erect lighthouses, for which they would pay a rent to Trinity House for the privilege and bear the costs of construction. By doing so,

the first lightship did it outside the Trinity House system (which opened litigation and lobbying against them by Trinity House) at the great delight of merchants who provided enough support to propose the opening of multiple other lightships to compete with Trinity House (Candela and Geloso, 2018a).

<sup>22</sup> On this point, see also Lucas and Fuller (2017).

<sup>23</sup> Such a reduction took place. The number of lighthouses built by Trinity House, the only organization that could legally bundle them with pilotage services, failed to increase for most of the 17<sup>th</sup> century. The number only increased modestly towards the end of the century and then remained the same until the 1780s (Stevenson, 1959, figure 165). This was at the same time as an increase in demand. First, the total volume of maritime trade increased (Usher, 1928) at a faster pace. Second, internal improvements in England increased the number of navigable riverways which would have required lighthouses and beacons (Satchell, 2017; Jackson, 1983; Willan, 1964). Some of these riverways include coastal access points which could be accessed from the sea and would definitely have required lighthouses (Satchell, 2017, pp. 19, 22, 25–27). Third, some new ports were opened for trade during the era (Jackson, 1983). A ramification from this point is that, by forcing private operators into costlier production structures, Trinity House was pushing up the light dues. This would explain why both Trinity House and private lighthouses were the object of varying degrees of scorn (Taylor, 2001).

the monopoly power in the acquisition of leases of operation that it received and strengthened allowed it to extract sizable revenues needed to fund the pensions that it offered to licensed pilots. While Trinity House was in charge of limiting entry, thus reducing supply, it was also in charge of charities aimed at its members most notably pensions to "decayed" pilots and their widows. The proceeds from the lighthouses served to finance the charities geared towards members (Candela and Geloso, 2018b). However, Trinity House officials also indirectly monetized such monopoly control over entry and exit in the lighthouse system via patents through direct purchase of leases in the lighthouses themselves. As Adams and Woodman state, "several lighthouse leases were being taken up by members of Trinity House itself. John Whormby, the Corporation's clerk until 1750, was part of a syndicate having shares in the Eddystone. This also included his predecessor Samuel Hunter, the deputy clerks and Collectors of the Light Dues at London, John and Richard Noyes, and Thomas Day, the Collector of Customs at London" (Adams and Woodman, 2013, 120). In effect, these individual members of Trinity House were able to privately gain from their monopoly privilege, the control of which also prevented potential bundling by private entrepreneurs between different services conducive to maritime safety, such pilotage and lighthouses.

Any increase in competition would reduce the revenues from the lighthouses and thus also reduce the stream of benefits going to House members. The same applied to ballastage which was monopolized by Trinity House in 1594 by a Charter granted by Queen Elizabeth (see Table 1). When, in the 1730s, the possibility seemed to emerge that this monopoly could be broken, Trinity House made the point that without control over ballastage, "Navigation on the River Thames would soon be ruined" (Trinity House, 1732b, p. 3) while also drying up revenues for its charitable endeavors. Implicitly, by limiting competition in order to extract a greater rent, they were blocking the ability to bundle by other actors. Explicitly, by monopolizing all the channels for bundling, they were limiting the ability to privately produce lighthouses.

#### 4.3. Pilotage in the United States during the colonial and early republic eras

As mentioned above, during the colonial era, pilotage was the first service provided and it was complemented by lighthouses. However, it did not take a long period of time before entry in the pilotage trade became regulated in a manner similar to England. The best example is provided by the aforementioned example of Boston harbor. This is largely because Massachusetts possessed the greatest number of lighthouses in all of the American colonies pre-1780s (Holland, 1972, pp. 8–12). It is also one of the earliest instances of legalized monopolization of the pilotage trade. In 1733, Robert Ball, who operated the lighthouse in Boston, complained that other pilots were stealing much of his business while he was operating the lighthouse (McKenzie, 2003, pp. 98–99; Clancy, 1984, pp. 47–48). Taking his complaints to the General Court (the legislature of the colony of Massachusetts), Ball requested and obtained that he alone be named official pilot (McKenzie, 2003, pp. 98–99). In exchange for giving him monopoly, the Court merely requested that he maintain two pilot boats stationed at the light (McKenzie, 2003, p. 99). Competition apparently persisted illicitly as the Court felt compelled to pass another act, in 1783, making it the sole authority for nominating pilots (McKenzie, 2003, p. 99). The management of pilotage accreditation was transferred to the Boston Marine Society – largely composed of pilots itself (Eastman, 1956, p. 17–18). Simultaneously, it also granted itself the sole authority for nominating lighthouse keepers. As such, the legislature granted itself the power to dispense political patronage (McKenzie, 2003, p. 121). In the process, it legislated away the bundling option between the two options. This was further intensified when, in the early republic

lic, Alexander Hamilton pushed for the federalization of lighthouses (Holland, 1972, p. 26). The lighthouses were to be financed per general appropriations rather than a specific light duty (Noble, 1997, p. 6).

In other states, the same process occurred. In Pennsylvania, during the 1740s, the colonial legislature proposed an act preventing pilots from “cruising for business” and forcing them to stay ashore waiting for a signal (Finger, 2010, p. 396). The purpose of this act was to limit the possibility that French and Spanish privateers would capture pilots who would then pilot them into the port of Philadelphia (Finger, 2010, pp. 394–396). Frightened at the possibility that they might be placed under a restriction which pilots in the neighboring state of New Jersey would not have to deal with, pilots lobbied the legislature to exert pressure on the New Jersey legislature. While the Aix-la-Chapelle peace treaty of 1748 rendered the issue moot, it shows that there was competition in the middle colonies. It was not until 1766 that restrictions on competition were introduced (Keller, 1977, p. 37).<sup>24</sup> In addition, the regulatory entity in charge also had the liberty to fix the rates that different classes of pilots could charge – rates that they had not changed between the enactment of the statute in 1766 and its reform in 1788 (after the American Revolutionary War had caused important price increases) (Keller, 1977, p. 38). As such, entry into the trade was regulated. A year after the enactment of the first entry barriers, the first lighthouse promoting access to the port of Philadelphia was constructed (Holland, 1972, p. 11). That lighthouse, the Cape Henlopen Light, also served as a pilotage station early on (Jones, 1828, p. 9).<sup>25</sup> In this case, the monopolization of the pilotage trade by legal channels preceded the construction of lighthouses which effectively meant that it had to be financed in large by public funds (Mixon and Bridges, 2018, p. 95) even if the complementary nature of the two services was well observed.<sup>26</sup> Together, the colonies of Pennsylvania and Massachusetts represented 5 of the 11 lighthouses in the United States prior to 1775 (Holland, 1972, pp. 8–12). In these two important colonies, we observe a similar outcome as in England whereby the main bundling option of the two complements was being legislated away.

#### 4.4. Pilotage in Canada and Quebec to the mid-19th century

The main difference between Canada and the United States is that pilotage existed in the former without formal lighthouses for more than a century – under both French and English rule. While there was a lighthouse built to help military ships at the French military fortress of Louisbourg in Cape Breton in the 1730s, it was destroyed in the sieges of the fortress. The first lighthouse guid-

ing access to the Saint-Lawrence River – the main seaway – was built only in 1809 at Isle Verte (Leclerc, 1989, p. 218). Akin to the case of Pennsylvania, the legal monopolization of the pilotage trade occurred before the building of lighthouses.

The first barriers to entry in the pilotage trade were erected when the colony was under French rule. Prior to 1711, although there are some historical uncertainties, the hydrography professors at the Collège de Québec were the only ones allowed to issue pilot certifications. Without such certification, it was illegal to participate in the pilotage trade (Leclerc, 2003, p. 48). After 1711, with the creation of the position of port captain, the colonial government awarded itself the ability to issue certification (Leclerc, 2003, pp. 48–49). This ability to restrict entry was solidified in the 1720s (Leclerc, 2003, pp. 51–54) and it was under the aegis of the government that the first pilotage station, that of the Île du Bic some 249 km northeast of Quebec City, was established (Leclerc, 2003, p. 54). Moreover, the colonial government selected certain pilots as the official pilots of royal vessels and only they could pilot these ships (Leclerc, 2003, p. 57). Nevertheless, there was competition as many locals who lived near these stations and coupled their occupations as farmers with occasional pilotage services – a skill which was generally transmitted within families (Leclerc, 2003, p. 57). They held no certification (as they were not trained by the Collège de Québec) which suggests that the ability to apply the restrictions was limited. This is well echoed in the recurrent complaints regarding how local fishermen and farmers were offering their services in competition with certified pilots.

Upon conquering the colony in 1760, the British tightened the enforcement of entry barriers. It started in 1762 with the enactment of an inspector of pilotage and the compulsory payment of pilotage services by foreign merchants (even if a pilot was not hired) (Leclerc, 2003, pp. 61–62). This served enforcement purposes in two respects. The first was that it allowed to identify illegal pilots. The second was that it would increase the cost to foreign merchants of hiring illegal pilots because they would have to pay twice. Rates were also uniformized and fixed legally (Camu, 1996, p. 95) while a formal compulsory apprenticeship program was also implemented (Leclerc, 2003, p. 73). In 1805, this system was institutionalized with the creation of the Quebec Trinity House, the organizational structure of which was modelled on the British Trinity House. The organization was composed of pilots and was in charge of accreditation as well as the maintenance and construction of seamarks such as buoys and lighthouses. The goal was to respond to a recurrent criticism that competition was out of control and needed to be curtailed. Similar complaints were reiterated in the 1830s when certain regulations were further tightened (Camu, 1996, pp. 122–123). This tightening occurred after several pilots testified that local inhabitants at key points had been offering pilotage services to large numbers of ships in areas that accredited pilots were less familiar with (House of Assembly of Lower Canada, 1829, pp. 216–221).<sup>27</sup>

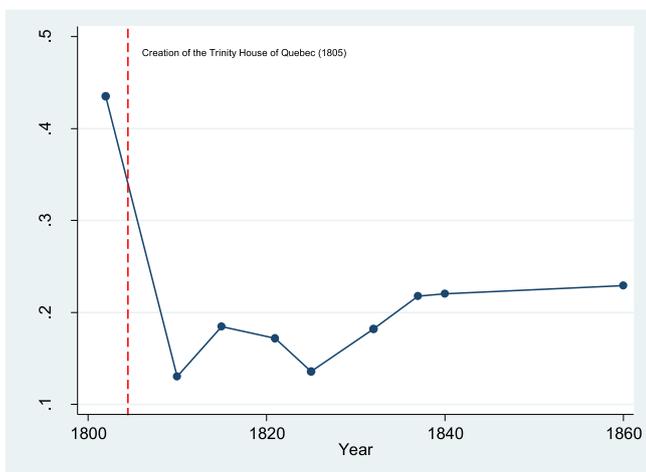
The advantage here is that thanks to the work of Jean Leclerc (1989, 2003), there is rich empirical evidence for Quebec regarding the number of pilots. As can be seen from Fig. 1 above, the number of registered pilots was equal to 0.4 per ship entering the port of Quebec City. Soon after, it fell to between 0.1 and 0.2 pilots per ship suggesting that there had been an effective restraint on the sup-

<sup>24</sup> Under this system of regulation, there would be three license classes going from first-rate (experienced pilots earning the highest fees) to third-rates (new entrants who, after an apprenticeship, earned the lowest rates). The regulations were created by Pennsylvania Assembly when it also created a board of wardens to manage the port. By 1788, the statute enacted by the Assembly was extended and the Board of Wardens was permitted to regulate ballastage as well as set up a fund for the support of decayed pilots (Keller, 1977, p. 37). One important difference here relative to other pilotage regulating entities is that it was not the pilot themselves who regulated entry but a third party, in this instance the Port of Philadelphia via its commissioned Board of Wardens. However, it is relevant to point out that when the pilots went on a strike in 1792 in order to pressure the Board of Wardens to increase wages, the pilots, according to Keller, did not direct their protest “against the state’s authority to regulate their trade” (1977, p. 40) and their dissatisfaction had more to do with “immediate economic circumstances” rather than “broader unhappiness with mercantile regulation” (Keller, 1977, p. 48). The strike ended with an increase of the pilotage fees.

<sup>25</sup> Although in Delaware today, the lighthouse was built at the behest of Pennsylvania (Holland, 1972, p. 11).

<sup>26</sup> Some 40% of the cost of the lighthouse was funded by proceeds from a lottery (Mixon and Bridges, 2018, p. 95). The rest came from a loan contracted by the government which issued bonds at 6%.

<sup>27</sup> The local inhabitants were more familiar with the local setting that pilots who, in an era of relatively limited cartographic knowledge (Leclerc, 2003), had to be familiar with all of the areas along the routes. As such, the locals provided superior services. In fact, one pilot confessed to the House of Assembly that the ships engaged in a perilous passage had accredited pilots on board and nevertheless allowed local inhabitants to conduct the ships to port (House of Assembly of Lower Canada, 1827, p. 292).



**Fig. 1.** Pilots per ship in the Saint Lawrence River.

**Source:** The number of pilots is taken from the work of [Leclerc \(2003, p. 102\)](#) while the number of ships entering the Port of Quebec City is taken from the *Sessional Papers to the Parliament of Canada* (1862).

ply of pilotage services. Indeed, these numbers are conservative estimates given that they report only the *registered* pilots and not those engaged illicitly in the trade (and which were deterred by the enforcement mechanisms implemented during the era of British rule). As such, the decline was probably more pronounced. Leclerc has no systematic evidence pre-1802, but it appears that the 1802 level in [Fig. 1](#) is in line with historical supply levels. [Leclerc \(2003, p. 64\)](#) reports that in 1768, the colonial governor passed an ordinance mandating that between 18 and 20 pilots should be available for service at the pilotage station. This meant 0.32 pilots per ship which is well above the post-1802 levels. Earlier statistics regarding the number of pilots suggest even greater supply in the era of French rule, especially in the 17<sup>th</sup> century where regulations were at their weakest. Leclerc states that in the 1663, there were 8 individuals who reported being pilots in the census (2003, p. 45). This was at a time when there were 17 ships entering the port on annual basis ([Pritchard, 1976, p. 201](#)) which means that there were 0.47 pilots per ship which is the highest point observed.<sup>28</sup> It is only after the

<sup>28</sup> There are also no signs of an improvement in security. The data we pointed to above taken from the work of [Bosher \(1992\)](#) and [Pritchard \(1976\)](#) suggests rates of shipwrecks between 2.0% and 3.3% during the period from 1718 to 1760. Given that most scholars of Quebec's economic history believe that the number of ships involved in trade in the Saint-Lawrence river during the French era is underestimated by anywhere between a tenth and a third of the current estimates ([Vallières et al., 2008, p. 2248](#)), these rates could fall as low as 1.5% to 2.5%. We have no clear data on shipwrecks until 1840-49. For that decade, Jean [Leclerc \(1989, appendix E\)](#) was able to collect an incomplete list of shipwrecks in the Saint-Lawrence. The total number of ships involved is known with better certainty for the period so that, using the figures in the *Documents de la Session* (1862) for entries in the port of Quebec City, we find a shipwreck rate of 2.1%. However, the list of shipwrecks is incomplete and is the rate is probably greater. Indeed, we know from reports by the [Dominion Board of Trade \(1875, pp. 112-114\)](#) that 71 ships were shipwrecked (13 of which were fully lost) in 1874 alone in the lower part Saint-Lawrence River – a shipwreck rate of 2.5% ([Camu, 2005, p. 300](#)). Other documents, such as the *Journals of the House of Assembly* (1821; 1822; 1827; 1829) provide evidence for the years soon after the creation of Trinity House. The number they suggest seem to propose roughly 20 to 25 ships wrecked annually which entails a rate of 3.0% to 3.8% for the 1820s. As such, there is uncertainty about whether or not things improved mildly or deteriorated mildly with regards to security as a result of licensing. However, the best-case scenario is a 1 point in the share of shipwrecks. This is to be contextualized by two facts. First, even by 1874, large number of ships *did not* use pilots because there were not enough available ([Dominion Board of Trade, 1875, p. 114](#)). As such, it is possible that part of the reduction came simply from improvements in mapmaking and ship technologies (notably the introduction of steamships which limit the odds of being blown onto sandbanks). Second, pilotage fees increased rapidly. The average annual nominal rate of pilotage rose from 16 shillings to 22.38 shillings between 1805 and

creation of Trinity House and that there was an important reduction in competition that lighthouses were built. Nevertheless, the pilots that were able to enter the trade did frequently lobby for lighthouses and were important promoters of them as they recognize the dual purpose that they could serve ([Leclerc, 1989, 2003](#)).

## 5. Options beyond bundling

The examples of Britain, the United States and Canada illustrate that historically recognized efficient solutions to the provision of lighthouses, namely their bundling with pilotage or ballastage, were made impossible by entry barriers in the pilotage and ballastage sectors. Given that our contention is that lighthouses, pilotage and ballastage were natural complements, it is not surprising that private provision of lighthouses has been so infrequent throughout history. What is surprising is that there has been so much private provision in spite of the fact that the seemingly first-best option was blocked.

Indeed, with this main option blocked, those who wanted to construct lighthouses were left with “second best” options. In fact, none of these alternative mechanisms were sufficient on their own to permit private production. They had to be mixed together to make them more potent. One such example would be to rely on ex-ante exclusionary mechanisms such as subscriptions and lotteries. The idea was to ask for large payment prior to provision of the public good. If payment was not made, the service would not be provided. We know that subscriptions were used in the case of England's first lightship in 1731, which was launched in competition with Trinity House and in violation of their monopoly privileges ([Candela and Geloso, 2018a, 2018b](#)). The two merchants relied on subscription lists they had left in different taverns and coffeehouses across London in order to collect the funds necessary to cover construction costs. Lotteries were also used in the American colonies in the case of the Cape Henlopen lighthouse on the Delaware river or the New London light in Connecticut ([Mixon and Bridges, 2018, p. 95](#)). These covered some of the costs, but they were not sufficient. While we know little about how much funds were raised from subscriptions for the lightship in England, we know that the lotteries in the case of the Cape Henlopen light collected only 40% of the funds necessary for construction while the New London light collected 70% of its construction costs through lotteries ([Mixon and Bridges, 2018, pp. 95-96](#)).

To increase the efficiency of these kinds of mechanisms, other solutions would be blended with those such as price discrimination in order to price in certain segments of the market ([Demsetz, 1970; Lai et al., 2008a, 2008b](#)). This was notably the case with the first lightship in England where the two merchants who constructed differed from the vast majority seamarks by providing a fee schedule that depended on the tonnage category within which a ship fell. By pricing according to marginal value, it was possible to induce more individuals to participate in the financing of the goods ([Candela and Geloso, 2018a, 2018b](#)). The problem is that, because price discrimination is itself a costly endeavor ([Leeson and Sobel, 2008](#)), it cannot solve the issue of excludability alone. It merely provides an additional channel to complement others.

Ostracism can also be used to exclude non-payers. The idea here is that individuals embedded in other social clubs can be made to contribute by fear of being ostracized by their fellow club members. We know that such mechanisms do exist in terms of permitting the provision of public goods ([Maier-Rigaud et al., 2010; Stringham, 2015; Kingston, 2007, 2014](#)). However, there is only suggestive evidence that this was used to help provide lighthouses. The case of

1849 ([Leclerc, 1989, p. 165](#)). This was at a time of a downward trend in the general price level ([Geloso, 2019](#)) so that the inflation-adjusted pilotage rates rose 120%.

England's first lightship again provides illustration as the two merchants who built it left subscriptions books in coffeehouses and taverns that were in essence the meeting houses of different trades (Candela and Geloso, 2018a).

Finally, it was also possible to innovate in a way that reduced costs sufficiently to make private provision more viable. This was again the case with England's first lightship which was much cheaper to operate than other lighthouses allowing the same pool of revenues (i.e. ships entering the Thames River) to generate more profits for the operators (Candela and Geloso, 2018a).<sup>29</sup>

The combination of these second-best options only became an attractive proposition because of the monopoly conferred on pilotage services. Absent regulated entry, these options might have been less frequently used than observed. The evidence from the pre-regulation markets of Canada and the American colonies suggest that these additional mechanisms went unused as pilotage was the primary reliant mechanism for the provision of lighthouses. However, each of these options have shortcomings and cannot be used alone for the purposes of permitting private provision of lighthouses. They are second-best solutions upon which potential producers must fall back upon as a result of a certain institutional framework. That institutional framework is the one where the most efficient provision mechanism was precluded by rent-seeking in other portions of the market for maritime safety. The traditional categorization of the lighthouse as a public good is thus not the result of the inherent features of the good itself. It is the result of the institutional framework within which they have been historically produced. In essence, the lighthouse has entered economic lore as one of the most popular examples of market failure when it was in fact the result of a government action that made the most efficient means of private production unavailable. This is why we assert that what is truly surprising is not that there was so little "privateness" but that there was so much.

## 6. Conclusion

Why has the lighthouse been treated as a public good? Historically, this may be because by the time Mill ([1848] 2004) introduced the notion that the lighthouse as a public good, the lighthouse market had already been nationalized in England and Wales. Once the lighthouse market had been nationalized, the incentive for the private sector to develop exclusionary mechanisms had essentially been eliminated (Cowen, 1985, p. 62).

Fundamentally, the classification of the lighthouse as a public good, we argue, has been more analytical in nature. The purpose of economic theory is to render economic history intelligible. However, when economic theory comes to *define* economic history, as it has with respect to the lighthouse, important historical facts become overlooked by virtue of the fact that theory has defined their possibility out of existence. This has been the case with the lighthouse, which was *never* non-rivalrous or non-excludable.

In this paper, we have illustrated, across place and time, the various exclusionary mechanisms that have been devised by entrepreneurs for the private provision of lighting services, defined broadly to include maritime security. Such provision included overlooked complementary features of the provision of lighthouses, specifically its being bundled with pilotage. This introduces an important implication for future research, which is to reframe

the lighthouse as a joint supply good, a concept that had been introduced by Alfred Marshall (1920, 2013), and emphasized by Buchanan (1968) and Demsetz (1970). Since the emission of light provides a service to both merchant vessels as well as pilots, their complementarity meant that lighthouse services could be bundled. This complementary feature was ruled out by government monopolization, redirecting entrepreneurs to innovate other mechanisms of excludability, including the use of ports and subscriptions. Such innovation implies that lighthouse services have been rivalrous in nature, since the innovation of exclusionary mechanisms were an endogenous feature of the cost of discovering relevant buyers. As a result, entrepreneurs had to innovate to reduce such costs through the various mechanisms we've described. Had the lighthouse been non-rivalrous, the incentive to engage in such productive entrepreneurship would not have existed. In the end, our article suggests that with respect to the lighthouse, economists have not yet fully moved away from the theoretical blackboard, and that future research should be redirected towards investigating the historical and institutional details of their provision across time and place.

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<sup>29</sup> There is another option for which there is much less evidence. Many lighthouses, especially during the Middle Ages, were operated by religious congregations. It is also known that the Church and many congregations actually owned ships and engaged in trade (Miller, 2003). Given this jointness, the Church could have operated lighthouses for the sake of increasing the safety of its own ships regardless of whether or not others acted as free-riders.

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