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The Lighthouse Reform Movement in Antebellum America

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Abstract

This study investigates whether economic differences attributable to the length of a state's coastline effected Congressional voting in the 1850s on measures to reform the lighthouse system, a service often thought to be best provided by the government. Probit estimation is used to analyze (1) roll-call votes in the House of Representatives in 1850 on a bill to convene a board of specialists to inquire into the condition of the lighthouse establishment and to make proposals to improve the system, and (2) roll-call votes in the Senate in 1852 on a measure to defeat the establishment of a lighthouse board to administer the lighthouse system. The historical record of lighthouse administration in America points to several conclusions: (1) in the early nineteenth century, the quality of lighthouse services in the U.S. lagged behind that in Europe; (2) the lag in quality of the U.S. lighthouse service appears to be due to its administrative practices; and (3) states with long coastlines expected greater net benefits from an investigation of the need to improve the lighthouse system. While the quantitative evidence indicates that geographic differences and party affiliation were influential in initiating an investigation of the lighthouse system, these factors were not influential in the subsequent attempt to defeat the establishment of a lighthouse board.

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The Lighthouse Reform Movement in Antebellum America

Introduction

When Christopher Columbus arrived in the New World, the coastlines were a lot darker than they are now. He experienced the difficulty of making out islands and rocky shoals with only moonlight, and he was well aware of the hazards of sailing at night in unfamiliar territory. After all, his uncle, Antonio Colombo, was the keeper of a light tower at Genoa.

Sea traffic increased dramatically as trade developed in the New World. As maritime commerce in the New World increased, the need to construct aids to navigation increased. Eventually, lighthouses were built in America to provide navigational information to mariners to help them determine their location, identify routes to their destination and avoid submerged rocks and dangerous land formations. This information was particularly useful in inclement weather and at night. No longer did seafarers need to rely exclusively on celestial navigation or dead reckoning, a method in which a ship's location is fixed using its speed and direction from point of departure.

Lighthouses are the subject of numerous books, including books by Hans Christian Adamson (1955), British lighthouse historian D. Alan Stevenson (1959), Patrick Beaver (1973), Francis Ross Holland, Jr. (1988), and Sarah C. Gleason (1991). These books focus primarily on lighthouse architecture, construction, illumination technology and tales of tragedy and heroism. Two scholarly papers also have examined the financing of lighthouses. Ronald Coase's article (1974) surveyed lighthouses constructed in Great Britain from 1513 to 1898. He sought to demonstrate that the construction of lighthouses has been financed by private enterprise. Of the

46 lighthouses in existence in 1820, Coase reports that 34 had been built by private individuals. (Coase, 1974, p. 367). Zandt (1993) claimed that for the period Coase surveyed and for both prior and subsequent periods, the government played a substantial role in the provision of lighthouse services above and beyond the enforcement of property rights and contract enforcement. Zandt reports that there were frequent complaints about the quality of the lighthouse service in Great Britain. "Apparently, these rational private entrepreneurs were only too willing to skimp on firewood and other fuels and repairs once they had secured the right to collect (with government help) from every passing ship." (Zandt, p. 69).

This paper expands on the contributions by Coase (1974) and Zandt (1993) by analyzing administration of lighthouses in early America. Lighthouses are often cited as an example of a public good. If provision of lighthouses is left to the market, it is maintained that a socially inadequate amount of the lighthouse services will be provided. Shortly after 1789, the lighthouses in the United States were financed and maintained by the federal government. Nevertheless, the quality of lighthouse services provided by the U.S. government lagged behind that in Europe until the 1850s when Congress approved lighthouse administration reform. One of the interesting issues is observing the factors which determine the amount and quality of lighthouses produced by the government and specifically the determinants of Congressional voting on lighthouse administration reform in the 1850s. This paper examines the relationship between geographic variations in states' shorelines and Congressional support for lighthouse administration reform in the 1850s. A tested hypothesis is that legislative support for improvements to the lighthouse establishment is related to the economic interests of the state's constituents, which in turn depends on the length of the state's shoreline. Probit estimation is

used to explore the relationship between geographic differences in states' coastlines, political affiliation and Congressional voting on reform to the lighthouse establishment.

Numerous economists have used roll-call regression to analyze Congressional voting in a variety of legislative matters. (Hayes, 1981; Baldwin, 1985; Coughlin, 1985; Tosini and Tower, 1987; McArthur and Marks, 1988 and 1990; Nollen and Iglarsh, 1990; Kalt and Zupan, 1990; Marks, 1993; Wise and Sandler, 1994; Calomiris and White, 1994; and Ellison and Mullin, 1995). Most research on Congressional roll-call voting adopts the intuition that the votes of legislative representatives reflect the economic interests of their constituents. Alternatively, Congressional voting may reflect legislator ideology or the influence of special interests groups outside the legislator's geographic region.

Following Marks (1993), I utilize the intuition that there is a link between legislator voting and the expected net benefits for various interests from proposed legislation. One possible explanation is that legislators are prodded by interest groups motivated by pecuniary economic interests, and the extent of interest group activity on any bill depends on the perceived incidence of costs and benefits of the bill. Alternatively, legislators may act on their own perceptions of the costs and benefits of the proposed legislation without any direct prodding from interest groups. (Marks, 1993)

Tests of constituent interest in legislative votes face several problems. First, determining the winners and losers of proposed legislation is often difficult. Also, legislators may vote strategically. For example, a legislator from a coastal state may vote to reduce appropriations for lighthouses only to forestall even deeper cutbacks in lighthouse appropriations. "[Strategic voting] can obscure the relative incidence of, and therefore preferences of various groups over,

proposed legislation in addition to obscuring the importance of the legislation." (Ellison and Mullin, p. 337). Also, the roll-call regression sometimes fails to account for influences of logrolling on legislators' votes and the possibility of interaction between interest groups.

The dominant political parties during the second quarter of the nineteenth century were the Whig party and the Democratic party. Founded around Thomas Jefferson, the Democratic Party emphasized a belief in a strict interpretation of the Constitution, states' rights and limited spending by the federal government. Planks in the party platforms in 1840 and 1844 maintained that U.S. Constitution did not confer upon the central government authority to carry out a general system of internal improvements or expend money except for the necessary expenses of the government. Its policy of "the less government the better," of laissez faire, had particular appeal among workingmen, immigrants and settlers west of the Alleghenies. The Democrats reduced tariff rates substantially in 1846 and 1857, and they killed steamship subsidies in 1858.

Formed about 1833 to oppose the Democratic party, the Whig party favored government aid, high tariffs and a loose interpretation of the Constitution. The Whig party generally stood for national unity and a tariff for revenue and to protect business. It was led by Daniel Webster of Massachusetts and Henry Clay of Kentucky. Henry Clay's American Plan was a program of federal action to aid the economy and tie together the sections of the country. The Whig party was beset by factions and disintegrated chiefly over the issue of slavery.

The Free Soil Party was formed in 1848 to oppose the extension of slavery into the new U.S. territories. The party's influence reached its peak in the 1848 election when it captured 10% of the popular vote and elected twelve Congressmen. Its platforms demanded no more slave states or territories. To broaden the party's appeal, planks were added demanding revenue-

producing tariff, cheap postage and river and harbor improvements to promote commerce.

Shortly after the election, the party went out of existence and its adherents found their way to the newly formed Republican Party.

This paper begins with a discussion about public goods and a review of the theoretical problems associated with the private provision of public goods. Then, I discuss the history of administration of the U.S. lighthouses through the first half of the nineteenth century. Briefly, the historical record indicates that the quality of lighthouse services in the U.S. lagged behind that in Europe during this period. This study examines the qualitative evidence regarding the costs and benefits of lighthouse reform in the 1850s and summarizes the political debate surrounding the lighthouse administration in the early nineteenth century. I focus on the only lighthouse administration reform bills for which roll-call votes were taken: (1) the final vote in the House of Representatives in 1850 on a bill to convene a board of specialists to inquire into the condition of the lighthouse establishment and make a general detailed report and program to guide legislation to improve the system, and (2) a vote in the Senate in 1852 on an amendment which would strike the portions of a bill that established a lighthouse board to administer the lighthouse system. I provide econometric evidence on these legislative votes by relating voting patterns to the length of shoreline of each state. Based on the estimation results and the qualitative evidence, I draw conclusions regarding the pattern of expected costs and benefits of these legislative initiatives for constituencies in various states. The results generally support the hypothesis that support for an investigation of the lighthouse establishment arose from representatives from states likely to benefit from improvements to the lighthouse administration. While the quantitative evidence indicates that geographic differences and party affiliation were

influential in initiating an investigation of the lighthouse system, these factors were not influential in the subsequent attempt to defeat the establishment of a lighthouse board.

Public goods

Lighthouses are sometimes considered a classic example of a public good. The identifying characteristic of a public good is non-rival consumption. A good is considered public if its use by one agent does not prevent other agents from using it. Many, but not all, public goods are also non-excludable.¹ In other words, the cost of excluding nonpaying beneficiaries who consume the good (i.e., free-riders) is often so high that no private profit-maximizing firm is willing to supply the good.

Historically, economists have advanced many arguments to support the view that markets provide less than the efficient number of lighthouses. A summary of these arguments is provided by Coase (1974). Zandt (1993) argues that private parties were never able to finance the provision of lighthouse services because of the problem of excludability. He argues that entrepreneurs could not charge users of lighthouse services because the seas cannot be owned by private parties and historically there was no cost-effective way for a passing ship and a lighthouse proprietor to communicate to form a contract before the fact.

Lighthouses are likely to benefit a variety of constituencies: shippers, local merchants and consumers. Harbor conditions can affect the personal safety and livelihood of shippers. Improvements to a harbor also may expand the opportunities of local merchants to trade with

¹It is possible to exclude people from some public goods (e.g., police can remove people from a public park).

outsiders. For these constituencies, coastal states are more likely to benefit from aids to navigation. Consumers of all states are likely to have a diffuse stake in improvements to coastal transportation. Dangerous harbors may increase transportation and storage costs and raise consumer prices (without necessarily increasing the risk-adjusted income of market intermediaries).² In a speech in the House of Representatives in 1852, Representative Moore (Whig) of Pennsylvania described the losses arising from inadequate aids to navigation along the Delaware river leading to the port of Philadelphia.

Now, the serious losses and inconvenience arising from this entirely inadequate light-house accommodation, in the Delaware river, does not fall entirely on the citizens and business men of Philadelphia; for there is not a portion of our country which has any commercial intercourse whatever with the city of Philadelphia, or the State of Pennsylvania, that does not suffer from it in one way or another. Does not the detention of our coal and iron and other vessels in the bay, for the want of proper lights to run by at night, increase the price to the consumer of these articles, by increased freight and insurance? (Congressional Globe, 32nd Cong. 1st sess., 13 Aug. 1852)

Shippers and merchants whose business relies on shipping are concentrated geographically near the coasts and are more likely to seek pecuniary gain arising from aids to navigation by forming coalitions to lobby for such improvements. Consumers typically spend only a small portion of their overall expenditures on goods imported by sea. Dispersed throughout the economy, consumers have less incentive to overcome the costs of collective action.

Using graphical analysis, Harold Demsetz established that private producers can produce public goods efficiently if nonpurchasers can be excluded from consuming the public good. (Demsetz, 1970) He also concluded that payment of different prices for the same good is

²For example, improvements to the harbor may permit reduction of domestic stocks and a reduction in the cost of storing foodstuffs meant to carry consumption in the face of sharp declines in domestic production.

consistent with competitive equilibrium if the good is a public good. The appendix contains another illustration of the result that private producers can produce the efficient amount of a public good.

Private financiers of public goods may encounter many obstacles. In the model presented in the appendix, each purchaser may pay a different amount for the public good. Setting different prices may present political problems, and the added complication may prevent the parties from reaching an agreement to finance the public good. Also, it is difficult to design a mechanism to determine each purchaser's value for the public good. The trouble with most schemes is that they do not provide good incentive for individuals to reveal their true willingness to pay. Kenneth Arrow noted that strategic behavior by the parties may prevent a deal from being struck to the detriment of all parties. Parties behave strategically when, for example, they take bargaining positions to establish reputations as tough bargainers. If the government does not provide lighthouse services; ship captains, private lighthouse operators and other interested parties must reach some kind of an agreement to obtain an efficient outcome; strategic behavior may prevent an agreement from being reached. Finally, if information is incomplete, producers may produce less than the efficient amount of a public good. (Johnson, 1996) If there is incomplete information and parties do not have an opportunity to coordinate their offers, the Bayesian Nash equilibrium strategies in the voluntary contributions game may miss some mutually beneficial trades. Also, multiple Nash equilibria can exist, and the parties may not be able to coordinate on a single equilibria.

In summary, while it is theoretically possible for private parties to reach a mutually advantageous bargain to finance the provision of a public good, there are significant obstacles

that may prevent the bargain from occurring. The failure of the market to provide the efficient amount of a public good is often used to justify government provision of the public good.

The early history of lighthouses in America

For many years, America's lighthouses were concentrated on the rocky and jagged coastline and offshore islands of New England, the most populous region in America and hub of America's shipping industry. Early American lighthouses were authorized and constructed by the colonial government. Often after a disastrous shipwreck, local merchants and mariners lobbied the local or colonial government to construct a lighthouse. Construction of the first lighthouses was financed by the government in a variety of manners including harbor dues, lotteries and general taxation. However, they were often poorly built and inadequately maintained.

The first lighthouse erected in North America is thought to be a lighthouse on Little Brewster Island at the entrance to Boston Harbor. After the apparent loss of several lives due to the absence of a navigational aid, the governor of the General Court of Massachusetts in 1715 authorized erection of a lighthouse at the state's expense. The government set and enforced a fixed schedule for light dues. For maintenance of the lighthouse, ships using the port had to pay "one Penny per Ton Inwards and another Penny Outwards, except Coasters, who are to pay Two Shillings each at their clearance Out, and all Fishing Vessels, Wood Sloops, etc. Five Shillings each by the Year." The Treasury paid a salary to the lighthouse keeper. To assist the keeper in supplementing his income by obtaining work as a harbor pilot, the General Court in 1734

designated him principal pilot of the port.³ The state operated the light until it was turned over to the federal government in 1790.

Erected in 1746, the second lighthouse established in America is thought to be one erected at Brant Point, Massachusetts. "The town of Sherburn, now Nantucket, provided the tower in the expectation, which proved misplaced, that shipping would pay voluntarily for its maintenance." (Stevenson, p. 176) The early lighthouses such as this one were often made of wood, an abundant resource, and were subject to damage due to fires, storms, the sea and military operations during the Revolution. After a gale blew down the structure on this site, the Colony granted the town permission to collect light dues from vessels using the port to pay the cost of maintenance. A light at Fort William and Mary at Portsmouth in the colony of New Hampshire also was maintained by charging harbor dues to all ships anchoring in the harbor.

Early American lighthouses were financed not only by harbor dues, but also by lotteries. In 1760, the Colony of Connecticut decided to erect a lighthouse at the west side of the entrance to the harbor at New London. The Colony financed the construction by selling tickets for a lottery. When these funds were found insufficient, the Colonial Assembly increased the tax on shipping to cover the cost. In the early 1760s, the New York Colonial Assembly also used lotteries to fund the construction of a lighthouse at Sandy Hook, a slice of land on the northern end of New Jersey's coast near Staten Island. The Assembly of Pennsylvania used a combination

³The job of harbor pilot was often lucrative. To supplement his meager income, a lightkeeper at Ocracoke kept a tavern at the lighthouse. It is relatively inexpensive to exclude patrons who are unwilling to pay a cover charge or the price of a drink to enjoy the ambiance and panoramic view available at a lighthouse. Hence, this new function contributed to the viability of a lighthouse without requiring further government assistance. However, in an intrusion into a budding new market, the governor in 1797 forbid the retailing of spirits on the premises.

of lottery and bonds to construct a lighthouse on Cape Henlopen at the entrance to the Delaware Bay which leads to Philadelphia.

Occasionally, the central government reimbursed individuals for expenses incurred in maintaining a lighthouse. When a fire destroyed the Gurnet lighthouse at Plymouth in 1802, "merchants of the town promptly subscribed to replace it by temporary lights, as the Government had no immediate funds at its disposal. An Act of Congress of 1802 allotted \$2,500 for building another set of twin lights and reimbursing the merchants for their expenditure." (Stevenson, p. 179)

Before 1771, the chief purpose of erecting lighthouses was to direct vessels to the entrances of ports of trade. Lighthouses were not constructed in areas where few people lived despite serious dangers to navigation. The cost of constructing a lighthouse in a distant location may have exceeded the benefits to the people in any one location. In 1771, two lighthouses were erected at Cape Ann on the northern side of Massachusetts Bay with the primary purpose to assist general coastal traffic rather than benefit one particular port.

After 1789, the government financed the operation and maintenance of the lighthouses from general revenues (obtained mostly from import duties). Realizing the need for lighthouses and other aids to navigation to serve intercity routes, the U.S. Congress in 1789 declared in its ninth act "that all expenses ... in the necessary support, maintenance and repairs of all light-houses, ... placed, or sunk before the passing of this act, at the entrance of, or within any bay, inlet, harbor, or port of the United States, for rendering the navigation thereof easy and safe, shall be defrayed out of the Treasury of the United States...." By 1795, all states had given up control of their lighthouses to the general government. (White, 1948, p. 399) Management by the

Lighthouse Service of all lighthouses then in operation ensured that the governmental entity with jurisdiction encompassed almost the entire area in which the benefit of a lighthouse could be felt. Washington himself decided that customs collectors should supervise the lighthouses in their respective districts. However, the customs collectors were political appointees, and few were conscientious in supervising the keepers. The Lighthouse Service began its operations with twelve lighthouses as well as four under construction. The number of lighthouses increased rapidly as indicated in Table 1.

Table 1: Lighthouses in early America.

Year	Number of lighthouses
1789	12
1800	24
1812	49
1820	55
1838	204
1842	256
1852	331

Source: Beaver, 1973; Holland, 1972.

In 1810, Winslow Lewis introduced Argand lamps to America. Invented by Ami Argand in 1781, Argand lamps were first used in Britain in 1789. Argand lamps had tubular wicks which admitted air producing a brighter flame than the existing spider lamps, pans of oil with a number of wicks protruding around the edges. Further, the Argand lamps consumed less oil and could be easily installed in existing lighthouses. In 1812, Congress bought Lewis' patent on the lantern and rewarded him with a monopoly right to install Argand lamps in all of America's lighthouses. The government also agreed to pay Lewis to keep the lights in repair for a period of

seven years. Unfortunately, the model introduced by Lewis was outdated. It had a thick lens in front of the lamp which absorbed some of the emitted light and its reflector had a somewhat spherical shape which scattered the light, not a parabolic shape capable of intensifying the light by projecting it outward.

In 1815, Lewis was granted a new seven-year contract to distribute whale oil to America's lighthouses, to inspect them annually, and to report on their condition to the commissioner of the revenue. While inspecting the lighthouses and installing illuminating apparatuses, Lewis, a former ship captain, gained considerable technical knowledge on lighthouse matters.

In 1811, Napoleon created a commission of lighthouses to improve aids to navigation. Military men and prominent scientists, including Augustin Fresnel, were appointed to the commission. After being appointed to the commission, Fresnel constructed the first lighthouse lens which used a central reflecting bull's eye surrounded by refracting prisms and glass rings to focus and bend light into narrow beams. The Fresnel lens produced a brighter beam and consumed a fraction of the oil compared to Lewis' lamps and reflectors. When informed of this system, Lewis remarked that the Fresnel lights were too complicated, too expensive and too liable to injury.

In 1817 and 1818, David Melville conducted an experiment with gas lighting at Beavertail Lighthouse in Rhode Island. There are numerous reports indicating that his gas lights were brighter and less costly than those fueled with whale oil.⁴ Further, whale oil was often smokey and hard to ignite at cold temperatures. Because the gas lights burned cleaner, the lamps,

⁴The real price of sperm oil burned in lighthouses doubled between 1820 and 1850 but then began to fall. (Davis, Gallman and Hutchins, 1989, p. 102).

windows and reflectors collected less soot and required less cleaning. Another experiment was conducted at the Christiana Creek (Delaware) lighthouse to determine the expediency of using gas instead of oil in the lighthouse establishment. The conclusions are as follows:

The most accurate computation of the cost of lighting the light-houses with oil, agreeably to the plan now in use, is at an average of one dollar per night for every ten lamps. The cost of gas light, agreeably to my plan, is twenty cents per night, and the amount of light given is three times as great as from oil, each gas burner being equal to three of the best light-house lamps. (U.S. Congress. 28th Cong. 2d sess. Sen. Doc. 166, 1844)

The government did not adopt gas as a lighthouse fuel. One possible explanation is that the whaling industry and dealers in whale oil opposed the use of gas as a substitute for whale oil. It is also possible that a vibrant whaling industry was considered necessary to supply experienced seamen from which the government could draw to develop a navy.

In 1820, administration of the operation of the lighthouses was transferred to the fifth auditor of the treasury, Stephen Pleasonton. Pleasonton objected to the use of gas in the lighthouses.

The gas light at the Christiana light-house has been so recently put into operation ..., that sufficient time has not been allowed to test its economy, as compared with oil light.... We should adopt this change in our light-houses with extreme caution, and not until full and ample experiments shall have shown its safety and utility. (U.S. Congress. 28th Cong. 2d sess. Sen. Doc. 166, 1844)

Pleasonton then noted that gas had once caused an explosion in a British gas-house.

In a letter to Congress, Stephen Pleasonton described his administrative procedures.

Since I took charge of the establishment, collectors have been designated, as formerly, to act as superintendents.... When a lighthouse is to be built within the district of any one of them, he is ordered to select the proper site, is furnished with a plan of the building by this office, and is directed to employ a suitable mechanic to see that the materials are good, and the work well done. On the certificate of the overseer to this effect, payment is made, but not otherwise. The superintendent is required, also, to make at least one visit a year ... to each of the light-houses in his district, and to report to me the condition of each

.... (U.S. Congress. 28th Cong. 2d sess. Sen. Doc. 166, 1838)

Despite the rapid increase in the number of lighthouses, overall coordination and control of the geographically-dispersed lighthouses remained the responsibility of a small number of individuals. "[Pleasanton] and his staff in Washington were clerical administrators contracting for everything needed to maintain aids to navigation. He contracted with a builder to erect the lighthouses, with shipyards to build lightships, with Winslow Lewis, usually, to install the lighting apparatus, with an oil merchant to supply the whale oil for the lights, and with builders for lighthouse repairs beyond the capability of the keepers." (Holland, p. 31)

Pleasanton, a career bureaucrat with little maritime experience, relied extensively on Winslow Lewis on technical matters and was subject to his influence. Winslow Lewis received contracts to inspect many of the lighthouses and supply them with whale oil. He also wrote the specifications for many of the contracts to construct and repair the country's lighthouses, and he was the successful bidder on many of those contracts.

Pleasanton kept a close watch on the expenditures of local superintendents of lights. Pleasanton reported to Congress in 1842 that he ran the U.S. lighthouses at half the cost at which the Trinity House operated English ones. In a report filed in 1843, Pleasanton boasted that he spent less than Congress appropriated on construction of lighthouses.

Thus it appears that the buildings in these three districts did not cost, upon an average, more than \$4,312.20; and that they were built, in many cases, so much below the appropriation, is to be ascribed to the circumstance of my having, in every instance, advertised for proposals, and given the contract to the lowest bidder; by which means great competition was elicited, and, as a security for the public for the faithful performance of the contract, no part of the money was ever paid until the work was done to the satisfaction of the overseer, who was, in all cases, appointed to oversee the work, day by day, as it progressed. The money saved in this manner, and carried to the surplus fund, is unexampled, so far as I know, in the annals of government. The building erected

at so cheap a rate, however, could not be expected to be as substantial and durable as those built in England and France, where the towers are chiefly built of hewn dimension stone, and cost from \$50,000 to \$60,000 each. (U.S. Congress. 28th Cong. 1st sess. H. Doc. 38)

The administration's practice of awarding building contracts to the lowest bidder sometimes resulted in the purchase of local supplies of inferior quality. Pleasonton was also reluctant to employ architects and engineers to design structures and supervise construction. Pleasonton acknowledged that half the annual expense for lighthouse maintenance went to repair. (Gleason, p. 87) In his defense, it should be noted that Pleasonton was responsible to a parsimonious Congress and that he lacked modern forms of transportation and communication to monitor and supervise the lightkeepers' performance of their duties and to disseminate improvements from one area to another.

Pleasonton's administration of the lighthouses received mounting criticism for the poor quality of the service provided by the lighthouses. One ship captain said, "The lights on Hatteras, Lookout, Canaveral and Cape Florida, if not improved, had better be dispensed with, as the navigator is apt to run ashore looking for them." (Holland, p. 21) The lighthouses were criticized for their dim lights, for the soot coating on their reflectors, and for their improper location. Edmund March Blunt, a vocal critic and publisher of *The American Coast Pilot*, criticized the administration and Winslow Lewis for changing the features of lighthouses without notifying mariners. In the late 1820s, Edmund March Blunt's sons, Edmund and George William, took over publication of the nautical works. After the younger Edmund took a trip to Europe in the early 1830s where he observed the Fresnel lenses used in France, he and George began pressing for their adoption in the United States. They recruited their friend Matthew

Calbraith Perry, a naval officer in New York, to their cause. The Blunts forwarded mariners' complaints about the lighthouses to congressmen. "At about this time, Congress received a letter from a chamber of commerce, probably New York City's, stating that a committee it had appointed had heard testimony from ship captains, insurance inspectors, and others, and had concluded that the lights on the towers of France and Great Britain were superior to those of the United States." (Holland, p. 18) Pleasonton responded to criticism by gathering favorable statements of harbor pilots and captains. The Blunts claimed that Pleasonton's supporters were "mostly local seamen who did not know the better lights abroad." (Gleason, p. 81)

In 1838, Congress authorized the Secretary of the Treasury to purchase two Fresnel lenses. Commodore Matthew C. Perry was sent to Europe to examine lighthouses and to buy two Fresnel lenses. Senator John Davis of Massachusetts submitted a report in the U.S. Senate in 1838 which concluded that the Fresnel lens was superior to the Argand light. The report added

The learned and distinguished Dr. Brewster, after examining the subject fully, holds this language, "... the lens apparatus is far more intense than the reflector apparatus of the same size; with the same intensity of light, it consumes much less oil; in reference to original cost, repairs, and renewals, it is more economical; it requires a less expensive light-room, and it demands much less time and trouble from the keeper...."

The committee find at page 72, Senate document 138, present session, an extract from a French document, which has in it the following language: "From numerous experiments made comparatively on several apparatus of the old and new system, it is satisfactorily demonstrated that a given quantity of oil employed in the illumination of light-houses, [Fresnel lens] gives *from three to four times* more useful light, that is transmitted horizontally, than if this same quantity of oil was consumed for illumination of the best apparatus with reflectors."

3d. The kind of light should be such as to enable navigators to identify it at first sight from all others. This is of the first importance, as any mistake in the recognition of a light is quite as likely to end in disaster as safety. The committee have heard complaints on this head, that our lights are in some places either too numerous, or not so distinctly characterized as to be readily distinguished from each other. The great lake coast is pressing heavily for improvements, as well as the southern Atlantic coast, which greatly needs more and better lights. (U.S. Congress. 25th Cong. 2d sess. Sen. Doc. 428, 1838)

However, Pleasonton did not support the adoption of the Fresnel lens, claiming that any change from the reflector system must be authorized by law. As a result, the United States had only three Fresnel lights until 1851.

Also in 1838, Congress launched a five-year-long inquiry of the lighthouse system. Naval officers appointed by the President were responsible for reporting on the conditions of the aids to navigation. One of the reports noted that in two different places on the Maine Coast, "there are nine lights to be seen at one time, which must confuse the navigator." Another inspector found three lights being built 150 feet apart where he thought one light would have been sufficient. Several inspectors found lighthouses constructed with shoddy materials and faulty construction techniques. The controversy increased the public's awareness of the problems. Although Congress did not pass legislation reforming the lighthouse administration at this time, Congress ordered the construction of a large number of lighthouses. Table 2 shows the nominal lighthouse appropriations during the period 1790-1850. Data on lighthouse appropriations was obtained from a speech of Representative Spaulding (Whig) of New York. (Congressional Globe, Appendix, 31st Cong, 2d sess., 15 Feb. 1851)

The amount of expenditure in any given year, compared with that of another year, will appear more or less depending on the number of new constructions, either of houses or boats, in respective years, the amount of repairs, cost of oil &c. Some seasons are noted for their frequency and violence of their storms; in such years the expense of repairs will be great.... This large increase in disbursements [from 1837-1841] was the consequence of legislation in 1837 and 1838, in which years a large number of lights were ordered to be constructed. (U.S. Congress. 27th Cong. 2d sess. H. Doc. 811, 1842)

For comparison, Table 3 shows the gross tonnage of merchant vessels during the same period. Data on merchant marine tonnage was obtained from the U.S. Department of Commerce, Bureau of Marine Inspection and Navigation.

Table 2: Lighthouse appropriations, 1790-1850

Table 3: Gross tonnage of merchant vessels built, 1790-1850

In 1845, the Secretary of the Treasury sent two navy lieutenants to Europe to research foreign lighthouse systems. Their recommendations incorporated several features of European systems, and their report was endorsed by the Secretary of the Treasury. However, Congress failed to take further action.

Meanwhile, maritime traffic increased rapidly. While the history of American whaling spanned centuries, the peak occurred in 1841-51. (Davis, Gallman and Hutchins, 1989, p. 99) New Bedford whaling rose to prominence in the years 1820-1845 and remained a prosperous industry during the 1840s and 1850s. (Davis, Gallman and Hutchins, 1991, p. 222) The average annual vessel tonnage of the U.S. whaling fleet is presented in Table 4.

Table 4: Annual average US vessel tonnage: US whaling fleets, 1816-1855

Years	Tonnage
1816-25	27,775
1826-35	70,352
1836-45	159,788
1846-55	202,143

Source: Davis, Gallman and Hutchins, 1989.

As maritime traffic grew, so did the number of wrecks. Representative Spaulding (Whig) of New York reported the following losses on the Great Lakes attributable to maritime disasters during the period 1848-1850:

Table 5: Losses on the Great Lakes, 1848-1850.

Year	Loss of property	Loss of Lives
1848	\$420,512	55
1849	\$368,171	34
1850	<u>\$558,926</u>	<u>395</u>
	\$1,347,609	474

Source: Congressional Globe, 31st Cong., 2d sess., 14 Feb. 1851.

In remarks in the House of Representatives in 1852, Representative Moore (Whig) of Pennsylvania stated, "This branch of the public service has, in my opinion, become, at this time, one of very great importance, because of the immense yearly expenditures which have become necessary to support and maintain it, and because of the very great and extended interests connected with it--such as the safety of human life, and the great and constantly-increasing commercial and maritime interests of our country." (Congressional Globe, Appendix, 32nd Cong. 1st sess., 13 Aug. 1852)

Legislation to reform the lighthouse administration in the 1850s

In 1851, Congress authorized and required the Secretary of the Treasury, Thomas Corwin, a friend of George Blunt, to convene a board of specialists to inquire into the condition of the lighthouse establishment and make a general detailed report and program to guide legislation to improve the system. The bill also required that all new lighthouses be installed with the Fresnel lens system, the lenses commonly used in Europe. The House of Representatives in 1850 gave final approval to this bill in a roll-call vote with 107 yeas and 50 nays.

While the board credited Pleasonton for his spirit of economy, it criticized nearly every

other aspect of the lighthouse establishment and its operation. The Board recommended the establishment of a nine-member lighthouse board composed of people representing several professions.⁵

If the indictment handed up by the board was not sufficient to motivate congressional action, the balance in Congress may have been tipped in favor of reform by luck. In 1852, several members of Congress were on board a ship that was detained in fog. (Gleason, p. xv) Shortly thereafter, reform legislation was passed.

The reform legislation passed in 1852 made appropriations for construction of new lighthouses and navigational aids, authorized the Secretary of the Treasury to direct the Superintendent of the Survey of the Coast or the Colonel of the Corps of Topographical Engineers to determine the site of proposed navigational aids and to ascertain which type of navigational aid is most suitable for the location, and established a nine-member Lighthouse Board to administer the lighthouse administration. The nine-member Lighthouse Board consisted of two officers of the Navy of high rank, two officers of the Corps of Engineers of the Army, two civilians of high scientific attainments, an officer of the Navy and an officer of Engineers of the Army as secretaries and the Secretary of the Treasury being *ex-officio* president. The Board was required to direct an officer of the Army or Navy to supervise each lighthouse district. Prior to passage of this bill in the Senate, Senator Hamlin (Dem.) of Maine offered an amendment to strike out the portions of the bill described above that established the framework of the lighthouse board. The amendment was defeated on August 30, 1852, in a roll-call vote

⁵At that time, England, France and other European countries employed several types of professionals in their lighthouse administration.

with 10 yeas and 28 nays.

Shortly thereafter, Congress passed the reform legislation creating the nine-member Lighthouse Board. Pleasonton soon lost his position. The Board instituted standing committees for finance, engineering, floating aids to navigation, lighting and experiments. Under the Lighthouse Board established in 1852, there were rapid improvements in the quality of lighthouse services. Fresnel lenses were installed, new navigational aids were placed in areas where needed and new technologies were employed to provide greater safety to seagoers. The Board replaced old light towers with taller towers to increase the light's range before it is concealed by the curve of the earth's surface.⁶

Perhaps because seven of the Lighthouse Board's nine members were drawn from the military, the lighthouse establishment was better organized and better administered. Naval officers appointed as district inspectors were required to visit the lights at least once a quarter if practicable and make a report on the condition of the lighthouse and the repairs and renovations needed. They were instructed to make unannounced inspections and occasional inspections at night. District engineer officers were soon appointed to supervise the construction and renovation of lighthouses in their districts. The inspector was required to inform the Board when lightkeepers failed to perform their duty.

Political debate surrounding legislative reform in the 1850s

Excerpts of the political debate in the early 1850s reveal the legislators' perceptions of the

⁶"At 100 feet above sea level, a primary light will have a range of 13 miles. At 500 feet, the same beam could be seen at a distance of 29½ miles. Aboard ship a lookout can see a light from the masthead two to three miles 'sooner' than he can on deck." (Adamson, p. 34)

costs and benefits of lighthouse reform. In a speech in the House of Representatives in 1851, Representative Evans (Whig) of Maryland stated as follows:

In France, England, Scotland, Belgium, and in Denmark, the method of lighting now in use casts totally into shade the imperfect kind of reflectors employed in the United States of America. The reflectors made in the United States are not ... made or placed in the lighthouses by those who understand them, but they are placed there in the nature of jobs. They are not even superintended by persons who know anything in connection with the subject. I call the attention of the committee to the fact, that according to the estimates furnished by the Treasury Department, that light-houses now in the course of erection call for repairs in the mason work even before they are put up, to the amount of four thousand or five thousand dollars... The mortar is badly made, and the light-houses are put up without any competent person to superintend their construction. It is true, as the gentleman from Virginia [Mr. Bayly] has told us, that the collector of customs is paid to superintend these light-houses, but he scarcely goes near them once a year, and there is no engineer appointed to superintend their erection. The great fault is, that there is really no efficient superintendence; the mortar is badly made, being composed chiefly of sand, and, as a consequence, the erections are not such as are likely to be durable. You are required to expend some \$4,000 to repair these light-houses before they are completed, when, for one tenth of that sum, you could thoroughly repair an ordinary country residence.... In respect to the amount of oil used in the light-houses according to our system, I may remark, that the quantity used is at least twice as great as that required by the system in use in other civilized countries, at the same time that our light is far from being so brilliant.... The French system is one that enables you to see the light before you come up to the horizon--a system by which one lamp answers the purpose of fifteen or twenty lamps used in your system--a system that consumes but one half of the oil, and is five times as efficient as the American system. (Congressional Globe, Appendix, 31st Cong. 2d sess., 3 March 1851)

Senator De Saussure noted that the board convened in 1851 found that "the distribution of the lights is imperfect and unequal; that on some parts of the coast, to wit: at the North, there is an accumulation of lights far beyond what the exigencies of the case demand, so much so that they are accumulated in some places as to be a nuisance to the navigator instead of a benefit, and a great many of them are defective. At the South there is a far less proportion of lights than at the North." (Congressional Globe, 32nd Cong. 1st sess., 30 Aug. 1852)

Not all members of Congress agreed with the Board's recommendation to use Fresnel

lenses. Senator Davis (Whig) of Massachusetts worried that the use of Fresnel lenses would be expensive and create a dependence on foreign manufactures. He stated,

We built a light-house, and we put reflectors in it for some \$3,000 or \$4,000. That is the common grant made to set up a lighthouse and light it. Now, you cannot purchase a set of lenses for less than about \$6,000; and has it ever occurred to the Senate that there is not a manufactory of these lenses on earth, except those which are set up by the French Government? And are we to be dependent on the French Government for every light we burn? Those great leading points ought to have the best lights, regardless of expense; but when you go into questions of expenditure, it must be admitted that it takes a much greater portion of labor to superintend and take care of the lenses than it does in the case of the common reflectors..... It is a notorious fact, that it takes a greater number of men to take charge of these lights than of the reflectors.... [You] cannot change the lights of the United States into lenticular ones short of an expense of millions of dollars. You would have to alter every lantern. The reflector lanterns are not adapted for lenses. They are not high enough. They are not adapted to the introduction of the machinery necessary for the lenses. (Congressional Globe, 32nd Cong. 1st Sess., 30 Aug. 1852)

The proposal to establish a nine-member board to administer the lighthouse administration was controversial. Senator Hamlin (Dem.) of Maine objected to the composition of the proposed lighthouse board and the establishment of a lighthouse board without committee sanction.

[I] ask the Senate carefully to consider, whether it is not better to postpone this matter until it can receive the sanction of its own committee? I ask the Senate if it is not better, if it is not more proper, that our legislation should be marked by such a course, than by the outside pressure of Army and Navy officers, for I see them all around me now. I am for a board, but I am not for one that is to be controlled altogether by Army and Navy officers. I am for incorporating in it as many scientific officers as are necessary, but I am not for a system that shall be built up and placed solely under their control. (Congressional Globe, 32nd Cong. 1st sess., 30 Aug. 1852)

He stated a board would make the U.S. system as expensive as the English system. Senator Davis also objected to the proposal to establish a board.

Then it follows that we should have at the head of the system an able and efficient man. One head is better than ten, and an able and efficient man who understands the subject from top to bottom will be able to go into it, and from his knowledge to regulate it

according to economy, and according to the position in which the lights should be placed.... But I must say, however respectable these boards are, I never have thought them worth anything. You had a Navy Board, but were obliged to give it up. You had a Census board, but it did nothing. You had a Board connected with the Patent Office, but who ever heard of it doing anything? I never did. These boards only serve as a shelter to cover some other person who does the business allotted to them. (Congressional Globe, 32 Cong. 1st sess., 30 Aug. 1852)

Senator Davis also expressed doubt about the credibility of the report prepared by the board convened in 1851.

As far as I recollect, in all that book, there is not one thing in the present system that the board approves of. I read it with some care and attention, and I was astonished at the declarations made in it. For, while I will not deny that there are defects in it, yet, in a system like this, which has stood more than half a century, to find no one thing to approve of in it, is a little extraordinary. I hold that the report is an unfair, unjust, and exaggerated statement of facts. (Congressional Globe, 32 Cong. 1st sess., 30 Aug. 1852)

In a speech in the House of Representatives in 1851, Representative Spaulding (Whig) of New York stated that the recommendation to establish a lighthouse board "has been characterized by gentlemen on the other side of the House as intended to rob the Treasury...." (Congressional Globe, 31st Cong, 2d sess., 14 Feb. 1851) Senator Davis claimed the proposed system would be

enormously expensive; that it is vastly more expensive than ours.... I say that your experience with boards tells you that they are inefficient and unnecessary.... Where improvements are necessary, I am for them. I am from a commercial part of the country, and I want as good lights as any gentleman. There is not a portion of the country that has more ships and more tonnage afloat than my State of Massachusetts. I am, therefore, the last man to stand in the way of any improvements; but I wish to act deliberately upon this subject, and in a way that I can vindicate my conduct. (Congressional Globe, 32nd Cong. 1st sess., 30 Aug. 1852)

Senator Davis of Massachusetts was one of several senators from New England who voted to defeat the establishment of the lighthouse board. According to Representative Spaulding, Representative Morse (Dem.) of Louisiana stated the recommendation "is calculated to uproot the foundations of government--that it is local and sectional in its character, and that for these

and many other reasons it ought not pass." (Congressional Globe, 31st Cong. 2nd sess., 14 Feb. 1851) Senator Weller supported establishment of a lighthouse board.

The question is, whether, in order to make the light-house system what it should be--an effective one--it is necessary to establish a board to control the whole? In my judgment, it is necessary, and therefore, although there may be defects in the bill, I am disposed to vote for the organization of that board.... I am anxious that the first step should be taken now to make the system an effective one. And in order to make it so, you must have some persons at its head who can give their personal attention to it, and who have sufficient ability to look into the whole. It is for that reason I desire that the board shall be established. (Congressional Globe, 32nd Cong. 1st sess., 30 Aug. 1852)

Senator Mallory (Dem.) of Florida stated, "We have the best reflectors which are used, and they show you the light as far as the curvature of the earth will permit. There is no urgent necessity for adopting the system proposed by the House.... There is ... no such urgency in the matter as to require the adoption of the board, when no committee has reported in favor of it; when no Senator has had an opportunity to examine the evidence, and when the chairman of the Committee on Commerce pledges himself, within the next three months, to systematize and bring forward a plan for the better regulation of light-houses." (Congressional Globe, 32nd Cong. 1st sess., 30 Aug. 1852) Senator Houston (Dem.) of Texas added,

[Until] a measure of so much importance, involving the expenditure of so much money, is recommended by a committee, I am unwilling to go for it.... I care not for the opinion of any board whatever, nor for its action, for I am satisfied, from the best information which I have been able to obtain upon this subject, that the expenditure will not be less than \$4,000,000, and it will be a continued and increased expenditure upon the nation. If the lights now are sufficient to operate as beacons to vessels, so far as the curvature of the earth does not interfere with them, I see no necessity for any improvement.... I cannot support any legislation of this character, that involves millions, when we know what influences out of the House are pressed upon Senators to rush it through, under the present pressure and haste of circumstances. (Congressional Globe, 32nd Cong. 1st sess., 30 Aug. 1852)

Roll-call regression

A probit estimation is used to study the probable support of legislators in the two roll-call votes described above. Specifically, probit estimation is used to analyze (1) the vote in the House of Representatives in 1850 approving the bill to convene a board of specialists to inquire into the condition of the lighthouse establishment and make proposals to improve the system, and (2) the vote in the Senate in 1852 on an amendment which would strike from a lighthouse reform bill the provisions creating the framework of a lighthouse board to administer the lighthouse system. The attempt in the Senate to defeat the establishment of the lighthouse board was unsuccessful. Data regarding these roll-call votes was obtained from the Congressional Globe. Data regarding the length of the shoreline of the outer coast and the Great Lakes was obtained from the National Oceanic and Atmospheric Administration. Summary statistics for these votes are contained in Table 6.

Table 6: Summary statistics on Congressional votes.

	House of Representatives vote on lighthouse bill, 1850		Senate vote on amendment to bill, 1852		Shoreline length (miles)
	For	Against	For	Against	
All representatives	109*	51	10	28**	
Whigs	71	5	4	9	
Democrats	27	46	6	15	
Free Soilers	10	0	0	0	
Maine	6	0	1	0	3478
New Hampshire	2	1	1	0	131
Massachusetts	7	0	1	0	1519
Rhode Island	2	0	1	0	384
Connecticut	4	0	0	1	618
New York	26	0	0	1	2550
New Jersey	4	1	1	0	1792
Pennsylvania	15	3	1	1	149
Delaware	4	1	0	2	381
Maryland	1	0	0	2	3190
Virginia	5	6	0	2	3315
North Carolina	2	4	1	1	3375
South Carolina	1	6	0	1	2876
Georgia	1	0	0	1	2344
Florida	1	0	1	1	8426
Alabama	2	3	0	0	607
Mississippi	0	1	0	0	359
Louisiana	1	0	0	1	7721
Texas	1	0	1	1	3359
California	0	0	0	1	3427
Illinois	1	3	0	0	851
Indiana	2	3	0	1	60
Michigan	2	0	0	2	3200
Ohio	8	7	0	2	310
Wisconsin	3	0	1	0	840
Arkansas	0	1	0	1	0
Iowa	0	1	0	2	0
Kentucky	1	4	0	0	0
Missouri	0	3	0	0	0
Tennessee	3	3	0	0	0
Vermont	4	0	0	0	0

*This figure includes the votes of Representative Fitch (Dem.) of Indiana and another representative whose state and party are unknown who were recorded as supporting the bill, although they did not vote. One representative from Massachusetts whose party is unknown voted for the bill.

**Four senators whose party and state is unknown voted against the amendment.

Source of votes: The Congressional Globe.

Source of data on shoreline length: National Oceanic and Atmospheric Administration.

The votes were not strictly along party lines. However, the percentage of Whigs in the House who voted for the lighthouse bill exceeded the percentage of Democrats who voted for the bill. The five Whigs who opposed the bill were from the states of North Carolina, Ohio, and Kentucky. The fact that voting was not strictly along party lines suggests only a secondary role for ideology in the lighthouse reform debate, leaving legislative voting open to the interplay of economic interests based on how those interests were affected by improvements to the lighthouse administration. The representatives of some of the northeastern coastal states stood staunchly in favor of the bill in 1850. Presumably, their constituencies felt a strong need for an investigation of the lighthouse system.

The variables included in the probit model to account for influences on the representatives were party affiliation and the length of shoreline of the representative's state. The predictive power of party has received a variety of explanations. "Some interpret the predictive power of the party variable to indicate the importance of 'party discipline' or party-wide logrolling on votes. Others view party as a proxy for legislator ideology." (Ellison and Mullin, p. 359) Also, political party may be correlated with omitted constituent interest variables. In this context, a state affected by lighthouse reform may have elected representatives more concerned with this issue. The dummy variable *Party* takes on the value of 0 if the representative was a Whig and 1 if the representative was a Democrat. Only votes of Whigs and Democrats will be considered in this analysis, thereby excluding votes of a small number of Free Soilers. The variable *Shore* measured the absolute length of the shoreline of the legislator's state, a proxy for the economic importance of lighthouse reform to the state. An alternate specification would measure the shoreline variable on a per capita basis. The absolute length of the shoreline is an

appropriate measure of constitute interest when, for example, the length of the shoreline is a measure of the stake of interested parties. Even in populous coastal states where the measure of shoreline per capita is low, the interested parties might exercise considerable influence.

Probit model results of the empirical analysis of the House of Representatives vote in 1850 are contained in Table 7. The OLS model results are included for comparison. The dependent variable equals 1 if the legislator voted in favor of the bill, and 0 otherwise. A "Yea" vote in 1850 on the House bill is support for the bill to convene a board to inquire into the condition of the lighthouse establishment and to make recommendations to improve the system.

Table 7: Roll-call regression of vote in House of Representatives, 1850.

Explanatory Variables	OLS		Probit			
	Estimate	t-statistic	Estimate	Standard Error	t-statistic	Marginal
Constant	0.861	16.2*	1.27	0.246	5.1*	...
Party 0 if Whig 1 if Democrat	-.569	-9.2*	-1.92	0.277	-6.9*	-0.454
Shore	0.000472	2.3*	0.00194	0.000864	2.2*	0.000046
Adj. R ²	.37		.39			
Log-likelihood value			-62.84			
Percent of positive observations			.66			
Percent correct predictions			.81			
Observations	148		148			

*Significant at the 0.05 level.

The model predicted the correct outcome 81 percent of the time in the House vote. The marginal effects in the probit model indicate the marginal propensity to have an impact on the legislative outcome. The sign and t-statistics of each coefficient indicate the direction and significance of any association between the independent variable and votes. Since a "Yea" vote was coded as 1

and a "Nay" vote was coded as 0, positive coefficients indicate that an increase in that particular variable would increase the probability that the legislator would vote "Yea" on the measure. In the House vote in 1850, the signs of all the coefficients in the probit estimation were the same as those determined by OLS estimation. The signs of the coefficients are significant and plausible for the House vote in 1850. The length of a state's coastline had a positive and significant effect on its representatives' support for the bill. Also, party affiliation was a significant factor in the analysis. Being a member of the Democratic party, the party that favored laissez faire policies, had a negative and significant effect on the tendency of legislators to support the bill. In a separate, unreported probit analysis, I found that states with a high percentage of urban population were more likely to elect a representative from the Whig party; states with a high percentage of rural population were more likely to elect a Democratic representative. Data on population of each state in 1850 was obtained from the U.S. Department of Commerce, Bureau of Census.

The probit model results for the Senate vote in 1852 on the amendment are contained in Table 8. Again, the dependent variable equals 1 if the senator voted in favor of the amendment, and 0 otherwise. A "Yea" vote in 1852 on the amendment in the Senate is a vote to strike the portions of the bill which establish a board to manage the lighthouse system.

Table 8: Roll-call regression of vote in Senate on amendment to bill, 1852.

Explanatory Variables	OLS		Probit			
	Estimate	t-statistic	Estimate	Standard Error	t-statistic	Marginal
Constant	.694	4.4*	.509	.430	1.2	...
Party 0 if Whig 1 if Democrat	.0219	0.13	.064	.465	.14	0.022
Shore	-.0000089	-0.025	-.0000291	.000986	-.03	-.000001
Adj. R ²	-0.06		0.0055			
Log-likelihood value			-20.59			
Percent of positive observations			.71			
Percent correct predictions			.71			
Observations	34		34			

*Significant at the 0.05 level.

In the roll-call regression of the vote on this amendment, the independent variables are insignificant. Hence, being a legislator from a state with a long coastline was less important in the vote on the measure to defeat establishment of a lighthouse board than on the vote to investigate the condition of the lighthouses. There are several possible explanations for this. Congressional debate suggests that the costs and benefits of creating a lighthouse board were uncertain. Therefore, it is difficult to determine the winners and losers under a lighthouse board. Also, some senators objected to the establishment of a lighthouse board because it was not approved by a committee. Perhaps some of these senators would approve the creation of the same board once it had received committee approval. A vote in support of the amendment may

not have been considered vital to the establishment of a board. Also, the Chairman of the Committee on Commerce had pledged to bring forward within three months a better plan for the regulation of lighthouses. Some senators may have voted to defeat the establishment of the lighthouse board to spur the development of a better administrative system within a few months. Further, some of the senators may have been influenced by the military or other special interest groups outside their geographic region. Other factors which may have contributed to the poor results of the probit model in this vote include logrolling and strategic voting.

Conclusion

It is often thought that markets fail to provide the socially adequate amount of a public goods such as lighthouses. However, the historical record indicates that the federal government also had difficulty providing lighthouse services of high quality during the first half of the nineteenth century. During this period, the quality of lighthouses in the U.S. lagged behind that in Europe. Reform to the U.S. lighthouse administration began with legislation passed in the 1850s. This study explores the link between differences in the length of a state's coastline, political affiliation and legislator voting on lighthouse reform in 1850 and 1852. The probit estimation revealed that the geographic distribution of coastline was positively and significantly related to probable support for an investigation of the lighthouse system. The qualitative and quantitative evidence together provide a basis for inferring a pattern of expected costs and benefits for legislation in 1850 to convene a board to investigate the lighthouse system and make recommendations for improvement. Taken together, the quantitative and qualitative evidence are consistent with the hypothesis that the primary beneficiaries of an investigation of the lighthouse

system are along the coast, and the investigation's expected net benefit to a state depends on the length of a state's coastline. While the quantitative evidence indicates that geographic differences and party affiliation were influential in initiating an investigation of the lighthouse system, these factors were not influential in an unsuccessful attempt to defeat the establishment of a lighthouse board.

Since 1850, technology has significantly improved aids to navigation. Most of the lighthouses were converted to electricity during the 1920's and 1930's, making the service more reliable and reducing the cost of the lighthouse service and the need for human attention. The lightkeeper is no longer the only source of navigational information useful to determine the seaman's location. The Coast Guard has introduced Long Range Navigation (LORAN) and short-range navigation (SHORAN) which allow navigators to determine their location using signals from Coast Guard stations. Ships also have radar and sonar to locate other vessels, the coast, and the sea bottom. These systems are effective day and night and are not disturbed by fog and storms. With completion of the Coast Guard's Lighthouse Automation and Modernization Program (LAMP) in 1989, all lighthouses in America were automated and lighthouse keepers were eliminated (with the exception of the Boston Light which is to remain permanently manned to preserve its historical character). Now, mariners can determine their location using automated lighthouses, radio signals, radar and sonar, and the Global Positioning System which uses satellite signals to help mariners fix their position within a margin of error of 100 feet. Dredging equipment also has reduced the danger. It thus appears that the lonely lightkeeper who maintained the lighthouse and watched for those at sea provided an important benefit to coastal communities. While technology has made navigating the seas safer, it has reduced the number of

people employed in keeping lighthouses.

Appendix

The following is an illustration of the result that private producers can produce the efficient amount of a public good. I present a nonstochastic, full-information model. Suppose that the production of x units of a good by a single producer directly effects the utility of n agents indexed $\{1, \dots, n\}$. The welfare of the agents increases with the level of production. The firm's profit depends on the level of production and its monetary receipts. If p_i is the price agent i pays the producer to increase production by one unit, the profit of the producer is given by

$$\pi = \sum_i p_i x - c(x) \quad (1)$$

I assume that the cost function is strictly increasing and convex in x . Each purchaser has a utility function given by

$$U_i(v_i, x) = v_i x - p_i x \quad \forall i = 1, \dots, n \quad (2)$$

Each agent's utility function is strictly increasing and linear in x . However, the agents may differ in v and therefore their desire for x . If $v_i > 0 \forall i = 1, \dots, n$, $v_i x$ can be interpreted as the benefit realized by individual i due to the production of the public good. Benefit to all agents regardless of the amount of payment makes the good a nonexcludable public good. All of the above is common knowledge among the parties.

In the absence of any payment from the agents, the firm's profit-maximizing level of production, x_n , satisfies the following Kuhn-Tucker condition:

$$\partial \pi / \partial x = - \partial c(x_n) / \partial x \leq 0 \quad (3)$$

The producer will not produce any of the public good, i.e., $x_n = 0$. The associated profit and utility levels are

$$\pi = -c(0)$$

$$U_i = 0 \quad \forall i = 1, \dots, n \quad (4)$$

The Pareto efficient allocation maximizes the sum of the profit of the producer and the utilities of the agents. Let the social welfare function be

$$SWF = \pi + \sum_{i=1}^n U_i(v_i, x) = \sum_i p_i x - c(x) + \sum_{i=1}^n (v_i x) - \sum_i p_i x \quad (5)$$

I avoid boundary problems by assuming the production of a positive amount of output. The first order condition is

$$\partial(SWF)/\partial x = -\partial c(x_e)/\partial x + \sum_i v_i = 0 \quad (6)$$

Obviously, $v_i > 0 \forall i = 1, \dots, n$ implies that $\partial c(x_n)/\partial x < \partial c(x_e)/\partial x$. The strictly increasing and convex nature of the cost function implies that the firm producing a public good will produce, in the absence of compensation, less than the efficient level of the good, i.e., $x_n < x_e$.

Now suppose that a public-goods market is created and that the agents can jointly buy the public good from the producer. In the market for the public good, there are $n+1$ participants: n purchasers or agents and a producer. The agents who desire the public good must compensate the firm to induce the firm to produce. Let x_f be the quantity of the public good produced by the producer in this solution. The firm's profit maximization problem is to pick x to solve

$$\max \pi = \sum_i p_i x - c(x) \quad (7)$$

The output of the firm in this solution satisfies the first order condition

$$\partial \pi / \partial x = \sum_i p_i - \partial c(x_f) / \partial x = 0 \quad (8)$$

The producer receives compensation from agent i in the amount of $p_i x_f$ for production of the public good. In this problem, x_f is the same for all agents. Each agent's utility depends on the level of production and his or her monetary payments. Each purchaser picks x to solve

$$\max U_i = v_i x - p_i x \quad (9)$$

The first order condition is written as

$$\partial U_i / \partial x = v_i - p_i = 0 \quad \forall i = 1, \dots, n \quad (10)$$

A competitive equilibrium requires equality of supply and demand in the market for the public good. Combining (8) and (10) yields the first-order condition that characterizes the efficient amount of the public good, (6). By adding a market for the public good, Pareto optimality is restored. The associated profit and utility levels are

$$\begin{aligned} \pi &= \sum_i p_i x_f - c(x_f) \\ U_i &= v_i x_f - p_i x_f \quad \forall i = 1, \dots, n \end{aligned} \quad (11)$$

We know from standard considerations that the competitive equilibrium from this endowment is at least as desirable to each agent as the initial endowment.

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