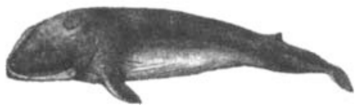
12 The Americans Replace the British



As the brief survey in chapter 2 indicated, a single nation at a time has typically dominated the world's whaling activities, but there has been a series of displacements of one leader by another.[1] In the seventeenth century the Dutch replaced the British. In the eighteenth century the British regained their former position, but were again replaced three-quarters of a century later—this time by their former colonists, the Americans. Before the end of the nineteenth century the Americans were replaced by the Norwegians, and within five decades Norway's position had been undercut by the Japanese and the Russians. International rivalry has been characteristic of the industry; one such conflict—between Great Britain and the United States—ushered in the Golden Age of American whaling. The short period of intense British-American competition (1817–42) provides an ideal laboratory in which to examine the effects on productivity and profits of the managerial choices and national-policy constraints that marked the British and American experiences.

Whaling's natural resource, whales, was not the property of a single country, nor were the stocks available to one country of better or worse quality than those available to any other. Except in time of war, the vessels of every maritime nation enjoyed equal access to the supply of whales. Moreover, for at least a century before 1817, the same store of technical knowledge was open to all competitors. The ship *Truelove,* for example, one of the most successful British

1. The argument in this chapter follows closely that in Davis, Gallman, and Hutchins 1987b. The current American data set, however, is much larger than the data set underlying the earlier paper; we have restricted the data set used in this chapter to voyages that brought back little or no sperm oil; a number of small errors have been corrected; and productivity has been calculated in a slightly different way. The most important change is the restriction of the data set to voyages that brought back chiefly baleen and whale oil. Also, the current profit estimates are of pure profits; the figures in the earlier paper were gross of various costs, and the profit rates published therein are therefore higher than the rates here. In spite of these differences, the chief conclusions in this chapter remain the same as those in the paper.

whalers, was neither designed nor built in Great Britain. She was commissioned in the colonies in 1764 and owned and sailed by colonists, from colonial ports, until she was captured by the Royal Navy during the Revolutionary War. In 1780 the ship was sold to private owners in the United Kingdom. Between then and 1868 the *Truelove* completed seventy-two whaling voyages under British command (Jenkins 1921, 194–95). Many of the most successful British whaling entrepreneurs were American émigrés who left Nantucket at the beginning or the end of the Revolutionary War.[2]

Similarly, sailors and whaling experts were drawn from a variety of labor markets. The composition of the crew of the *Pequod* may reflect literary imperatives, but it does not distort the whaling world unduly. Melville sailed in American and Australian whalers in the 1840s, and knew that their crews were recruited from many races and many nations. American law required that whaling officers be American citizens, and, if penalties were to be avoided, two-thirds of the crew also had to be American, but there were ways around the rules.[3]

These international elements meant that to a large extent the differences between the British and American fleets reflected managerial and political decisions, not natural endowments or asymmetric information. First, although before 1825 or 1830 most U.S. whaling crewmen were Americans, American agents had access to an international labor market. After 1830, as the industry expanded and exhausted the native labor markets, crew lists frequently contain names such as Joe or Sam Kanaka, and the lists of stations, or positions, are scattered with descriptions such as Green Portuguese, Malay, and Spanish Islands. The present population of New Bedford, heavily weighted by descendants of nineteenth-century Portuguese and Cape Verde whalemen, attests to the international character of the whaling labor market. In Great Britain, where the government viewed the fishery as a training ground for the navy, both officers and crew members were usually British.

Second, both American and British entrepreneurs were required by law to acquire their vessels from domestic shipbuilders or owners.[4] The Americans were fortunate to be buying from the cheaper source.

Third, with the exceptions noted above, concerning the provenance of the

2. Jackson 1978, 93–94, describes negotiations in 1785 between one of the Rotches, then still at Nantucket, and British authorities. The proposal was made that five hundred Nantucketers, with their vessels, move to Milford Haven, on the west coast, and create a new whaling community. To this plan the London expatriates—Enderby and Champion—objected strenuously, and in their objections they were supported by the Board of Customs. The Londoners would have been pleased to add Nantucketers to their crews, but found the idea of a competitive whaling community at Milford Haven unappealing. Rotch left in a huff for Dunkirk, but plans for a Dunkirk-Nantucket whaling center fell through.

3. For example, the second rule did not hold if crewmen who were lost by desertion, illness, or death had to be replaced in a foreign labor market in which there were no American seamen. Also, stateless persons counted as Americans. See An Act concerning the Navigation of the United States, 1817, *Stats. at Large of USA* 3:351–52; Hohman 1928, 48–52.

4. There was an exception: foreign vessels captured in war could join the American fleet.

vessel and the composition of the crew, the American effort was conducted in an economic environment largely free of government restrictions or subsidies. Heavy British subsidies were not without cost; major restrictions—direct and indirect—were placed on managerial decisions by the government.

As a result of American and British restrictions, neither capital nor labor was completely mobile, and entrepreneurs in the two countries faced different relative prices. Because of these differences, or perhaps because of variations in taste or culture, there were international differences in vessel design, in the skill composition of crews, and in the organization of voyages. Thus, international differences in productivity could and did appear. The differences are both worthy of and readily susceptible to analysis. Pure productivity effects—including effects embodied in the capital stock, the human resources, and the institutional structure that regulated and constrained economic activity—seem easier to sort out in whaling than in most other industries.

This chapter focuses on competition between the British northern fleet and the American Atlantic fleet in the years 1817–42. The American fleet captured some sperm whales, but the prize both primarily sought was the baleen whale. The areas hunted by the British included Davis Strait, Greenland, and the North Atlantic. The American fleet hunted there, and in the Central and South Atlantic when winter drove it from the northern waters.[5]

At the end of the War of 1812 the British fleet dominated world whaling, and more than two-thirds of the British effort was focused in the North Atlantic.[6] In 1816 British owners sent about 130 vessels to the northern fishery. Although the numbers fluctuated substantially from year to year, an annual average of more than 125 British vessels sailed for the North Atlantic between 1814 and 1824 (McCulloch 1842, 163). In contrast, in the first peacetime year (1815) American owners sent no more than 20 vessels there. Twenty-seven years later, in 1843, the entire British fleet, northern and southern, had shrunk to fewer than 34 vessels. In that year the Americans could count almost 675 ships, barks, brigs, sloops, and schooners (Tower 1907, 121).

To understand the dynamics of the competition, it is necessary to analyze the activities of the two fleets in the area in which they came into closest contact—the North Atlantic.[7]

5. It would be preferable to study fleets hunting over identical grounds, but this is impossible. Both fleets could have operated in the North and South Atlantic, but the British did not choose to send their vessels south in winter (see below) and the Americans usually did. The sperm whales appearing in the American records were taken chiefly in the Central and South Atlantic.

6. It is estimated that there were about 150 vessels in the northern fleet (vessels bound for Davis Strait and Greenland) in 1820. In the same year the southern fleet (vessels hunting in the South Atlantic, the Pacific, and the Indian Ocean) is estimated to have had about 66 vessels (Jackson 1978, 117, 136). (The number of vessels in 1830 was extrapolated to 1820 on the tonnage of the southern fleet to obtain the number of vessels in the fleet in 1820.)

7. Data on the British northern fleet have been taken from British Parliamentary Papers and from Jenkins 1921; Jackson 1978; McCulloch 1842, 1854. The American data refer to New Bedford vessels hunting in the Atlantic and its northern reaches. The British northern fleet did not hunt in the Central and South Atlantic; they sought only baleen whales. In order to increase the

12.1 Styles of Whaling

No family is better known in the annals of the British southern whale fishery than the Enderbys. Like the other old, established whaling houses—the Champions, the Mathers, and the Roaches—the Enderbys were American expatriates. In 1787 they owned seven whalers; at the turn of the century they, together with the other three families, owned thirty-eight with an estimated value of £273,800. Samuel senior, Samuel junior, and Charles Enderby were the leading spokesmen for the British industry from the late eighteenth century until the failure of the Southern Whale Fishery Company, which Charles founded in 1849 in a last attempt to "rehabilitate British whaling." The company survived for only twenty months. When it went bankrupt, Charles Enderby attributed the British loss in the competitive struggle with the Americans to three factors: the failure of British vessel design, the failure of British seamen, and the high costs of British vessels (Jackson 1978, 99, 142; Fairburn 1945–55, 2:1008). To these should be added a fourth: changes in government policy.

For almost a century before 1849 British whalers had received a stream of direct and indirect government subsidies. According to William Fairburn (1945–55, 2:1007), "The whaling industry was not a success in Britain except during the years that the government supported it with bounties and warships." From 1795 until 1824, a subsidy of twenty shillings a vessel ton (it had been forty until 1790) inflated the returns from a typical voyage by $1,302, while very high tariffs protected British whalers from foreign competition in the domestic market.[8] In 1843, for example, when the price of whale oil in the American market was $0.41 a gallon, the British *tariff* on whale oil was $0.72 a gallon (tariff figure from Jackson 1978, 121). In this chapter the trends in British and American productivity and profitability are compared, and an attempt is made to assess the relative contribution of each of the four factors—vessel design, vessel cost, the quality of seamen, and government policy—to the measured differences between the two fleets and to the eventual results of their competition.

Although whaling agents on both sides of the Atlantic had access to the same technology, there were important differences between the technical con-

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comparability of the two sets of data, we have omitted from consideration American voyages whose catch was at least 25 percent sperm oil by volume. See also appendix 12A.

8. Over time the bounty payments fluctuated: 1734–39, 20 shillings per ton; 1740–49, 30 shillings; 1750–76, 40 shillings; 1777–81, 30 shillings; 1782–86, 40 shillings; 1787–91, 30 shillings; 1792–94, 25 shillings; 1795–1824, 20 shillings per ton (Jenkins 1921, 306). To make comparisons easier, all cost and revenue figures in this chapter have been denominated in U.S. dollars of 1880. Michie (1977–78, 64, 68) says that, in the case of Scottish whaling in 1763–74, the bounty increased average profits from a negative 15.2 percent to a negative 2.2 percent. Over the profitable years 1800–1815 the bounty still accounted for a 3.5 percent return on investment for the Peterhead fleet (or almost one-tenth of its total profits) and a 4.3 percent return on investment for the Aberdeen fleet (more than one-fifth of its total profits).

figurations of the British and American fleets. The British used larger vessels and adopted a configuration that displayed a much higher labor/capital ratio than did that of the Americans. British owners recalled their vessels after each hunting season;[9] most American vessels remained at sea for two or more seasons—an important difference. The institutional choice did not affect the mode of hunting whales; it did produce differences in the way a carcass was handled when it was brought back to the vessel. Finally, the two sets of agents adopted very different methods of paying their seamen.

In 1815 the typical British northern whaler measured 323 tons, the typical New Bedford Atlantic whaler, only 168. Over time, the size of the average vessel rose in New Bedford and fell in Britain.[10] By the turn of the decade there was little difference between the two: the British average was 302 tons (1841), the New Bedford, 283 tons (1838).[11] As Averch and Johnson (1962) have demonstrated for public utilities, when, because of the decisions of a regulatory body, profits are in part geared to the size of the capital stock, under a wide variety of conditions a firm has an incentive to "gold plate"—that is, to use more than a market cost-minimizing quantity of capital. In Great Britain the amount of the government subsidy was based on the registered tonnage of the vessel, so there was an incentive to use larger vessels than cost minimization would have called for. When the subsidy was cut off in 1824, the incentive disappeared. The decline in British vessel size can be traced in part to that event.

It was costlier to build vessels in Great Britain than in the United States. Historians and contemporaries have generally agreed about the range of the ratio of British to American vessel costs. It appears that, depending on time, place, and source, a British vessel cost between 1.5 and 2.2 times as much per ton as a similar vessel built in the United States (Hutchins 1941, 202). Higher construction costs, however, were partly offset by lower interest charges. Over the period 1816 to 1842 the long-term yield of British 3 percent consols averaged 3.62 percent, and the safest American securities (in the earlier years Massachusetts 5s [5% bonds], in the later, Boston City 5s), 4.96 percent.[12]

The typical British northern whaler was rigged as a ship, carried six or seven small boats, and employed forty to fifty men. The *Brunswick,* for example, signed on twenty-three additional crew at Stromness, Orkney, on 21 March

9. Michie (1977–78, 75) says that by the early 1850s, "[e]specially amongst the ships traveling the longer distance to Davis Strait, 'wintering-out' was adopted, though it remained an exception to normal practice." Eber (1989, 11) says that the Americans introduced the practice in 1851. It may have been associated with the exploitation of Cumberland Sound.

10. The size of British vessels actually increased over the first fifteen years. Chatterton (1926, 47), for example, puts the average size of the Hull fleet at 330 tons per vessel in 1830.

11. After 1838, however, New Bedford ships moved into the Pacific and Indian Ocean fisheries, and the American Atlantic fleet was again dominated by brigs, sloops, and schooners (see below).

12. Homer and Sylla 1991, 195, 196, 299, 305. The U.S. yields refer to Massachusetts 5s (1816–21) and Boston City 5s (1824, 1825, 1827, 1829, 1830, 1832–42).

1824. "With a total of fifty he would be able to dispatch seven five-oared whaleboats in pursuit of whales, with enough men left over to handle the ship" (Ross 1985, 6).

The New Bedford fleet was more diverse. Between 1816 and 1825 ships accounted for about one-half of the Atlantic voyages, brigs, sloops, and schooners, the rest. Those proportions changed over time. In the mid-1830s virtually all Atlantic voyages were conducted by ships. Then the proportions shifted again; in the 1840s virtually all Atlantic vessels were of the three small types (brigs, schooners, and sloops) or were barks. An American vessel usually carried only four boats, and the crew averaged fewer than twenty-five (twenty-five on a ship, twenty on a bark, fifteen on a smaller vessel). Over the full period, however, despite the substitution of the smaller barks, brigs, sloops, and schooners for the larger ships, average crew size rose from just fewer than twenty to just more than twenty-three.

Differences in vessel and crew sizes gave the two fleets different labor/capital ratios. On average an American vessel employed 0.08 men per ton, a British vessel, 0.14, during the months of active hunting. There is little evidence of a move toward a single labor/capital ratio. In the years 1817–26 the British used 1.9 times as much labor per ton, and the ratio for 1836–42 was still 1.7. The disparity may reflect adjustment to differences in crew quality or in hunting style. Initially, it was probably also a response to the government's requirement that an owner of a British vessel sign two apprentices for each one hundred tons, if he wished to qualify for the tonnage bonus (Jackson 1978, 72; Crisp 1954, 30).

Weather in the North Atlantic and Davis Strait is foul. Between storms and the ice pack it was impossible to hunt for more than a few months in the late spring and summer. Vessels that failed to retreat south in time were caught in the ice—leading, at best, to severe hardship, at worst, to sailors' deaths and vessels' destruction. In 1830 nineteen of the ninety-one vessels in the British fleet and one French whaler were destroyed by the ice pack. They included six double-bottomed and reinforced whalers, designed for the Arctic ground, that were smashed in a single accident. Attempting to shelter behind a large ice floe, the *Eliza Swan*, the *St. Andrew*, the *Baffin*, the *Rattler*, the *Achilles*, and the French *Ville de Dieppe* formed a line, bow to stern, and very close together. The floe was driven on the *Eliza Swan* and the *St. Andrew*, and "passing along the line dashed against [the other vessels] with such energy that within fifteen minutes these four strongly built, especially fortified whalers . . . were . . . converted into mere fragments of wood."[13] Trapped vessels that escaped being

13. Chatterton 1926, 56–59, 62; Crisp 1954, 60–61. Although the city did not lose its first whaling vessel until 1813, of a total of twenty Aberdeen ships involved in whaling over the years 1800 to 1840, 60 percent were lost while whaling (Michie 1977–78, 69–70). Overall the record was almost certainly not that bleak. Of the 2,561 voyages made to the northern ground over twenty-seven of the twenty-eight years between 1815 and 1840 (the losses, if any, for 1839 were not reported), 112 vessels were lost at sea—about 4 percent of the total (McCulloch 1854, 642).

This map shows the principal northern whaling grounds—Spitsbergen, Davis Strait, Baffin Bay, Hudson Bay, the Beaufort Sea, the Chukchi Sea, Bering Strait, the Bering Sea, and the Sea of Okhotsk.

Courtesy of the Printing Services Department at the University of North Carolina, Chapel Hill.

crushed fared little better. In 1836, for example, the British whaler *Dee* was caught in the freeze and remained icebound for five months and eight days (until 16 March 1837). By the time the ship returned to its home port (Aberdeen), forty-six men had died; another died later of illness contracted during the winter (Ross 1985, 89–107).

British vessels went north each spring and returned to port when the hunting season was over. Except in an emergency, no major repairs were done at sea. Returning vessels were refitted and repaired in the dockyards of their home ports, and blubber was refined at a shore-based refinery.

For the Americans the journey south did not always mean a journey home. Instead of steering for New Bedford or Nantucket each fall, many vessels headed for the Central or South Atlantic and continued the hunt. American agents had concluded that it was more efficient to keep them out for at least two seasons. As a result repairs, even major ones, had to be made at sea. British vessels returning home each season required few skilled artisans; in a forty- to fifty-man crew there would be a cooper and probably a carpenter (Chatterton 1926, 53). American crews, even though they were much smaller, almost always included not only a cooper and a carpenter, but usually a blacksmith and often a sailmaker, boatbuilder, painter, mechanic, machinist, and caulker, or a second cooper, carpenter, or blacksmith.

The difference in time at sea also had implications for the method of storing and transporting oil. In the British case, blubber was brought back unrefined. After a whale was killed, its carcass was towed to the ship and attached with blocks and tackle to the mast. The head was usually severed to make it easier to get at the baleen, "but a boat *can* enter the mouth of a whale, and, if necessary, several men could at the same time stand upright and be at work, removing the whalebone from the upper jaw, the head of the whale being about one-third of the bulk of the creature (Ross 1985, 187). At the same time, under the direction of the *specksioneer,* or head fat cutter, the expert of experts on the cutting of whales, men working from mollie boats and from the carcass itself flensed the blubber off the skeleton, and *gummed* (scraped) the bones.[14] The blocks of blubber were then hoisted on deck, trimmed by the krengers, skinned by skinners, sliced into small pieces by choppers, and pushed into the speck trough and down the lull (the process controlled by the lull-boy, equipped with nippers) to the hold where the skeeman and the king stored the pieces in barrels (Chatterton 1926, 132; Ross 1985, 61–63).

14. On Dutch whalers by the seventeenth century it was the specksioneer, not the captain, who was the final authority. This command structure was initially adopted by the British, but by the late eighteenth century, at least in the northern fleet, the framework had evolved dramatically. Even while whaling, the vessel was under the direct command of a regular seafaring captain, and "the specksioneer was merely a senior harpooner" (Chatterton 1926, 132). Not only had experience demonstrated conclusively that ship handling and navigation were very important, but captains had become experts on whales and their habits. Chatterton, however, says that, on American whalers as late as the early nineteenth century, the specksioneer still retained some of his earlier authority.

The first stages of the American process were similar, but instead of the cutters' working from mollie boats, a cutting stage was rigged and the men worked from the stage. A winch was used to peel the blubber from the carcass, and the strips were cut into pieces aboard the vessel. For the British the disassembly process was complete when the blubber was barreled; for the Americans there was still much to do. Only after it had been minced and then boiled in the tryworks was the blubber, by now semirefined oil, stored in barrels.

An average voyage for a British vessel was five and one-half months, and there is no evidence of a trend over time. For the New Bedford sailors who worked the North Atlantic, the average was almost fourteen months, and the figure rose from just over eleven and one-half months to just over eighteen in the years before 1843. It might appear that the British and the Americans drew from different pools of institutional technology, but this was not the case. Both technologies (one season and then home for repairs and refining, versus several seasons with some repairs and refining effected aboard ship) were known and available in both countries. Like the choice of different production technologies in high-wage low-interest and low-wage high-interest countries, the choice of an appropriate institutional structure was made by the agent—the entrepreneur who managed the voyage.

Theory suggests that his choice was dictated by the desire to maximize profits, but the initial conditions were very different in Great Britain than in the United States—leading the British entrepreneur to choose short voyages, the American, longer ones. In the first place, although American vessels did at times shift from whaling to the merchant service and vice versa, while they were in the whaling fleet (with few exceptions) they focused solely on whaling. For the British northern fleet, whaling was often a part-time activity, an enterprise of choice in the off-season for the merchant trade or, a somewhat more permanent transfer, when that trade was in the doldrums. It was not unusual for a vessel to operate as a whaler in the summer and transfer to the coastal or Baltic trade in the winter.

In the second place, profits are maximized within a structure of relative prices. To the British entrepreneur, effective relative prices, as opposed to those observed in the market, were until 1824 biased by the mechanism chosen by his government to distribute the bounty payment. A British shipowner was paid a lump-sum subsidy per registered ton for each voyage to the northern fishery, and the Board of Customs counted each round trip from home port to home port as a voyage. In the same way that the institutional mechanism—the subsidy—induced businessmen to choose larger vessels than market prices would have dictated, the government's policy led British agents to bring their vessels back at the end of each season. Consider what might have happened had the Board of Customs chosen the same mechanism for distributing the subsidy to the northern fleet as to the southern. In that case a premium of £500 was paid to each of the four vessels returning with the largest catch, rapidly declining bonuses to some predetermined number of other ships that performed well, and nothing at all to those who returned relatively empty (Jackson 1978, 96–97).

It has often been suggested that relative voyage lengths explain the differences in the structure of labor payments. Whether or not that is correct, the institutions that evolved in the two countries were quite different.[15] In the United States, in addition to subsistence and occasional supplements, each crew member was paid a specified fraction of the net revenue earned on the voyage. The sum of these lay payments rose from about 31 percent of net revenues in the early 1840s to about 36 percent in the mid-1850s (see table 5.15). In Britain the payment was a mix of monthly wages, bonuses that were "catch" dependent, and until 1824 some fraction of the government tonnage subsidy. Despite the higher labor/capital ratio on British ships, *annual* payments to labor were lower than in the United States. The effect of larger crew size was more than offset by the shorter length of the voyage. Thus, labor costs (exclusive of subsistence) on British vessels averaged 24 percent of revenues per voyage of five and one-half months in the profitable years 1817–36. (See appendix 12C.)

A seaman of each country generated about the same amount of revenue per year, but the cost of a year's work by a British seaman was about two-fifths more than the cost of an American's work. Moreover, there are at least three reasons to think that this 40 percent differential, large as it is, represents a lower bound on the effective ratio of the cost of British seamen to the cost of American seamen. First, because of the differential demand generated by the need to repair and refit at sea, there was a much higher concentration of artisans on American vessels. Second, the British government continued to attempt to entice American whalemen to relocate in England or Scotland and lend their services to the British effort. Finally, in the southern fishery, despite an average total lay of 44 percent, British owners were unable to attract seamen as skilled as the Americans. Thus, on average the quality of American crews was probably higher, and an adjustment for those quality differences would push the ratio above 1.4.

12.2 Productivity Differentials

On the one hand, the victory achieved by the American industry might be explained purely in terms of market opportunities. That is, both fleets might have been equally productive, but the Americans might have been favored by locational factors, lower input prices (lower opportunity costs for labor, for example), or more favorable treatment at the hands of their government. On

15. In the southern fishery, where voyages were longer, the British used a system of payment very similar to the American. Both made the lay the major component of the remuneration package. See Jackson 1978, 100; chapter 5 above.

the other hand, the victory might have resulted from differences in physical productivity, produced by a better choice of technology (either narrowly technical or broadly institutional), higher qualities of nationality-tied inputs (either capital or labor), or better entrepreneurial skills.

The productivity index introduced in chapter 1 and used extensively in the analysis of American productivity change (chapter 8) can, with only minor adjustments, provide the basis for a comparison of the physical productivities of the two fleets. In this formulation only two outputs are distinguished: whale oil and baleen. New Bedford whalers returned from the North Atlantic with some sperm oil, which has been treated in the calculations as whale oil. This procedure biases the estimated relative American productivity downward. Nineteenth-century whalemen recognized that more resources were required to produce a barrel of sperm oil than of whale oil, and the long-run relative price of the two commodities confirms that view.

As before, no allowance is made for vessels lost at sea; only those that returned to port are included. The issues involved in incorporating lost vessels (and men) are complex. In any case both fleets displayed virtually identical loss rates; ignoring losses should not affect relative levels of estimated productivity.

Labor is measured in man-months, capital, in ton-months—the tons referring to registered vessel capacity. The British and American formulas for measuring tonnage were not identical, but it is likely that the differences cancel out.[16] The tonnage measures were probably similar and are assumed to be identical for the purposes of the calculations.

One major problem remains. Records indicate that, upon returning from a voyage, an American crew was paid off. Although there were substantial voyage-to-voyage differences, the typical vessel remained in port for sixty to seventy-five days (see note 20), during which time it was refitted and outfitted. At the end of the refitting and with a new crew aboard, it again put to sea. British vessels returned after only five and one-half months at sea and did not set out again until an additional six and one-half months had passed. For Amer-

16. The British and American formulas for estimating vessel capacity were similar, but not identical (see chapter 6). If all measurements were made in the same way, the U.S. rule would result in measured tonnages just over 1 percent smaller than those produced by the British rule.

Measurements, however, were not made in the same way. In both countries breadth was to be measured at the widest place—in the words of the British law, "from the outside of the outside plank in the broadest part of the ship." For the British the measurement was "exclusive of all manner of doubling planks that may be wrought upon the sides of the ship"; the American rule makes no mention of deductions. Since northern whalers were often doubled and sheathed, the American system probably produced wider breadths than did the British. Both countries called for measures of length from stem post to stern post; in the American case the measurement was made above the main deck, in the British case, along the keel, with an allowance made for the overhang of the bow but not the stern. Again, the American dimension was probably slightly larger than the British (McCulloch 1842, 977; An Act for Registering and Clearing Vessels, Regulating the Coasting Trade, and for Other Purposes, 1789, *Stats. at Large of USA* 1:55–65).

The British rule changed in 1836, but vessels built before that date were allowed to retain their original measurements. In our calculations all British whalers were assumed to have been built before 1836.

Table 12.1 **Total Factor Productivity, British Northern Fleet and American (New Bedford) Atlantic Fleet, 1817–42 (percentages)**

A. American Productivity as % of British Productivity

	Variant S	Variant L	Variant M
1817–25	74	107	139
1826–35	78	107	131
1836–42	122	187	243
1817–42	89	129	164

B. Indexes of American and British Productivity, Base 1817–25, Variant L

	U.S.	Great Britain
1817–25	100	100
1826–35	121	121
1836–42	69	39

Sources: See the text and appendix 12A.

ican vessels the time spent in port was needed to refit and outfit. Refitting certainly did not take three and one-quarter times as long in Britain. The question is, what happened to the British vessel and crew during that six-and-one-half-month hiatus?

In an attempt to work around this problem, three sets of productivity indexes were calculated (see table 12.1). They differ in their measurement of the time dimension of the two inputs: man-months and ton-months. Variant S (time at sea) uses months at sea. Clearly, since the procedure makes no allowance for the time ships were down during refitting or for unemployment among the crew between voyages, variant S understates the true volumes of capital and labor used by the industry. In the American case the understatement of labor is probably slight; the fleet was expanding and vessels sailed regularly, regardless of season, so that a seaman discharged after one voyage could usually sign on for another immediately, if he chose. That was not the case for British seamen, who at the end of a voyage would have to wait more than six months to ship again in the northern fleet. In the meantime British seamen could seek employment in other activities to tide them over, but there was no guarantee of reemployment.

The variant S estimates thus understate the volume of inputs used by the two fleets, thereby overstating productivity. The overstatement is greater for the British, and consequently the estimates overvalue the comparative productivity levels of the British fleet.

The variant M (maximum inputs) estimates rest on the assumption that both men and vessels were held out of other gainful activity when they were not whaling. Given the relative sea times of the two fleets, variant M maximizes the relative productivity of the American fleet.

If some part of the downtime imputed to British vessels in variant M was actually spent in another productive activity (the coasting trade, for example), the estimates would exaggerate the relative productivity of the American fleet—but not badly. The opportunities for off-season employment open to British whalers would have been second-best alternatives (why else would an owner risk his capital in the waters off Greenland or in Davis Strait during the whaling season?), much less productive than whaling.[17]

A similar argument can be made for the biases inherent in variant M's assumption that there was no alternate employment for workers. No plausible maritime alternative could have employed a majority of the fifty-man British crew, most of whom had little traditional maritime experience. A large part of a British crew would have been either unemployed or forced to take less remunerative, unskilled positions ashore during the long period between voyages. Why would a man risk life and limb in northern waters if he had a close employment substitute available? Nevertheless, the most likely estimate of relative productivities is not the M estimate, but something between variants S and M: that vessels were usually employed in the off-season, and a fraction, no more than one-third, of the crew transferred with their vessel to mercantile pursuits.

Finally both of these indexes incorporate three recognized biases, each of which leads to an understatement of American relative productivity. First, the British brought back unprocessed blubber; Americans tryed out the blubber aboard ship and returned with semirefined oil. A correct productivity comparison would require that some additional labor and capital be assigned to British production to adjust for the resources used by the Americans in the first stage of the refining process. Second, the inclusion of skilled craftsmen in the American crews meant that a great deal of refitting and repair was done at sea. Shore-based shipyard workers, of course, were employed when the vessel returned home. The British employed shipyard workers in their home ports for almost all refitting and repair. Variant S picks up none of those workers, and variant M captures only a part of the labor done ashore. Variant M assumes the crew stayed with the vessel while it was in port, and the crewmen could have been used to refit. British crewmen were seamen, however, not artisans; unaided, they could not have carried out many of the repairs needed after a season in the northern seas. Third, the British brought back only whale oil, the Americans, a

17. Michie (1977–78, 69) finds evidence of vessels used in the off-season in the Baltic, Atlantic, Mediterranean, and coastal trades. For example, he cites the case of "two Aberdeen whaling ships, the *Jane* and the *Neptune*," that "returned from a voyage to America in February 1809 in time to sail at the end of the month for the whale-fishing." He also says that owners needed to keep their vessels regularly at work in profitable undertakings and, in the years 1800 to 1820, "[w]haling was proving sufficiently attractive . . . because of good catches and high profits, and so shipping moved into the whaling trade." If this argument is correct, it suggests that the tonnage bonus was sufficient to make whaling more attractive than the merchant marine, but the industry without the subsidy was not as profitable. If it had been, entrepreneurs would have adopted the American institutional technology of longer voyages.

mix of whale and sperm oil. To the extent that, in the long run, prices reflect real costs, sperm whales must have been more costly (i.e., required more labor and capital) to catch than baleens. Between 1816 and 1845 the price of sperm oil was, on average, 2.3 times that of whale oil. Both index variants assume that a gallon of oil was a gallon of oil, thus tending to understate U.S. relative productivity.

The variant L (most likely) estimates were produced to deal at least roughly with some of these biases and to establish productivity levels between the limiting S and M variants that would more closely approach the truth. They make three adjustments to the data underlying variant S. First, American output levels are raised by 10 percent, to take into account both the trying out of oil aboard American whalers and the fact that some of the oil they brought back was the more valuable sperm oil.[18]

Second, the time dimension of the capital input for both the British and American fleets is taken to be the time at sea plus two and one-half months for refitting between voyages. The typical (mean) refitting period for American vessels was, in fact, about two and one-half months (table 6.7). British vessels were a shorter time at sea, which might suggest that they required less refitting. They hunted exclusively in the harsh Arctic environment, however; American whalers spent only part of their time in the Arctic. Furthermore, American vessels carried artisans who were able to make some repairs at sea. Finally, British whalers that operated in the coasting or Baltic trade in the off-season would need to be refitted twice, once to clean and prepare them for mercantile service, once to refit them as whalers. It seems unlikely, then, that British whalers required less time to refit than did American whalers, and they may have required more.

It is not clear that all British northern vessels found employment in the off-season, or that those that did were as productively engaged then as when hunting whales. The third adjustment is to assume that British whalers and crewmen were only three-quarters as productive in the off-season as during the whaling season. Even with these adjustments, the variant L estimates are likely to be biased against a showing of high American productivity.

The estimates were made in the manner described in chapter 8 (for further details see appendix 12A), which yields productivity indexes expressed in natural logs. The antilogs were then taken and used to compute the figures in table 12.1. The indexes are highly volatile from one year to the next. To get a clear sense of the relative performance levels of the two fleets, it is necessary to study multiyear averages, and such averages appear in table 12.1. The three variants give very different results, but the preferred estimates (variant L) suggest that in the period 1817–35 the productivity levels of the two fleets were

18. Michie (1977–78, 71) places the 1846 cost of "boiling and coopering" at £1 a ton (tun) or about 2.3 cents a gallon—about 7 percent of the American price. Since the whale-oil market was competitive, that figure must also reflect about 7 percent of the cost of the oil.

close (panel A). The Americans seem to have been a little more productive, and the true margin of difference is almost certainly greater than the figures in the table show.

In the period 1835–42, when the American fleet came into its own, the productivity gap became very wide. Even the variant S estimates, seriously biased against a finding of high American productivity, show that the American fleet was more productive. The measured gap, according to variant S, was 22 percent; the true difference was more likely between 87 percent (variant L) and 143 percent (variant M).

The dramatic relative American gain shown in panel A was not due to a dramatic improvement in American productivity. As chapter 8 shows, American whaling productivity fell during this period, in the Atlantic fleet as well as the entire industry (table 12.1, panel B). The relative American gain resulted from an even greater drop in British productivity. Why was the experience of the British fleet in this period so unsatisfactory? The fleet had been shrinking and now consisted of very few vessels. Average productivity reflected a relatively small number of unsuccessful voyages. As the fleet shrank, it may have lost its best vessels and men. The few voyages at the end may have been conducted by thoroughly depreciated hulks from which agents were trying to squeeze a last bit of revenue. Finally, the sharp decline in productivity may have reflected a thinning out of whale stocks in the northern grounds, due either to overhunting or to the passage of whale groups under the Arctic ice cap to the Western Arctic, a ground not yet hunted (Jackson 1978, 126–30).

One probable reason the American fleet was more successful is that it was less dependent on the northern grounds; its versatility served it well. Also, unlike the British, the American fleet was expanding and drawing to it able agents, captains, officers, and boatsteerers. Eventually, the Americans had trouble maintaining the quality of their corps of seamen (see chapter 8) in the face of the strong labor demands created by the expansion of the fleet. Nonetheless, there was a vitality to the industry at this time that could not be matched in Great Britain.

12.3 Differential Profitability

The productivity indexes show that resources devoted to whaling by American firms produced, on average, more oil and bone than the same quantities of labor and capital did when applied to the same task by British firms. It is profit, however, not productivity that induces entrepreneurs to organize economic activity, capitalists to provide vessels and whalecraft, and workers to leave the farm for a life before the mast.

Relative profits are not easy to estimate. Not only are the British aggregate data open to questions of interpretation, but there are theoretical problems as well, stemming from the part-time nature of British whaling. On the one hand, if whaling was a secondary activity—pursued only when there were no mercantile opportunities—then any return over total variable cost represented a net gain to the primary activity. On the other hand, if management chose to engage in the Baltic or coasting trade only to make use of vessels when weather prevented Arctic whaling, then total whaling profits were the profits earned in whaling *plus* any return above total variable costs earned in the mercantile trade.

If the two activities are assumed to have been competitive, however, it should be possible to estimate whaling profits directly. Assume that the coasting and Baltic trades were competitive with whaling and that they could be pursued year round. Then, if firms chose to whale in the summer, not only must the profits in whaling have been higher than those that could have been earned in the merchant service, but also they must represent the actual profits from whaling. In short, it is as if there were two firms—a whaling firm that operated in the summer and a mercantile service that operated the rest of the year.[19] We have assumed that this institutional structure best characterizes the British fleet, and that assumption provides the basis for the profitability calculations reported in this section.

Table 12.2 gives several alternative estimates of the average profits that were (or might have been) earned by a British entrepreneur, as well as those of his American competitors.[20] The two sets of British estimates in panel A and column 1 of panel B reflect two alternative assumptions about the relative cost of British vessels and outfits (see appendix 12B). Panel A shows that before 1836 both fleets were making good profits, but thereafter profits fell, disastrously for the British. These patterns are very similar to those of the productivity data.

The contrasts between panel A and panel B, column 1, however, are of greater interest. The panel A estimates are based on the total revenues actually

19. Again, of course, this set of assumptions implies that the merchant service was more profitable than off-season whaling in the Central and South Atlantic. Moreover, each of the three possible assumptions about industrial structure opens the possibility that the decline in British whaling could be attributed, at least in part, to the declining profitability of the Baltic trade, as trade patterns shifted, and/or of the coasting trade, as railroads offered increased competition.

20. The U.S. profit figures are voyage figures from the New Bedford fleet averaged by year. Revenues were calculated by multiplying each element of the annual catch (whale oil, sperm oil, and whalebone) by its average price in the year of the vessel's return. Costs included (1) depreciation, (2) value of vessels lost at sea, (3) cost of outfitting the vessel, (4) forgone interest, (5) wages, and (6) crew maintenance. See appendix 12B. British profits were calculated similarly, except that the sources were not voyage records but aggregate studies and reports on part or all of the whaling fleet. These sources include Jenkins 1921; Scoresby [1820] 1969; Jackson 1978; McCulloch 1842; House of Commons 1845. All other estimates are drawn from the sources cited. See appendix 12B.

The American profit calculations are based on the assumption that vessels remained in port between voyages for an average of 2.5 months—a figure that almost certainly represents an upper bound. Both the median and the modal stay in port for all New Bedford voyages returning from the Atlantic ground between 1817 and 1843 was 2.0 months. If, on the assumption that any vessel that did not put to sea on another whaling voyage for more than 10 months after it returned was actually up for sale or engaged in some alternative nonwhaling activity, the distribution of observations on port time is truncated at that figure, the mean for all 1817–43 Atlantic voyages is 2.3 months. Of the 211 observations 119 have port times of less than 2 months and another twenty of less than 3.

Table 12.2 **Profit Rates, British Northern Fleet and American (New Bedford) Atlantic Fleet, 1817–42**

	A. Actual Rates	
	U.S.	Great Britain
1817–25	16.2	7.2 to 22.8
1826–35	17.6	28.5 to 51.8
1836–42	7.9	−18.6 to −15.0

	B. British Counterfactual Rates[a]	
	Fleet Required to Use British Vessels	Fleet Allowed to Use American Vessels
1817–25	−9.6 to −0.3	4.4
1826–35	−14.0 to −6.6	−3.7
1836–42	−27.3 to −26.6	−32.5

Sources: See appendix 12B.

[a]Rates the British fleet would have earned, had the fleet received no subsidies or tariff protection.

received by British shipowners. They include earnings from the subsidy as well as from the sale of oil and bone at tariff-inflated domestic prices. The panel B estimates represent the hypothetical revenues that shipowners *would* have earned had there been no subsidy and had they been forced to market their output at prices that prevailed in the United States (i.e., prices unaffected by the British tariff). Finally, the data in panel B, column 2, describe the profit rates British owners would have earned if there had been no tariffs or subsidies, but they had been able to buy American vessels.[21]

Two conclusions stand out. First, if the British government had pursued a hands-off policy (that is, no bounties, no tariffs, and no military blockades) but had continued to demand that owners use British-built vessels, it is highly unlikely that there would have been *any* British whaling industry. By the lower estimate of the cost of British vessels (1.5 times the American cost), profits in all three periods would have been negative. Nor would the substitution of American for British vessels have improved the situation much (panel B, column 2). At the same time, the owners of American whalers were earning pure profits of between 7.9 and 17.6 percent.

Second, given the actual levels of government support, profits in Great Britain were easily sufficient to command new investment until the mid-1830s. British whaling profits in the period 1817–25 fell into the 7 to 23 percent range, and these returns were in addition to implicit interest, computed at competitive

21. Oddly enough, loss rates would have been *higher* if U.S. hulls had been used in place of British hulls. *Losses* would have been lower with American hulls, but, since U.S. hulls were so much cheaper than British hulls, investment itself would have been lower and loss *rates* would have been higher.

rates. Between 1826 and 1835 earning rates were even higher. They almost certainly approached 30 and may have been over 50 percent.

After 1835, despite the continued protection afforded by the tariff, the British industry was in severe straits. Whatever the measure of vessel cost, profits were negative on average, and substantially so. Losses more than wiped out imputed interest. No wonder the industry contracted rapidly.

The analysis to this point has laid out the chief differences between the two fleets, but it has not systematically explored the roots of the poor performance of the British. There are data that allow the issues to be sorted out. The relatively high prices of the vessels that the British were forced to employ were partly to blame. In order to protect the domestic shipbuilding industry, Parliament prohibited the importation of foreign-built vessels in the Navigation Acts (repealed in 1849). A potential shipowner who wished to sail under the British flag and to enjoy the protection of both the navy and the tariff had to use a vessel that had been built in Great Britain or one of its colonies. When the American states ceased to be colonies, their vessels were included in the prohibition. Had the battle of the North Atlantic been fought thirty years later, British whalemen could have turned to Canadian shipyards for vessels that were as good as their American counterparts and sold for even lower prices; in the 1830s and 1840s the Canadian shipbuilding industry was still in its infancy—capable of exporting fewer than one hundred poor-quality vessels a year. (In 1860, or even in 1850—when they could have turned to American shipyards—there were few whaling entrepreneurs left in either England or Scotland.[22])

Even if British owners had been able to use American-built vessels while continuing to sell their oil in the protected domestic market, it is unlikely that the industry would have remained economically viable after the mid-1830s. Using American-built vessels would have yielded positive profits in 1817–25 and 1826–35, but over the last seven years (1836–42) not even that would have made British whaling profitable.

A complete substitution of American for British vessels would not have

22. The anti-American prohibition was contained in 26 Geo. III c. 60, an extension of the Navigation Acts that dealt with the registration of vessels from the "now American colonies." The law was finally repealed in 1849. See Hutchins 1941, 175.

During the years in question the Canadian industry was not in a position to meet the demands of the whaling industry. Its "vessels, which in model resembled the American cargo ships, were generally constructed at first of relatively poor hardwoods, and later of Canadian spruce, which timbers were often used unseasoned, were frequently of light scantling [the dimensions of timber in breadth and depth], and were commonly poorly fitted and fastened." The Canadian vessels were, however, inexpensive. In 1840 they sold for about three-fourths as much as those built in the yards south of the border. By 1860 the industry had expanded, quality had improved, and relative prices had fallen. Canadian shipyards had become a force to be reckoned with in world shipbuilding (Hutchins 1941, 300–301).

Although there were still nearly forty vessels employed in the northern fishery during the early 1860s (the average for 1861–64 was thirty-eight), most of their activity was directed toward hunting seals rather than whales. Over the decade 1848–57, for example, those vessels brought back on average 111 whales a year. At the same time they were returning 95,927 seals. The seals were valued for both oil and fur (Jackson 1978, 145–46).

saved the industry had there been no bounty and had British whalemen been forced to compete with Americans in the British domestic market. Selling at American output prices, they would rarely have been able even to cover imputed interest on investment.

It seems that Fairburn is correct: British whaling was a creature of war and government policy. Before the Boston Tea Party, the New England colonies supplied four-fifths of the whale oil sold in the British market (Jackson 1978, 66). Early in 1783 British owners were faced by Yankee whalers in the Thames, "with full cargoes of oil of excellent quality . . . offered below the prevailing London price" (Fairburn 1945–55, 2:996). Given the industry's history, the Yankees should not have been surprised that their attempt to penetrate the British domestic market was met by the government's imposing a prohibitive tariff on whale oil and by one more formal attempt to induce Nantucket whalemen to shift their base of operations to Great Britain. In a free market the advantage goes to the low-cost, efficient producer, but how many markets are free? In a market that is not free, the advantage goes to the producer with the most political clout. In the 1780s the political position of British whalemen and whale oil merchants was strong (they had, after all, no domestic competitors), and was reinforced by the international situation. A militarily strong France lay across the Channel, and it was obvious to all that the Royal Navy was the island nation's first line of defense.

For an industry long dependent on the good offices of the government, it is not surprising that the absolute and relative decline in the profitability of British whaling can, in part, be traced to changes in government policy, but this is not the only explanation. The two economies—Great Britain and the United States—developed at different rates and in somewhat different directions, with implications for the relative profitability of the two whaling fleets—at least in the short term.

On the one hand, government policy did change, and with it profits. In 1824 the government, bowing to free-trade sentiment and pressure from the manufacturing sector, broke with half a century of tradition and refused to renew the tonnage bounty. One historian has maintained that its value was "[s]o slight . . . that its passing was hardly noticed," but the bounty had accounted for between one-fifth and one-fourth of the industry's profits over the nine preceding years (Jackson 1978, 119).

Similarly, although the tariff on whale oil remained high until 1843, the impost on the importation of some substitutes was cut sharply at an earlier date. Take the case of rapeseed oil. Wool is cleansed with oil before it is spun. Ideally, a manufacturer would use oil made from the seed of the rape plant, but whale oil could be substituted in producing cheaper cloth.[23] The price of whale

23. Jackson 1978, 55. Jackson's evidence is from the testimony of Jervis Walker before the Select Committee to Examine into the Policy of Imposing an Increased Duty on the Import of Foreign Seeds in 1816. Rape is an Old World annual (*Brassica napus*) akin to the turnip.

oil—even after the duty had been paid—was much less than the tariff-inflated price of rapeseed oil, and industrial demand was substantial. Between 1816 and 1820 political efforts by owners of whalers and whale oil merchants were directed to holding the price of rapeseed oil above £50 a ton. Between 1822 and 1827 the duty on rapeseed was gradually cut from £1 to 1 shilling (from $4.54 to $0.24) a quarter. Over the same period, imports of seed rose by 650 percent (Jackson 1978, 120–21).

On the other hand, government policy is not totally exogenous. In the United States, demand for whale oil declined after camphene, coal oil, kerosene, and manufactured gas became available. These products, however, did not reach the American market in significant quantities until after midcentury. In Great Britain the first coal gas company was chartered in London in 1782, and by 1820 gasworks had been built in many of the larger towns. Despite major explosions in London, Edinburgh, and Manchester, by 1823 "the superiority and convenience of gas was . . . beyond dispute." In London alone, the forty-seven gasometers had a capacity of 917,000 cubic feet.[24] The substitution of gas for whale oil had gone so far that in the 1820s whale oil merchants, in an attempt to regain their lost market share, began to manufacture gas from whale oil. This was technically feasible; the enterprise foundered because of the relatively high price of whale oil.

The British and American responses to new technologies raise an important, but little understood, issue about the long-run effects of government policy. Why did the Americans lag in the innovation of whale oil substitutes? How much of the lag can be attributed to differences in the structures of the two economies (the degree of urbanization, for example), and how much to differences in the relative prices of whale oil and coal, reflecting the high British tariff on whale oil?

Given that it was saddled with a cost structure that made it noncompetitive in the international market, no tariff or bounty within reason could have supported the British industry in the face of an almost complete dearth of domestic demand. It is not surprising that, when in 1843 Her Majesty's government reduced the tariff on whale oil from $0.72 to $0.16 a gallon, the effect was felt by only twenty-five shipowners and hardly more than one thousand seamen.[25]

12.4 Conclusions

At the end of the Napoleonic wars, British whalemen enjoyed a near monopoly of the fishery. The Dutch had turned to other maritime pursuits, the Royal

24. Jackson 1978, 123. Jackson's source is the testimony of Humphrey David before the Select Committee on Gas Light Establishments in 1823.

25. Jackson 1978, 121, 129. In 1843 the duty on whale oil was reduced from £27 18s 7d per tun to £6 6s. In 1843 there were twenty-five ships with 1,146 men engaged in the northern fishery, but in the two previous years the numbers had been nineteen and eighteen vessels, with 897 and 830 men, respectively.

Navy had eliminated American competition, and government subsidies had increased revenues. British whaling was profitable. After Yorktown, tariffs had replaced naval squadrons as barriers to foreign competition in the British domestic market, and during the Napoleonic wars the Royal Navy, charged with isolating Europe, provided de facto protection in most of the rest of the markets in the developed world. In 1814 almost two hundred British whalers hunted in the northern and southern fisheries; fewer than five American whaling vessels were active.

Twenty-seven years later the American fleet was almost seven hundred vessels, the British, thirty-four. With equal access to the stock of natural resources and to the menu of alternative technologies, the two fleets had met in head-to-head competition in the waters off Greenland and in Davis Strait. In the study of the relationships among productivity, policy, and economic change, the microcosm that was the northern fishery is a nearly ideal historical laboratory. What factors explain the shift in industrial leadership from the Old World to the New? Was it rooted in emerging differences in underlying productivity, to differences in input or output prices, or to changes in the economic environment?

The evidence indicates that all three factors contributed. On average, American productivity was higher than British, but it was probably not enough higher to account fully for the observed differences in profitability, even in the years 1836–42, when the productivity gap was very wide. Still, it is comforting to note that the productivity and profit estimates move in parallel. British profit rates did fall drastically, as British relative productivity fell.

The British were less productive, and they ultimately became substantially less profitable. In the middle decade (1826–35) the productivity difference narrowed, and the British whalers proved themselves to be more profitable than their American competitors. If in that period the British had been able to operate in the protected domestic market but had been permitted to employ American-built vessels, they would, on average, have earned very much more than their Nantucket and New Bedford peers. Other "it might have been" estimates, however, indicate that, despite the profits that could have been earned if only the world had been different, low British productivity had important implications for the industry's long-term survival. Even American-built vessels would not have saved the British whaling fleet, had the owners been forced to face American competition in the domestic market for whale oil and baleen.

Higher wages and vessel costs depressed British profits, but they do not account for the measured productivity gap. The question remains, why, if larger crews and shorter voyages were both unproductive and unprofitable, didn't British owners and captains adjust to the superior American technology? That they did not adjust suggests that, in the British economic environment, American technology was not superior.

The answer may lie in the quality of British crews. The literature is replete with horror stories about the sailors who manned those vessels. Jackson (1978, 72–73), writing about the northern fishery during the period of its most rapid growth, has little good to say about the British decision "to recruit 'Greenmen', a term which had nothing to do with Greenland, but indicated that they were new to the job—and therefore cheaper. . . . [T]he *Robert* of Peterhead . . . in 1795 had only two 'sailors' among its crew of twenty-three. The final stage . . . came when even the cheapest native crews were swelled by half-starved wretches picked up for a song in the Shetlands."

Nor does the quality of the crews seem to have improved over time. An owner appearing before a parliamentary select committee testified that British seamen, who had been, in his words, "the best sailors in the world" in 1801 were in 1844 "the worst description."[26] It should be noted that 1801 was only six years after the crews had been "swelled by half-starved wretches." Meanwhile, American "crews, bred in the trade and enthusiastic in their pursuit of it, were said to be better whalermen than the British" (Jackson 1978, 141).

Although it is difficult to sort out cause and effect, crew quality may have affected productivity not only directly but also indirectly through voyage length. British vessels usually carried a carpenter and perhaps his mate, and a cooper, but few other artisans (Jenkins 1921, 189). American vessels carried a wide range of skilled workmen, including painters, boatmakers, and even machinists. The British had to depend on shore-based workmen for the bulk of their refitting and repair. The Americans were able to effect maintenance and repair during the voyage itself; in fact, these were primary activities on American vessels during the winter when weather and ice pushed vessels southward. Without thoroughly revamping their staffing policies, it would have been impossible for British owners to adopt American cruising schedules.

And there was no economic reason for the British to revamp. It was not intransigence that led them to eschew long voyages. With the bounty payment tied to voyages, innovation of the American institutional technology would have been costly. The bounty did disappear in the mid-1820s, but given the lags inherent in any structural innovation (recruiting and training artisans and altering the duties of officers and other crewmen would take time), the industry might well have been out of business before entrepreneurs could exploit the American institution. The same circumstances trapped British whalemen in the northern seas, despite the growing scarcity of whales.

The evidence indicates that, by American standards, British whalers after 1835 were neither productive nor profitable. Bounties and warships enabled the British both to replace the Dutch and, supported by a series of protective tariffs, to fend off incipient American competition. British dominance was rooted, not in economic superiority, but in government policy.

Such policies are not immutable. To the extent that they work by distorting

26. Jackson 1978, 135. The quoted remarks are from the testimony of Joseph Somes, a Londoner who owned three whalers engaged in the southern fishery. Whitecar (1864, 122, 123) has very critical things to say about British crews and officers in the southern fleet in the 1850s.

relative prices, they induce substitution against the protected commodities. Competition springs up everywhere, and is almost impossible to restrain. In a technical sense coal oil may have been an inferior substitute for whale oil; in an economic sense it was a more than adequate substitute at the tariff-inflated domestic price of whale oil.

Again, policy frequently derives from some noneconomic argument in the government's utility function; the weights assigned to the argument can, and do, change with conditions—social, political, and economic. As long as a Continental war was a serious threat, the British government was prepared to pay (or let its citizens pay) handsomely for a ready supply of ships and seamen. As the threat of war receded, the political revenues of the policy receded as well, but the political costs in taxes, forgone alternatives, and consumer discontent remained high. The policy became politically unprofitable.

Finally, the distribution of political influence is not fixed. Whalemen and oil merchants were forces to be reckoned with in the eighteenth century; fifty years later textile manufacturers and merchants commanded the government's attention.

As the British industry contracted, the American expanded. Fewer British vessels meant less crowding in the North Atlantic, and reduced British tariffs meant a larger export market. American entrepreneurs—New Bedford owners and agents in particular—secured a commanding position in all the whaling grounds of the world.

Appendix 12A

Computing the Relative Productivities of the British Northern and the American (New Bedford) Atlantic Whaling Fleets

Three variants of productivity were calculated: variant S (time at sea), variant M (maximum inputs), and variant L (most likely). For the American fleet the M and L variants are identical. See the text for a full account of these variants.

Productivity Formula

The formula for calculating the productivity of an individual voyage is described in chapter 8. Only American voyages can be analyzed in this way; data on individual British voyages are not available. In order to compare the two fleets, computations must be made at a fleet level, treating all of a fleet's voyages in one year as one grand voyage. The formula for doing so can be broken into four parts.

1. (The share of oil in the value of output of the given fleet [i.e., British or American] in the given year, plus the mean of the shares of oil in the value of

output of both fleets across all years) times (the natural log of the output of oil of the given fleet in the given year, minus the mean of the natural logs of the outputs of oil in both fleets in all years).

2. Part 2 is identical to part 1, except that the word *bone* is substituted for *oil,* wherever *oil* appears.

3. (The share of labor income in the value of output of the given fleet in the given year, plus the mean of the shares of labor income in the values of output of both fleets in all years) times (the natural log of the labor input into production [number of crewmen] in the given fleet in the given year, minus the mean of the natural logs of the labor inputs in both fleets in all years).

4. Part 4 is identical to part 3, except that the word *capital* is substituted for *labor,* wherever *labor* appears. (Capital input into production is represented by tonnage.)

Labor is measured in man-months (the number of the vessel's crewmen times the number of months of the voyage), capital, in vessel ton-months (the number of the vessel's tons times the number of months). Labor income equals the value of lays (American), or wages (British), plus subsistence. The productivity of a given fleet in a given year equals

$$((\text{Part 1} + \text{Part 2})/2) - ((\text{Part 3} + \text{Part 4})/2).$$

The resulting productivity measurements are expressed in natural logs. They may also be given in the form of the antilogs, and that is the form underlying the figures in table 12.1. Comparisons may properly be drawn within each fleet, across time, or between fleets.

Data Sources: United States

The American data were taken from the Voyages and Crew Counts data sets (see chapter 3). In order to enter the calculation, a voyage had to sail for the Atlantic Ocean, Hudson Bay, or Davis Strait; sail from and return to New Bedford; return between 1817 and 1842; and carry home a ratio of sperm oil to whale oil of no more than 0.25. In addition we had to know the size of its crew, its tonnage, and the length of its voyage. Two hundred and eighty-one voyages met these conditions. (Since each voyage was allocated to the year in which the vessel returned to New Bedford, the calculation omits voyages that resulted in the condemnation, loss, or sale of the vessel before it could return to New Bedford. See the text for a further treatment of this topic.)

Shares of Labor and Capital Income in the Value of Output. The amount of income flowing to labor was computed for each voyage as the sum of the value of the crew's lay shares and the cost of their subsistence. The value of lays was taken to be 31 percent of the value of the catch (see the text, table 5.15, and appendix 9A). The cost of subsistence depends on the size of the crew. In 1844 it cost $35 a year to feed one whaling crewman (see appendix 5C). The algorithm for subsistence is thus $35 times the food price index[27] times the number of men in the crew times the length of the voyage in years.

Lay value and subsistence amount were summed at the voyage level. These total labor income amounts, and the per-voyage value of catch amounts, were then summed by arrival year. The ratio between them is labor's share of output, and the remainder is capital's share (see table 12A.1).

Data Sources: Britain

Oil Outputs. Tuns of oil were taken from Gordon Jackson (1978, 270).[28] See table 12A.2. A *tun* was an old British measure approximately equal to 252 British gallons (169 n. 18). The British gallon was equal to 1.20095 American gallons. The American barrel—the unit in which our American oil figures were generally reported—was equal to 31.5 American gallons. In order to convert British tuns to American gallons, then, we multiplied Jackson's oil catch figures by (252 × 1.20095)/31.5, or 9.608.

Oil Prices. British oil prices (per tun) were taken from J. R. McCulloch 1842, 162; 1854, 1404. Between his two volumes McCulloch gives a complete series of prices for the southern fishery for the years 1817–42. His prices for the northern fishery, present only in the 1854 edition, are not a complete series. Where the southern and northern prices are both present, they are almost always identical (and we see no reason why they should in fact have differed). In those few cases where the southern and northern prices differ in McCulloch, we have used the price that seems more reasonable: for 1825–26 the southern price, for 1840–42 the northern price.

Bone Outputs. Tons of bone for 1817–34 and 1837–41 come from Gordon Jackson 1978, 270. Tons of bone for 1835 and 1836 were estimated on the basis of the output of oil in these years and the ratio (.0533) of tons of bone to tuns of oil, 1831–34 and 1837–39, for the British fleet. The output of bone for 1842 was estimated in the same way as the outputs for 1835–36, except that the estimating ratio (.0340) was computed on the basis of bone output to oil output in 1840 and 1841.

American bone output was reported in pounds. In the nineteenth century the British used the short ton of two thousand pounds (McCulloch 1842, 1165). We multiplied British bone figures by two thousand to make them equivalent to American figures.

27. Warren and Pearson "Foods" wholesale price index (U.S. Department of Commerce 1975, series E-54), divided by seventy-two (the 1844 value), so that 1844 = 1.0.

28. Jackson gives as his source McCulloch 1854, 1:642, and notes one change he made to McCulloch's figures.

Table 12A.1 **Shares of Labor Income and Capital Income in the Value of Output, American (New Bedford) Atlantic Fleet, 1817–42**

Year	Labor	Capital	Year	Labor	Capital
1817	.3860	.6140	1830	.3533	.6467
1818	.3715	.6285	1831	.3670	.6330
1819	.3828	.6172	1832	.3753	.6247
1820	.3713	.6287	1833	.3771	.6229
1821	.3495	.6505	1834	.3890	.6110
1822	.3742	.6258	1835	.3865	.6135
1823	.3913	.6087	1836	.3924	.6076
1824	.3619	.6381	1837	.4001	.5999
1825	.3552	.6448	1838	.4121	.5879
1826	.3541	.6459	1839	.4174	.5826
1827	.3568	.6432	1840	.3933	.6067
1828	.3673	.6327	1841	.3599	.6401
1829	.3785	.6215	1842	.3947	.6053

Sources: For a description of the data sources and computation, see the text.

Table 12A.2 **Data on the British Northern Whaling Fleet, 1817–42**

Year	Oil (tuns)	Oil Price (£ per tun)	Oil Value (£)	Bone (tons)	Bone Price (£ per ton)	Bone Value (£)	Tonnage Setting Out	Tonnage Returning	Crewmen Returning
1817	10,871	30	326,130	539	80	43,120	48,084	46,481	6,156
1818	14,482	36	521,352	666	80	53,280	50,362	49,720	6,516
1819	11,401	33	376,233	517	80	41,360	51,082	47,227	6,589
1820	18,745	30	562,350	946	80	75,680	50,546	49,592	6,749
1821	16,853	19	320,207	923	80	73,840	50,709	46,244	6,261
1822	8,663	22	190,586	422	185	78,070	38,144	35,622	4,883
1823	17,074	21	358,554	921	185	170,385	36,759	35,816	4,744
1824	9,871	22	217,162	534	185	98,790	35,013	34,698	4,798
1825	6,370	36	229,320	350	210	73,500	34,751	33,171	4,604
1826	7,200	34	244,800	400	220	88,000	30,414	28,813	3,999
1827	13,186	27	356,022	733	243	178,119	28,273	27,952	3,880
1828	13,966	25	349,150	802	331	265,462	28,665	27,740	3,856
1829	10,672	27	288,144	608	325	197,600	28,812	27,517	3,836
1830	2,199	43	94,557	119	255	30,345	29,396	23,258	3,143
1831	5,104	43	219,472	273	213	58,149	28,608	27,633	4,020
1832	12,610	28	353,080	676	159	107,484	26,393	24,764	3,510
1833	14,508	25	362,700	802	156	125,112	25,294	24,966	3,553
1834	8,214	23	188,922	442	247	109,174	24,955	23,970	3,440
1835	2,623	28	73,444	140	242	33,880	23,482	21,498	3,115
1836	707	32	22,624	38	282	10,716	20,183	19,521	2,858
1837	1,356	35	47,460	65	221	14,365	16,789	16,153	2,392
1838	4,345	25	108,625	236	210	49,560	11,809	11,506	1,727
1839	1,441	25	36,025	79	192	15,168	12,530	12,530	1,907
1840	412	25	10,300	14	196	2,744	9,966	9,323	1,441
1841	647	31	20,057	22	198	4,356	5,742	5,742	897
1842	668	30	20,040	23	244	5,612	5,118	5,118	830

Sources: For a description of the data sources and computation, see the text.

Bone Prices. Bone prices for 1817–21 and 1822–24 are available in Jackson (1978, 118).[29] We divided the 1824 British price by the 1824 American price, and multiplied each succeeding American price by this ratio in order to extrapolate missing British prices.

Tonnages Setting Out. Knowing the size of the fleet that set out in each year is necessary to compute the size of the fleet that returned. The tonnages of vessels setting out in the northern fleet in 1817–34 were taken from Jackson 1978, 270, in 1841–42 from British Parliamentary Papers (House of Commons 1845). Tonnages for 1835–40, missing in these sources, were estimated by a regression on numbers of vessels and total tonnages for the years 1816–34 and 1841–42. The data on numbers of vessels were taken from Jackson 1978, 270. (The number of vessels sailing in a year is the sum of the number sailing for Greenland and the number sailing for Davis Strait.) The estimation equation is

$$\underset{}{\text{Tons}} = \underset{(-1.0)}{-360.86} + \underset{(+32.5)}{359.64\ VG} + \underset{(+20.8)}{276.78\ VD} - \underset{(-2.5)}{1.594\ YRVG} + \underset{(+3.4)}{1.715\ YRVD}$$

where VG is the number of vessels sailing for Greenland, VD is the number of vessels sailing for Davis Strait, $YRVG$ is $YEAR \times VG$, and $YRVD$ is $YEAR \times VD$. ($YEAR$ is the year in question minus 1800.) The figures in parentheses above are t values. The adjusted R^2 is .9993 and the F value is 7,561.9.

Tonnages Returning. Productivity is figured only for vessels that returned safely to port. The number of vessels sailing and the number lost in each year 1817–42 are given in Jackson 1978, 270. Dividing the initial tonnage by the number of vessels sailing gives tons per vessel. Subtracting the number of vessels lost from the number sailing gives the number returning. Multiplying the tons per vessel by the number returning gives the tonnage returning. (We assumed that, on average, a vessel lost had the same tonnage as a vessel setting out.)

Crewmen Returning. Jackson (1978, 129) reprints from British Parliamentary Papers total tonnage and crew figures for the years 1830–32 and 1841–42.[30] McCulloch (1842, 1241) prints total tonnage and crew figures for the years 1817–24. We calculated crewmen per ton using Jackson and McCulloch, and estimated ratios for 1825–29 and 1833–40 by interpolation. (There is no clear trend in the ratios for 1817–24 and 1830–32; therefore, we used as the interpolator for the years 1825–29 the mean ratio for 1822–24 and 1830–31. There is a clear trend thereafter. We estimated the ratios for 1833–39 on the assumption that the ratio rose at a steady pace between 1832 and 1840.) Multiplying crewmen per ton by returning tonnage gives returning crewmen.

29. Jackson used local prices at Hull.
30. These tonnage figures don't precisely match those Jackson prints on page 270.

Shares of Labor and Capital Income in the Value of Output. The share of income flowing to labor was 34.1 percent in 1817–25, 28.2 percent in 1826–35, and 61.8 percent in 1836–42. (See appendix 12B for a description of the data sources and computations. These shares can be computed from table 12B.3, lines 3, 7, and 8, as [line 3 + line 8]/line 7.) The share flowing to capital in each period was the remainder, or 65.9, 71.8, and 38.2 percent.

Appendix 12B

Computing Profit Rates for the British Northern and the American (New Bedford) Atlantic Whaling Fleets

Table 12B.1 Computation of Average Profit Rates, American (New Bedford) Atlantic Fleet, Returning Years 1817–42

A. Computation of Average Values per Ton as of Sailing Dates, 1880 Prices ($)

	Hull[a]	Outfit[b]	Subsistence[c]	Total Investment (hull + outfit + subsistence)
1817–25	40.66	18.89	3.74	63.29
1826–35	45.10	18.20	3.84	67.14
1836–42	44.73	24.36	6.56	75.65

B. Computation of Average Values per Ton of Hulls on the Return to New Bedford ($)

	Hull[a]	Depreciation[d]	Net Value of Hull (hull − depreciation)
1817–25	40.66	1.41	39.25
1826–35	45.10	1.56	43.54
1836–42	44.73	2.24	42.49

C. Computation of Average Net Revenues per Ton ($)

	Gross Revenue[e]	Lays[f]	Vessels Lost[g]	Interest Forgone[h]	Net Revenue[i]
1817–25	59.28	18.38	0.88	3.71	36.31
1826–35	63.49	19.68	2.08	3.87	37.86
1836–42	77.38	23.99	3.14	6.63	43.62

Table 12.B1 (continued)

	D. Computation of Average Profit Rates ($)				
	Net Value of Hull on Return	Net Revenue	Total Net Return (net hull + revenue)	Original Investment (from panel A)	Profit Rate[j] (%)
1817–25	39.25	36.31	75.56	63.29	16.17
1826–35	43.54	37.86	81.40	67.14	17.59
1836–42	42.49	43.62	86.11	75.65	7.86

Note: All monetary values are in 1880 prices. The deflator is the Warren and Pearson "All Commodities" wholesale price index (U.S. Department of Commerce 1975, series E-52). Values were adjusted to the 1880 level by dividing them by these index numbers (divided by one hundred).

[a]The value of a vessel at the beginning of the voyage was computed by multiplying its TONNAGE by BCOSTCN for SAILYR. These values and tonnages were summed up for 75 voyages arriving in the years 1817–25, 161 voyages arriving in 1826–35, and 74 voyages arriving in 1836–42. The sum of values was divided by the sum of tonnages. (For BCOSTCN—building cost per ton according to the Commissioner of Navigation, in 1880 prices—see chapter 6 and table 6.10.) Both the British and the American vessels were valued at new prices for purposes of these calculations, since we have no information on the market values of these vessels.

[b]The outfitting cost for each voyage was computed from the OPTM1880 value for the year in which the voyage began, times the vessel's TONNAGE, times the INTERVAL of the voyage. (INTERVAL is the length of the voyage in calendar months.) These costs were summed up within each period and the sum divided by the corresponding sum of vessel tonnages.

OPTM1880 represents complete outfitting costs for the whole voyage, exclusive of costs of provisioning and costs of outfitting the men. The outfitting cost per ton month, in prices of 1880, was computed as follows:

1. The costs of outfitting the *Callao* in 1871 and provisioning the bark during the voyage she began in that year were computed from data reported in Moment 1957. (This is an exceptionally clear and detailed accounting of outfitting costs.) Moment (271) reports total debits for outfitting the vessel of $33,472. He (272) reports that the captain spent $1,900 on provisions during the voyage. $33,472 + $1,900 = $35,372.

2. The value of subsistence and the value of advances were subtracted. We figured subsistence as $35 per year per crew member, in 1844 prices (see appendix 5C), times 33 crew members times 50/12 (the voyage lasted fifty months). In order to convert to 1871 prices, we multiplied by 1.80556—the ratio of the Warren and Pearson "Foods" index number for 1871 (130) to the index number for 1844 (72)—yielding $8,689. Of the amount that Moment reports as outfitting costs, $3,788 was charged to the crew (i.e., advances). $35,372 − $8,689 − $3,788 = $22,895.

3. This figure was divided by the tonnage of the *Callao* times the INTERVAL of her 1871 voyage. $22,895/(323.7 tons × 50 months = 16,185) = $1.41458, or $1.415.

4. This figure, in turn, was carried to other years on the Warren and Pearson "Textile Products" wholesale price index (U.S. Department of Commerce 1975, series E-56). (The idea is that outfitting costs fluctuated, roughly, with textiles [sails] prices.)

5. These numbers were then deflated using the Warren and Pearson "All Commodities" wholesale price index.

[c]Subsistence was calculated by multiplying the number of men in the vessel's crew for the voyage by $35 (subsistence per man-year in 1844 prices; see appendix 5C), the result multiplied by the ratio of the Warren and Pearson "Foods" wholesale price index number for the year in which the voyage began to the index number for 1844, the result multiplied by INTERVAL/12, the result divided by the Warren and Pearson "All Commodities" index for the beginning year (divided by one hundred). The resulting subsistence amounts and the tonnages of the vessels were summed up for 67 voyages arriving in the years 1817–25, 143 voyages arriving in 1826–35, and 71 voyages arriving in 1836–42. (Fewer voyages enter this calculation than entered the calculation of hull

(continued)

Table 12.B1 (continued)

values because here it is necessary to know also the size of the crew.) The sum of subsistences was divided by the sum of voyage tonnages.

[d]Assuming a life of thirty-four years (the average actual life of those vessels that lived to be condemned), depreciation is .02924 per year. The period over which depreciation was taken was the period at sea *plus* the period of outfitting. See table 12B.2.

[e]The value of the catch of each voyage was computed by multiplying the amount of sperm oil returned by the price of sperm oil in the year the voyage ended, multiplying the amount of whale oil by the price of whale oil, multiplying the amount of bone by the price of bone, adding up these three elements of value, and dividing the sum by the Warren and Pearson "All Commodities" index (divided by one hundred). These per-voyage value-of-catch amounts were summed up within each period and the sum divided by the corresponding sum of voyage tonnages. For catch prices see appendix 9A.

[f]The lay share was computed as 31 percent of the value of the catch (see chapter 5 and note e). Per-voyage lay shares were summed within each period and the sum divided by the corresponding sum of voyage tonnages.

[g]The total value of vessels lost within each period was divided among vessels returning to New Bedford, and expressed as a value per ton of vessels that returned safely to port. For example, five vessels that had set out from New Bedford for the Atlantic or Hudson Bay were lost in 1826–35. Assuming that they were equal in value per ton to the 161 vessels that returned to New Bedford from those hunting grounds in those years, the value of the lost vessels would be 5/161 of the value of the vessels that returned. If this value is distributed among returning vessels, the cost per ton of returning vessels is $2.08. One can think of these costs as insurance premiums.

	Lost	Returned	Fraction	Total Investment ($)	Cost per Ton ($)
1817–25	1	75	.013	63.29	0.82
1826–35	5	161	.031	67.14	2.08
1836–42	3	74	.041	75.65	3.10

The loss rate is overstated. The actual numbers of voyages that had set out for the Atlantic or Hudson Bay and returned safely to New Bedford during each period were 1817–25, 111; 1826–35, 236; 1835–42, 165. The number on which our rates were based are those that can be used in the computation of profit rates (i.e., we must know the length of the voyage and the amount of the catch to compute the profit rate) and that are comparable to the voyages of the British fleet (i.e., we have omitted voyages for which sperm oil accounted for 25 percent or more of the catch of oil). Because American loss rates are overstated, American profit rates are understated. Total investment figures are from table 12B.1, panel A.

[h]The interest rates we used are New England municipal bond yields, taken from Homer and Sylla 1991, 286–87: 1817–25 = 4.94 percent, 1826–35 = 4.84 percent, and 1836–42 = 5.02 percent. The period over which interest was forgone was the period of outfitting plus the period at sea. (See note d.) Thus the forgone interest should be computed as

$$1817\text{–}25: [(1.0494)^{1.1825} - 1] \times \$63.29 = .0586754 \times \$63.29 = \$3.71;$$
$$1826\text{–}35: [(1.0484)^{1.1867} - 1] \times \$67.14 = .0576924 \times \$67.14 = \$3.87;$$
$$1836\text{–}42: [(1.0502)^{1.7140} - 1] \times \$75.65 = .0875775 \times \$75.65 = \$6.63.$$

[i]Net revenue is gross revenue minus lays, vessels lost, and interest forgone.

[j]The profit rate was computed as $x = y(1 + r)^n$, where x = total net return, y = original investment, r = profit rate, and n = fraction of a year (see table 12B.2). This form of the computation is correct since most of the returns—virtually all, for the Atlantic—were realized at the end of the voyage.

Table 12B.2 **Depreciation Calculation for Hulls, New Bedford Whaling Voyages to the Atlantic and Hudson Bay, 1817–42**

	Interval[a]	Outfitting[b]	Total Months	Fraction of a Year	Depreciation per Ton[c]
1817–25	11.69	2.5	14.19	1.1825	1.41
1826–35	11.76	2.5	14.26	1.1867	1.56
1836–42	18.07	2.5	20.57	1.7140	2.24

[a]Mean values of INTERVAL (length of voyage in months) of the Atlantic voyages ending in these three periods.

[b]See table 6.7 and chapter 12, note 36.

[c].02924 × fraction of a year × hull (from table 12B.1).

Table 12B.3 **Computation of Average Profit Rates, British Northern Fleet, Returning Years 1817–42**

	A. True Profits ($), Variant A[a]		
	1817–25	1826–35	1836–42
1. Value of hull at sailing (U.S.)[b]	81.32	90.20	89.46
2. Value of outfits[c]	16.81	18.26	14.29
3. Cost of subsistence[d]	3.16	3.42	3.22
4. Total investment (1 + 2 + 3)	101.29	111.88	106.97
5. Depreciation[e]	1.53	1.85	1.70
6. Net value of hull on return to port (1 − 5)	79.79	88.35	87.76
7. Gross revenue[f]	44.89	70.93	20.27
8. Labor income[g]	12.16	16.58	9.30
9. Value of vessels lost[h]	4.31	6.59	2.87
10. Interest forgone[i]	2.33	2.74	2.29
11. Net revenue (7 − 8 − 9 − 10)	26.09	45.02	5.81
12. Total net return (6 + 11)	105.88	133.37	93.57
13. Profit rate (%)[j]	7.2	28.5	−18.6
	B. True Profits ($), Variant B[k]		
14. Value of hull at sailing (U.S.)[l]	60.99	67.65	67.10
15. Value of outfits[m]	12.60	13.70	10.72
16. Total investment (14 + 15 + 3)	76.75	84.77	81.04
17. Depreciation[e]	1.14	1.38	1.28
18. Net value of hull on return to port (14 − 17)	59.85	66.27	65.82
19. Value of vessels lost[h]	3.27	4.99	2.17
20. Interest forgone[i]	1.77	2.07	1.72
21. Net revenue (7 − 8 − 19 − 20)	27.69	47.29	7.08
22. Total net return (18 + 21)	87.54	113.56	72.90
23. Profit rate (%)[j]	22.8	51.8	−15.0

(continued)

Table 12B.3 (continued)

	C. Counterfactual Profits ($), Variant A[n]		
	1817–25	1826–35	1836–42
24. Gross revenue[o]	32.80	38.19	13.67
25. Net revenue (24 − 8 − 9 − 10)	15.16[p]	12.28	−0.79
26. Total net return (6 + 25)	94.95	100.63	86.97
27. Profit rate (%)[j]	−9.6	−14.0	−27.3
	D. Counterfactual Profits ($), Variant B[q]		
28. Net revenue (24 − 8 − 19 − 20)	16.76	14.55	0.48
29. Total net return (18 + 28)	76.61	80.82	66.30
30. Profit rate (%)[j]	−0.3	−6.6	−26.6
	E. Counterfactual Profits ($), Variant C[r]		
31. Value of hull at sailing (U.S.)	40.66	45.10	44.73
32. Total investment (3 + 15 + 31)	56.42	62.22	58.67
33. Depreciation[e]	0.76	0.92	0.85
34. Net value of hull on return to port (31 − 33)	39.90	44.18	43.88
35. Value of vessels lost[h]	2.40	3.66	1.56
36. Interest forgone[i]	1.30	1.52	1.24
37. Net revenue (24 − 8 − 35 − 36)	18.33	16.43	1.57
38. Total net return (34 + 37)	58.00	60.61	45.45
39. Profit rate (%)[j]	4.4	−3.7	−32.5

Note: All monetary values are per vessel ton, expressed in U.S. dollars of 1880.

[a]Variant A estimates rest on upper-bound estimates of the cost of British vessels and outfits.

[b]Average U.S. hull values per ton (table 12B.1) times 2.0. The estimate is intended as an upper bound, or close thereto. It is based on relative construction costs reported by Hutchins 1941, 202.

[c]British outfitting costs per ton were estimated on the basis of the U.S. estimates (see table 12B.1), on the assumptions that (1) they exceeded American costs, ceteris paribus, in the same proportion as British vessel construction costs per ton exceeded American vessel construction costs; and (2) they fell short of American costs, ceteris paribus, in the same proportion as British voyage lengths fell short of American voyage lengths. Thus

$$BOCPT = USOCPT \times BHCPT/USHCPT \times BVL/USVL,$$

where *BOCPT* is British outfitting costs per ton, *USOCPT* is U.S. outfitting costs per ton, *BHCPT* is British hull costs per ton, *USHCPT* is U.S. hull costs per ton, *BVL* is British voyage length, and *USVL* is U.S. voyage length. Thus

1817–25: $BOCPT = 18.89 \times 2.00 \times 5.2/11.69 = 16.81$;
1826–35: $BOCPT = 18.20 \times 2.00 \times 5.9/11.76 = 18.26$;
1836–42: $BOCPT = 24.36 \times 2.00 \times 5.3/18.07 = 14.29$.

The values for *BVL* are derived from Jackson 1978. We infer that Greenland voyages took about four and one-half months, and Davis Strait voyages about six months (78–81). Page 270 contains data on the number of voyages made to the two hunting grounds each year.

[d]These estimates are based on the assumption that British subsistence costs per man-year were the same as American costs. (See table 12B.1, note c.) In order to calculate British subsistence rates for this table, it was necessary to estimate the average tonnage and number of crewmen of the British northern fleet in each of the three periods represented, as well as the fraction of the year that British vessels were typically at sea. For the American calculation we used the Voyages and

Table 12B.3 (continued)

Crew Counts data sets. For the calculations of British tonnages and crews see appendix 12A. For the fraction of the year British vessels typically spent at sea, see note c.

[e]We assumed that British vessels had the same depreciation rate as American vessels—.02924 per year (see table 12B.2)—and here again figured depreciation on the period at sea *plus* the period of outfitting. (See table 12B.4.) To the extent that British whalers were unemployed when not whaling, these figures understate British depreciation. Depreciation for lines 17 and 33 use the same rate but different hull costs.

[f]Total revenues received by British shipowners, including earnings from the subsidy as well as tariff-inflated prices for whale oil and bone. See Davis, Gallman, and Hutchins 1987b, 753, table 2, panel C, "G.B.R1."

Appendix 12A describes the computation of British output volumes and values. Subsidies are available in McCulloch 1842, 1241. The pound-to-dollar exchange rate we used is derived from McCulloch 1842, 942. The conversion to constant dollars employed the Warren and Pearson "All Commodities" wholesale price index (U.S. Department of Commerce 1975, series E-52)—on the base 1880.

[g]See appendix 12C.

[h]The value of vessels lost is total investment times the fraction of the fleet lost. The fraction of the fleet lost was calculated from data in Jackson 1978, 270. Loss rates are the same in variants A and B.

[i]"Interest forgone" is the opportunity cost of the investments recorded in line 4. The interest rates were taken from Homer and Sylla 1991, 195–96, and are the annual yields on 3 percent consols: 1817–25 = 3.61 percent, 1826–35 = 3.51 percent, and 1836–42 = 3.31 percent. The period over which interest was forgone was the period of outfitting plus the period at sea. (See table 12B.5.) Thus the forgone interest should be computed

$$1817\text{–}25: \quad [(1.0361)^{.641667} - 1] \times \$101.29 = \$2.33;$$
$$1826\text{–}35: \quad [(1.0351)^{.7} - 1] \times \$111.88 = \$2.74;$$
$$1836\text{–}42: \quad [(1.0331)^{.65} - 1] \times \$106.97 = \$2.29.$$

Since the amount of investment per ton drops from variant A to B to C, so does the interest forgone.

[j]The profit rate was computed using $x = y(1 + r)^n$, where x = total net return, y = original investment, r = profit rate, and n = fraction of a year (see table 12B.4). This form of the computation is correct since most of the returns—virtually all, for the Atlantic—were realized at the end of the voyage.

[k]Variant B estimates rest on lower-bound estimates of the cost of British vessels and outfits.

[l]Average U.S. hull value per ton (table 12B.1) times 1.5. The estimate is intended as a lower bound. See note b.

[m]See note c. The formulas in this case are

$$1817\text{–}25: BOCPT = 18.89 \times 1.5 \times 5.2/11.69 = 12.60;$$
$$1826\text{–}35: BOCPT = 18.20 \times 1.5 \times 5.9/11.76 = 13.70;$$
$$1836\text{–}42: BOCPT = 24.36 \times 1.5 \times 5.3/18.07 = 10.72.$$

BOCPT is British outfitting costs per ton.

[n]These estimates rest on high (lines 1 and 2) vessel costs.

[o]Revenue figures *exclude* bounties and price inflation due to tariffs.

[p]Excluding bounties from labor payments.

[q]These estimates rest on low (lines 14 and 15) vessel costs. Revenue figures *exclude* bounties and price inflation due to tariffs.

[r]These estimates rest on U.S. hull costs and low (variant B) outfitting costs. Revenue figures *exclude* bounties and price inflation due to tariffs.

Table 12B.4 **Depreciation Calculation for British Vessels**

	Interval[a]	Outfitting[b]	Total Months	Fraction of a Year	Depreciation per Ton[c]
1817–25	5.2	2.5	7.7	.6417	1.53
1826–35	5.9	2.5	8.4	.7000	1.85
1836–42	5.3	2.5	7.8	.6500	1.70

[a]See table 12B.3, note c.

[b]The period to refit was assumed to be the same for the British as for the Americans.

[c].02924 × fraction of a year × hull (from table 12B.3).

Appendix 12C
Computing Labor Income for the British Northern Whaling Fleet

Crewmen on British whalers in the early nineteenth century received five types of payment: bounties (through 1824); bonuses for striking whales (paid to harpooners only), for killing whales, and for returning oil; and wages (Jenkins 1921, 189; see also Chatterton 1926, 53). Jenkins provides data on all of these types of payment, as of the late eighteenth century. We used his data to compute labor costs in British prices of the late eighteenth century, and converted them first to British prices of the nineteenth century and then to U.S. dollars of 1880. In questions of doubt we chose always the estimating decision that minimized labor costs and thus maximized profits and profit rates.

Estimates in Eighteenth-Century Prices

Since bounties, bonuses, and wage rates differed among ranks, we had to establish a typical crew roster before we could compute average per-voyage labor payments. The roster was derived from Jenkins and Chatterton, and consists of a captain, four mates, a specksioneer, six harpooners, a carpenter and his mate, two head-a-boats (called boatsteerers by Jenkins), six line managers, a surgeon, a cook, and twenty-four seamen. A crew of forty-four and an average vessel tonnage of 320 gives a ratio of tons per crewman (7.22) that is consistent with the data in table 12A.2.[31]

All payments were expressed in pence, for ease of computation. Table 12C.1 shows the detailed payment estimates. These rates were used to compute total labor costs per year.

31. Jackson 1978, 270. The mean vessel size for 1815–34, the only years for which Jackson has data, comes to just under 320 tons.

Table 12C.1 **Labor Payment Rates, British Northern Whaling Fleet, 1769–85 (pence)**

		Bonuses			
Crew Roster	Bounties per Voyage	Per Whale Taken	Per Strike	Per Ton of Oil Returned	Wages per Month
Captain	5,292	756	—	72	—
First mate	—	126	—	—	840
Second mate	—	126	—	—	480
Third mate	—	126	—	—	480
Fourth mate	—	126	—	—	480
Specksioneer	2,268	126	—	72	—
Harpooners	12,096	—	126	378	—
Carpenter	—	126	—	—	840
Carpenter's mate	—	60	—	—	600
Head-a-boats	—	120	—	—	960
Line managers	—	180	—	—	2,520
Surgeon	—	252	—	—	840
Cook	—	30	—	—	360
Seamen	—	660	—	—	8,782
Total	19,656	2,814	756[a]	522	17,182

Source: See text.

[a]We assumed there were six strikes for each whale taken (including strikes on whales that escaped).

Bounties. If the typical vessel was 320 tons, bounties per vessel ton came to 19,656d/320 = 61.4d. We multiplied tonnage returning in each year (table 12A.2) by this coefficient to obtain total bounty payments per year (see table 12C.2). (Bounties were suspended after 1824.)

Whale Bonuses. The number of whales taken each year (Jackson 1978, 270) was multiplied by the bonus rate (2,814 + 756 = 3,570, table 12C.1) to yield the annual total whale bonus payments (table 12C.2).

Oil Bonus. The bonus per ton of oil was 522d (table 12C.1). Our annual output data are expressed in tuns, not tons. Since tuns ran about 1,890 pounds, or 0.945 of a ton (2,000 pounds), the rate per tun would have been 522 × 0.945 = 493d (Jackson 1978, 169). (Jenkins's *ton* may actually be a *tun*. If so, our method of estimating understates costs and overstates profits.)

Wages. Table 12C.1 gives wages per vessel per month of 17,182d. Per voyage, then, wages were

$$1817\text{–}1825 = 17{,}182\text{d} \times 5.2 = 89{,}346\text{d},$$
$$1826\text{–}1835 = 17{,}182\text{d} \times 5.9 = 101{,}374\text{d},$$

Table 12C.2 British Labor Costs per Vessel Ton per Voyage

	A. Annual Figures								
		Late-Eighteenth-Century Pence							
Year	Tonnage Returning	Total Bounties	Total Whale Bonus	Total Oil Bonus	Total Wages	Total Labor Costs	Total Labor Costs, Current Pence	Total Labor Costs, Current $	Total Labor Costs, 1800 $
1817	46,481	2,853,933	2,955,960	5,359,403	12,977,495	24,146,791	32,839,635	643,914	426,433
1818	49,720	3,052,808	4,312,560	7,139,626	13,881,824	28,386,818	46,554,381	912,831	620,973
1819	47,227	2,899,738	3,527,160	5,620,693	13,185,778	25,233,369	37,850,053	742,158	593,726
1820	49,592	3,044,949	5,694,150	9,241,285	13,846,086	31,826,470	43,283,999	848,706	800,666
1821	46,244	2,839,382	5,015,850	8,308,529	12,911,324	29,075,085	25,004,573	490,286	480,673
1822	35,622	2,187,191	2,249,100	4,270,859	9,945,662	18,652,812	18,652,812	365,741	345,039
1823	35,816	2,199,102	7,204,260	8,417,482	9,999,827	27,820,671	26,429,637	518,228	503,134
1824	34,698	2,120,048	2,716,770	4,866,403	9,687,682	19,390,903	19,390,903	380,214	387,973
1825	33,171	—	1,785,000	3,140,410	9,261,343	14,186,753	23,266,274	456,201	442,914
1826	28,813	—	1,827,840	3,549,600	9,127,958	14,505,398	22,338,312	438,006	442,430
1827	27,952	—	4,148,340	6,500,698	8,855,194	19,504,232	23,990,205	470,396	479,996
1828	27,740	—	4,273,290	6,885,238	8,788,032	19,946,560	22,739,078	445,864	459,654
1829	27,517	—	3,109,470	5,261,296	8,717,386	17,088,152	21,018,426	412,126	429,298
1830	23,258	—	574,770	1,084,107	7,368,134	9,027,011	17,602,671	345,150	379,286
1831	27,633	—	1,610,070	2,516,272	8,754,134	12,880,476	25,116,928	492,489	523,924
1832	24,764	—	5,579,910	6,216,730	7,845,235	19,641,875	24,945,181	489,121	514,864
1833	24,966	—	6,051,150	7,152,444	7,909,229	21,112,823	24,068,618	471,934	496,773

1834	23,970	—	3,113,048	4,049,502	7,593,696	14,756,246	15,494,058	303,805	337,561
1835	21,498	—	596,190	1,293,139	6,810,566	8,699,895	11,048,866	216,644	216,644
1836	19,521	—	249,900	348,551	5,555,677	6,154,128	8,923,486	174,970	153,482
1837	16,153	—	435,540	668,508	4,597,144	5,701,192	9,064,895	177,743	154,559
1838	11,506	—	1,663,620	2,142,085	3,274,608	7,080,313	8,071,557	158,266	143,878
1839	12,530	—	410,550	710,413	3,566,038	4,687,001	5,343,181	104,768	93,543
1840	9,323	—	78,540	203,116	2,653,326	2,934,982	3,345,879	65,605	69,058
1841	5,742	—	185,640	318,971	1,634,173	2,138,784	3,015,685	59,131	64,273
1842	5,118	—	192,780	329,324	1,456,583	1,978,687	2,691,014	52,765	64,348

B. Sums

	Tonnage Returning	Labor Costs	Labor Costs per Ton per Voyage (1880 $)
1817–25	378,571	4,601,531	12.16
1826–35	258,111	4,280,430	16.58
1836–42	79,893	743,141	9.30

Source: See text.

Table 12C.3 **U.S. Price Index Numbers, Whale Oil (New Bedford) and All Commodities, 1817–42**

	Whale Oil (1769–85 = 100)	Warren and Pearson "All Commodities" (1880 = 100)
1817	136	151
1818	164	147
1819	150	125
1820	136	106
1821	86	102
1822	100	106
1823	95	103
1824	100	98
1825	164	103
1826	154	99
1827	123	98
1828	114	97
1829	123	96
1830	195	91
1831	195	94
1832	127	95
1833	114	95
1834	105	90
1835	127	100
1836	145	114
1837	159	115
1838	114	110
1839	114	112
1840	114	95
1841	141	92
1842	136	82

Source: See text.

and

$$1836\text{–}1842 = 17{,}182\text{d} \times 5.3 = 91{,}065\text{d}.$$

Dividing by 320 (the assumed average vessel size) yields wages per vessel ton per voyage of 1817–25, 279.2d; 1826–35, 316.8d; and 1836–42, 284.6d. Vessel tonnage returning each year (table 12A.2) was multiplied by the relevant wages-per-ton coefficient to yield total wage payments.

Estimates in Nineteenth-Century Prices

The total cost estimates in column 6 of table 12C.2 are based on late-eighteenth-century payment rates. We had to convert these figures into rates relevant to the period 1817–42, then to convert these values from sterling into dollars, and finally to deflate by the price index we have used throughout to denominate all values in U.S. dollars of 1880 (U.S. Department of Commerce 1975, series E-52).

Payment rates presumably changed in the long run more or less as the price of output changed. We therefore made up (table 12C.3) an index of whale oil prices on the base 1769–85 from data in table 12A.2 and Jackson (1978, 268). This index was used to convert our eighteenth-century estimates into nineteenth-century values. It should be said that annual wage-rate fluctuations are quite unlikely to mimic short-term movements in oil prices. Therefore, the annual data should not be understood to be true annual labor cost estimates. Wage rates and oil prices, however, are more likely to move in concert in the long run. Therefore, the average values for the years 1817–25, 1826–35, and 1836–42 are probably reasonable estimates of average labor costs. We used only these averages in our calculation of labor costs, profits, and profit rates.

In converting to dollars we used the exchange rate of $4.7059 to the pound, taken from McCulloch 1854, 942. There were 240 pence in a pound and therefore 51 pence in a dollar. Once costs were expressed in current dollars, we converted them to constant dollars on the basis of the Warren and Pearson "All Commodities" wholesale price index (U.S. Department of Commerce 1975, series E-52).