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## THE ESTABLISHMENT AND GROWTH OF IRON AND STEEL MAKING IN BETHLEHEM

THE TOWN OF BETHLEHEM, PENNSYLVANIA, was founded in 1741 by Count Zinzendorf, the leader of a group of Moravian settlers. By the mid-nineteenth century, the clearing they had made in the forest by the side of the Lehigh River had become a town of some three thousand people and a service and processing center for the surrounding agricultural area, with flour milling, brewing, tanning, saw milling, agricultural implement manufacturing, and so on. As late as spring 1852, C. H. Schwartz, traveling to Bethlehem from Doylestown, twenty miles to the south, was impressed by its unspoiled surroundings. Of the countryside south of the river he wrote, "Its richness was unsurpassed in my knowledge. The famous Saucon Valley was below me at one time, a veritable paradise."<sup>1</sup> In fact, well before then, bulk transport developments had begun to change the economy and character of the area. The Lehigh Canal had reached the southern edge of Bethlehem in 1829. The business expansion that followed was cut

short by the panic of 1837 and then by a general depression of trade until 1844. Local reaction to these threats to the traditional way of life of the town took a form that would shape its future distribution of industry and other urban functions. In 1847, the Moravian congregation sold a tract of land to C. A. Luckenbach. In this area, extending from the Lehigh toward South Mountain, were four large farms. Soon to be known as South Bethlehem, it would receive the larger-scale, nuisance-creating activities encouraged by the new transport facilities, while the old town largely retained its dignified ways. By 1855, the Lehigh Valley Railroad had more decisively altered the spatial relationships of the town, and development soon followed.

The first important manufacturing activity was zinc smelting, which drew on local calamine deposits. It led to bigger things, both in the scale of manufacturing and, much more importantly, in methods and in the entrepreneurial qualities it brought into the area. By 1854–1855, control of zinc mining and smelting operations had been incorporated in the Pennsylvania and Lehigh Zinc Company. This firm was managed by a Philadelphian and member of the Society of Friends who had received some chemical training and, as time was to prove, possessed great abilities in marketing, finance, and industrial promotion. At this time, Joseph Wharton was in his late twenties, a prototype of the new men who would transform the economy of the nation. He would be closely involved in the development of the lower Lehigh valley for half a century. When in the panic of 1857 the zinc company was forced into receivership, Wharton leased it, reconstructed it, and made it profitable. During that year, his commitments also extended into what would become a much bigger project.

During the 1850s, iron ore was discovered in the Saucon valley. An unsuccessful attempt was made to attract a government foundry to the area. Then, on 8 April 1857, the Saucona Iron Company was incorporated to build an anthracite iron works at Bethlehem, near the ore, and also favorably situated at the junction of the Lehigh Valley Railroad and the North Pennsylvania Railroad, the latter providing a link to Philadelphia. The initial idea came from a local merchant who had leased the Saucon ore beds: Augustus Wolle, one of the main investors in the Catsauqua Ironworks seven miles farther upriver. With two other local business leaders, C. Brodhead and C. W. Rauch, he was granted a charter for the new iron company. Wharton and Asa Packer of the Lehigh Valley Railroad Company were also involved. The promoters intended to make pig iron for sale. However, it was soon clear that they had chosen an

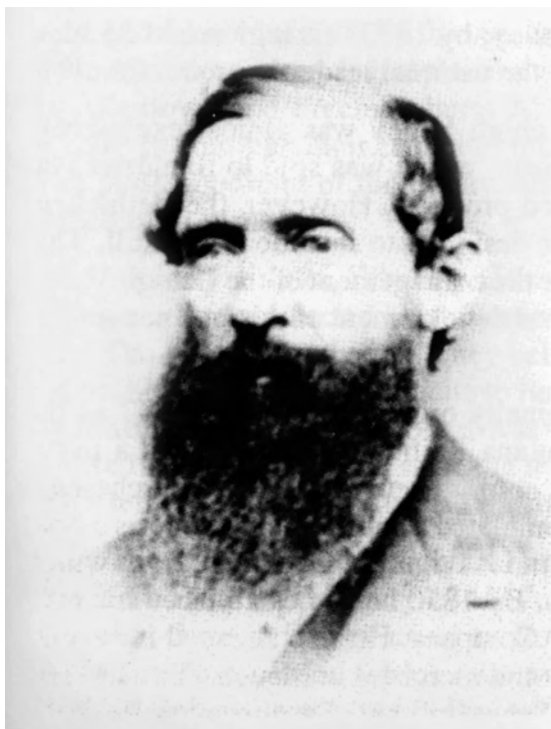
unpropitious time. The economic depression in 1857 that caused the failure of the zinc company also resulted in that year's production of anthracite iron falling 12 percent below the record level of the previous year. Output fell a further 7.5 percent in 1858. In such circumstances it proved impossible to sell sufficient stock in Saucona Iron, and the project fell into abeyance. As the iron trade recovered in 1859 and then surged on to new heights, the scheme was revived, but it now took a form different from that of the existing large iron works in the valley, a change mirrored in a new title: the Bethlehem Rolling Mills and Iron Company. Its first board, formed in June 1860, was again largely of local men, but with an admixture of regional railroad interests: Alfred Hunt of Philadelphia as president, with directors Asa Packer, who had first served the Lehigh Coal and Navigation Company and eventually was president of the Lehigh Valley Railroad, J. T. Johnston of the Central Railroad of New Jersey, John Knecht of Shimerville, and three Bethlehem men, Augustus Wolle, Charles W. Rauch, and their secretary, Charles B. Daniel.<sup>2</sup>

There seem to have been two reasons for adding finishing operations to the blast furnaces of the original scheme. One was to spread risks rather than be wholly dependent on sales of pig iron; the other, which gave this intention its particular shape, was the inclusion of a new promoter. Packer brought in as chief engineer and general superintendent a former civil engineer with the canal company, Robert Heysham Sayre. The LVRR had purchased rails from the Lackawanna Iron and Coal Company, but that company was associated with rival railroad interests and Sayre decided that his railroad needed a reliable alternate source of supply. He therefore pressed his fellow Bethlehem directors to install rolling mills. In spring 1861, another change of title created the Bethlehem Iron Company. Before this occurred, Sayre had made another vital contribution to Bethlehem Iron by securing for it the services of one of the outstanding men in the iron business.

After learning the trades of blacksmithing and machine work in the late 1830s, in 1846 twenty-four-year-old John Fritz worked on the construction of the new rolling mill in the iron works at Norristown. In 1849, he helped build a new iron plant and rail mill at Safe Harbor on the lower Susquehanna. Then, after a short time in a small foundry and machine shop at Catasauqua, he moved away from the anthracite iron district to western Pennsylvania, where he became general superintendent of the Johnstown works of the Cambria Iron Company, whose blast furnaces would use coke. There, in addition to molding the whole

Robert H. Sayre.

*Courtesy of the National Canal  
Museum, Easton, Pennsylvania.*

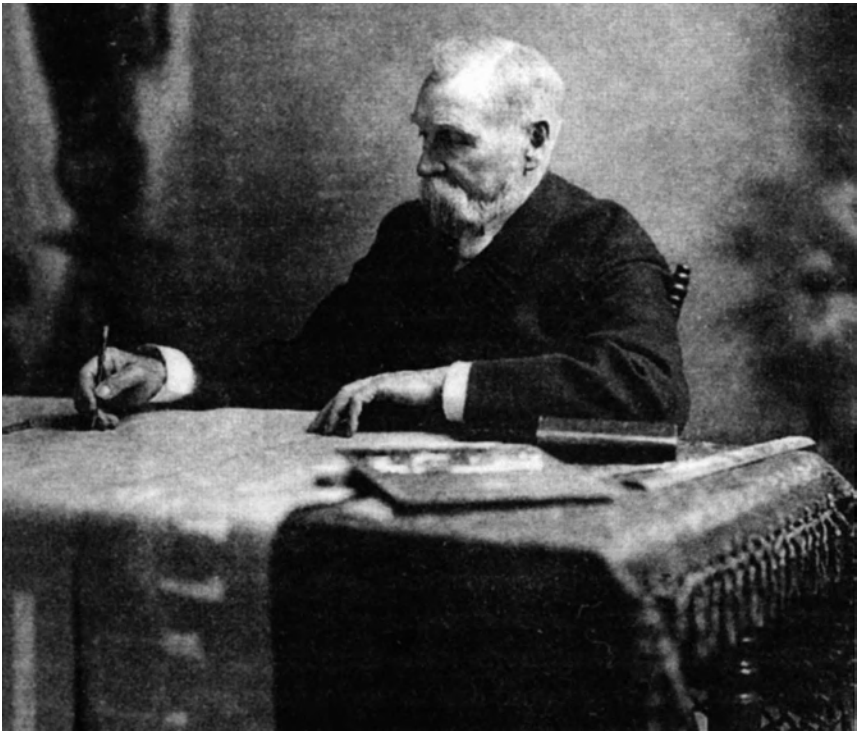


of a major plant into a viable operation, he demonstrated highly inventive abilities in pioneering the three-high rolling mill, which increased efficiency and reduced costs. Yet, despite successes as plant supervisor and technological innovator, his relations with the Cambria directors were far from harmonious. The latter provided an opportunity that Sayre proved adept at exploiting to the advantage of Bethlehem Iron. In spring 1860, he visited Fritz in Johnstown. Then on 1 May Sayre wrote to him. He explained that he could quite understand how Fritz might find it difficult to leave an establishment he was so identified with, but he believed that the Bethlehem area might suit him far better, and that a move would not affect his reputation: "You say truly that a man's merit is measured by his success." They could offer great opportunities: "The establishment of a good mill at this place producing a first rate quality of rails will establish your reputation in a section of the country that is destined to be in my opinion the most populous and wealthy in this or any other state. . . . I predict a growth for it that will surprise its most sanguine citizens." He mentioned that Rauch and Daniel concurred with Fritz that they needed sufficient capital to

purchase their machinery at cash prices and agreed that Fritz should have complete control: "I tell them that a rolling mill is like a man of war, it must have but one captain." Sayre ended on a persuasive note: "Hoping to have the pleasure of seeing you soon and of hearing you say that you are coming to dwell among us, I remain yours truly, Robert H. Sayre." Fritz arrived in Bethlehem on 5 July 1860, and two days later Augustus Wolle sent him the resolution made at a board meeting that day that appointed him superintendent and manager at a salary of four thousand dollars a year. In addition, on 1 July 1861 he would receive forty shares in the company and twenty more on 1 July for each of the three years after that. These shares were in exchange for his agreement to the free use of his patent for a three-high rail mill. It indicated that a vital decision had already been made that would differentiate the new Bethlehem Iron Company from its near neighbors and from the majority of those in the wider anthracite region. Wolle asked Fritz if he accepted the arrangements. He received a positive reply, and on 16 July 1860, only eleven days after Fritz arrived in the town, ground was broken for the plant that he would manage.<sup>3</sup>

The works of the Bethlehem Iron Company was built on the tract of land south of the Lehigh that the quiet Moravians of the old town had sold to Luckenbach thirteen years before. To ensure that their new operation would be the best possible, Sayre and Fritz visited many other eastern operations, paying particular attention to the Lackawanna rolling mill. But the outbreak of the Civil War nine months after construction began delayed work, and it was disrupted again by floods. As a result, the first blast furnace was not blown in until 4 January 1863. It marked an important new departure for the Lehigh valley as it was its first furnace to be plated in iron—a "shell furnace." The manufacture of wrought iron began on 27 July, and on Saturday, 26 September 1863, the mill rolled its first iron rails. Next year Bethlehem made 9,830 tons of pig iron, ranking it a poor eighth among Lehigh valley iron making establishments.<sup>4</sup> A second furnace was in operation by 1867, and a year later the company's absorption of the nearby Northampton Iron Company gave it a third one.

The Bethlehem Iron Company was soon busy supplying the railroads. Many of its outlets were either local or in eastern coastal and interior districts. For example, board minutes of 4 December 1864 recorded the sale of three hundred tons of rails to the Camden and Amboy Railroad at \$130 a ton and an order for one thousand tons of fifty-seven-pound rails from the Lehigh and Mahony at \$125.<sup>5</sup>



John C. Fritz c. 1900. *Courtesy of the Historic Bethlehem Partnership.*

Although its furnaces and rolling mills were of great importance in the locality, they were a small factor in the iron trade of the nation, which was already a highly competitive business. In 1864, Bethlehem's first full year of operation, there were thirty-eight rail mills in the United States, with a combined annual capacity of about 684,000 gross tons. Utilization of this capacity was low, for although at its highest level to date, rail output was only 283,000 tons. Imports accounted for 99,000 tons of rails. Not quite half of the domestically produced rails came from Pennsylvania mills: 40,000 tons from Cambria Iron, 22,000 from Lackawanna, and 20,000 from Pennsylvania Iron at Danville. The remaining 56,000 tons were supplied by a number of mills. Unfortunately, Bethlehem's figures for 1864 are not available, but the next year, an even better one, work over three summer months at its rail mill yielded 3,500 tons, which would be an annual rate of, at the most, 14,000 tons.<sup>6</sup> There is no evidence that over the next

few years output rose appreciably above this level. By 1873, the plant's annual pig iron capacity was 30,000 tons, requiring 70,000 to 75,000 tons of coal and 70,000 tons of Pennsylvania and New Jersey hematite ore a year. Most of the iron the plant made was used in its own rolling mills, whose capacity was by now 20,000 tons and whose work force numbered seven hundred. In 1871, 1872, and 1873 (the three record years for iron rails), Bethlehem turned out an average of 18,278 tons. As a contributor to national output, it was even falling behind, one estimate (admittedly a rough one) giving it a share in 1865 of about 4.4 percent and in 1871–1873, 2.5 percent. By the early 1870s, national production was more than double the level of the mid-1860s, but the keenness of the struggle for business had increased as new capacity was built. By 1873, the United States had some fifty iron rail mills.<sup>7</sup> In addition to the cut and thrust between iron firms, by this time another factor was beginning to upset the trade. This disturbing element was growing competition from rails made of steel.

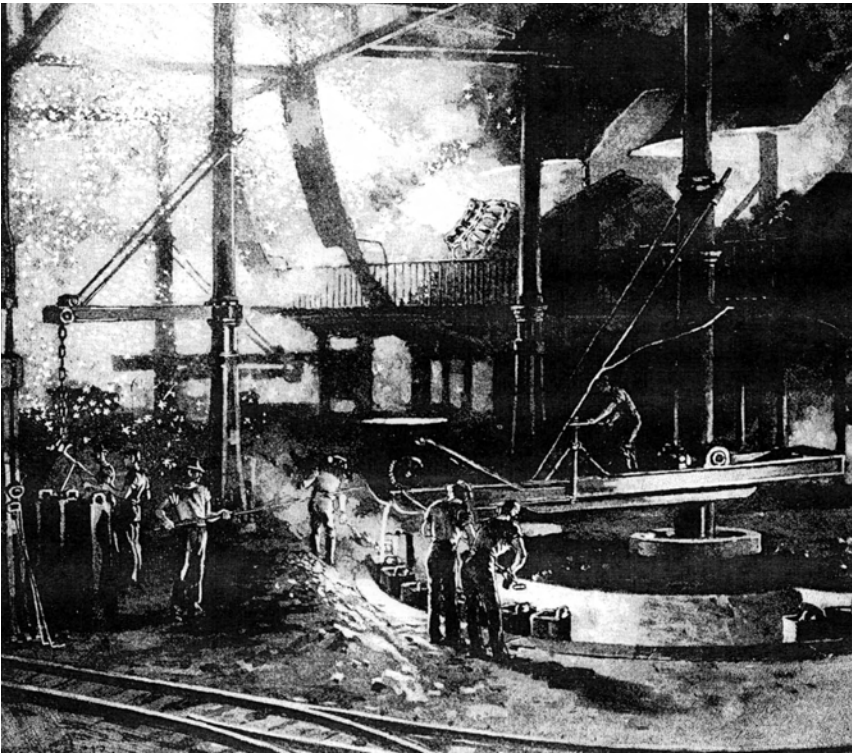
The Bethlehem Iron Company's delayed start in iron making, caused by the adverse reaction of investors to depressed trade and then by uncertainties at the outbreak of the Civil War, meant that by the time it was in operation the company was working with a process and a product that would soon be superseded. During 1862, while the works was still under construction, the Philadelphia merchant house of P. S. Justice handled the first imports of Bessemer steel rails, and steps were taken that would lead to their production in the United States.<sup>8</sup> Early that year, the engineer Alexander L. Holley traveled to Europe on behalf of Edwin Stevens, a railroad man and manufacturer who was planning to build an ironclad and wanting to learn of the latest techniques being used in Old World shipyards and armament manufacture. In his tour of industrial centers, Holley visited Sheffield, saw Henry Bessemer's steel making process in action, and was deeply impressed by its powers. During fall and winter 1863, he negotiated for its use by Griswold and Winslow at Troy, New York. Sometime during 1864, the first full year of operations in the iron plant he had just completed at Bethlehem, Fritz went to Troy to investigate its new Bessemer plant. For a time he was skeptical as to the prospects of the new process, believing America lacked the essential supplies of low-phosphorus iron ore. There were additional reasons for his caution. The rolling of steel required heavier and more powerful mills than those that were satisfactory in dealing with wrought iron and would therefore mean writing off old-style rolling mills, which at Bethlehem had been at work for a mere handful of years. Accordingly, Fritz concentrated instead on

trying to improve the quality of iron rails. As with some enterprising “finished” iron makers in Britain, he gave a good deal of attention to production of an iron rail with a steel head. However, there was strong countervailing pressure. As he had done a few years before when the iron works was first planned, Robert Sayre pressed the board to make a more decisive move. The motivation for this came from his experience at the Lehigh Valley Railroad. In 1865, it imported some British steel rails. Operating experience showed they were four times as resistant to wear as iron rails. Consequently, though on grounds of the quality and durability of the product rather than by answering Fritz’s doubts about the resource base for its manufacture, Sayre became optimistic about the possibilities in Bessemer rail manufacture.<sup>9</sup>

After further delays, but also after gaining useful experience by helping design a Bessemer plant for the Pennsylvania Railroad Company at Steelton, near Harrisburg, and visits in 1868 to Bessemer works in Britain, France, Germany, and Austria, in the fall of that year Fritz and Holley together began the installation of converters at Bethlehem. They designed a plant of four eight-ton converters, which, like other works at this early stage of the Bessemer steel industry, worked on pig iron remelted in cupola furnaces. New blooming and rail mills were purchased. The plant incorporated many new engineering features introduced by Fritz, and the quality of its product quickly gained a high reputation. In contrast to its relatively minor role in the iron rail trade, Bethlehem’s new steel rail mill was immediately acknowledged as a major new factor in the trade. Long before the mill was completed, the *Pittsburgh Evening Chronicle* extolled it as “the largest in the world.”<sup>10</sup>

As with the earlier iron plant, though in this instance for unknown reasons, construction and completion was a long drawn out process. One factor seems to have been Fritz’s desire to make his new plant the most mechanically efficient of all the American Bessemer works. At last, in early fall 1873, it was ready, and Schropp, the company secretary, communicated to the American Iron and Steel Association news of the successful first blow in the converter plant on Saturday, 4 October 1873. The association’s *Bulletin* duly recorded the triumph, typically using it to serve the protectionist cause: “The quality of the steel made was excellent. The whole process of conversion, from cupola to ingot, could not have been carried out more satisfactorily in every particular. This will be gratifying news to the friends of this great company and its hard-working and efficient officers. The Bethlehem Works have hitherto ranked among the very first iron





The rail trade: the Bessemer converter plant at Bethlehem c. 1875. *Harper's Weekly*, 1875.

establishments in the country, and now that their Bessemer plant is completed and in successful operation, they furnish a fresh illustration of what American energy, skill and capital are capable of accomplishing when sustained and encouraged by wise legislation.”<sup>11</sup> There seemed every prospect that Bethlehem would succeed in its new trade. It had a large mill, projected to have a starting capacity of one hundred tons of steel rails a day or approximately thirty-five thousand tons a year—more than double that of the largest mill yet built.<sup>12</sup> The high quality of this plant was suggested by a comparison. When the Edgar Thomson works was commissioned in 1875, it was said that its “rolling mill is more complete than any other, perhaps excepting that at Bethlehem.” Three years later, Holley wrote that Edgar Thomson was the best rail mill in the United States, again with the exception of the Bethlehem mill, whose annual capacity was by then put at fifty thousand tons.<sup>13</sup> Fritz was discontented with

their rails, however. His was the reaction of a perfectionist engineer. As he later recorded, his attitude was in sharp contrast to that of his directors, which was typical of a capitalist business community; for them, it was sufficient that their rails were as good as those made by others.<sup>14</sup>

Although the longer term prospects seemed good, Bethlehem began to make steel and steel rails at a difficult time. The rail network had been increasing rapidly; over the first five postwar years, 16,174 miles of track had been built and in the next two, 14,099 more were added.<sup>15</sup> Although the share of steel in the national rail system was as yet small, it was rising rapidly. Already by the end of 1869, about 110,000 tons of steel rails had been used, of which a third had been laid down that year. Only small tonnages had yet been supplied by domestic mills; steel rails came principally from Britain and to a small extent from Prussia.<sup>16</sup> But the Schenck Tariff Act of 1871 put a duty of \$28 a ton on imported rails, and a larger share of the increasing market fell to domestic rail mills. For a time this was accompanied by rising prices, the average annual price of rails sold by the Pennsylvania Steel Company increasing from \$102.50 a ton in 1871 to \$112 the next year, and in the first quarter of 1873, to \$120.<sup>17</sup> Much of the existing capacity was underused, but Bessemer works and rail mills continued to be added to the lists of producers. Reporting on 1874, the American Iron and Steel Association indicated that at the year's end, eight completed Bessemer establishments had a capacity of 250,000 net tons of steel; production that year, though the highest ever, was only 175,000 tons. Capacity in the rolling mills at these works was at least 20 percent more than their best-ever yield.<sup>18</sup>

The inevitable struggle for business was intensified by the onset of depression, for on 18 September 1873, the major banking house of Jay Cooke collapsed. After its long construction programs, Bethlehem was looking for a steady increase in output and good returns on its capital outlay, but instead near paralysis spread rapidly through large sections of the national economy. Indeed, the same issue of the *AISA Bulletin* that welcomed the new mill also pointed out that hard times lay ahead: "Many of the rolling mills and furnaces throughout the country have suspended work because of the difficulty of making sales and others are preparing to do so. Rail mills especially have but little encouragement to keep running. In very many cases manufacturers of iron are heroically endeavoring to tide over the crisis and the winter by decreasing the cost of manufacture through a reduction of wages, preferring this course, for the sake of their workmen, to putting out their fires."<sup>19</sup> This crisis began a long depression

through which, though domestic steel rail output still increased year to year, prices fell sharply, again, year after year. There was also another, associated problem. Although it came into production as conditions worsened, the Bethlehem mill had been installed in a time of high prosperity, which had pushed up capital costs. In contrast, mills brought in a year or so later benefited from reduced overheads because they had been built under depression prices. A leading instance was the Edgar Thomson works in Pittsburgh, constructed between 1873 and 1875. A conservative estimate put its cost at three-quarters what would have been required two or three years earlier.<sup>20</sup> Making the Bethlehem situation even worse, as the new plant was put up, an only partially amortized iron rail mill was largely abandoned.

In terms of railroad extensions, the long depression of the mid-1870s was a rather barren time, a challenging environment for the flowering of the domestic steel rail business. For the five years from 1873 to 1877, not quite two hundred more miles of railroad were built than in the two years of 1871 and 1872. Though they had to cope with falling prices, the rail mills were sheltered from the worst effects of the slowdown in construction by two other changes of the times: a rapid shrinkage in the output of iron rails and, because of the tariff, a spectacular decline, indeed near annihilation, of steel rail imports. Even so, in part because it was distant from main areas of railroad construction, now occurring more and more in the West, Bethlehem suffered badly. Mills in Cleveland, Pittsburgh, or Chicago were well placed to serve the Midwest market; the unquestioned center for serving outlets in the West was Chicago, whose mills by 1875 rolled about 29 percent of the Bessemer rails produced.<sup>21</sup> In supplying rails to the Pacific seaboard, eastern mills again came into their own. Major shifts in the center of production were also under way. In rails of all kinds, iron as well as steel, the share of output from rolling mills in New England, New York, New Jersey, and Maryland mills fell between 1871 and 1879, from 23.3 to 8.4 percent; for Ohio, Indiana, and Illinois, the respective shares rose from 23.2 to 36.4 percent.

From the outset of the panic of 1873, amid fast-changing levels of production and consumption and competing locations for manufacture, Bethlehem made its way. Because of difficult trading conditions, its first Bessemer blow on 4 October 1873 was not immediately followed by commissioning of the rail mill. In fact, it was not at work until March 1874, and in its first three or four months of operation, it made only 1,676 tons of rails though its annual capacity was 30,000 to 35,000 tons. By October, steel rails were selling at prices as low as those that

only two years before were being asked for good iron rails. In the year prior to June 1875, it made no more than 13,440 tons of rails. By 1877, rail mill capacity was put at 50,000 tons, but average output from 1876 to 1878 was only 35,000 tons. The price trend was strongly downward. The company did benefit from close connections with some regional railroad companies. In the month the mill started work, it received an order from the Central Railroad of New Jersey, and that fall the Lehigh Valley Railroad contracted to buy 6,000 tons of rails at eighty dollars a ton. Next year the Southern Pacific Railroad contracted for 15,000 tons of rails from Pennsylvania Steel and Bethlehem Steel, but these had to be delivered by the long, costly, and uncertain haul around Cape Horn.<sup>22</sup>

Reports to the Bethlehem board vividly convey the distressed state of its trade. In June 1875, reporting on the first full year of their steel plant and rail mill, Alfred Hunt gave this summary: "The past year has been one of generally unprecedented dullness and depression from which our special interests have suffered, more perhaps than their share." For the next decades, that last phrase became a leitmotif of Bethlehem Iron experience. After another year—one in which national rail output doubled—Hunt reported things had been better, but prices had fallen all the time and if things continued along the same lines, they would have to close the works. Next year his tone was even more somber. Since the last meeting, "there has not been even a temporary improvement in our business, as prices have steadily declined, and the same may be said of the demand for our products—with no present prospect of an early improvement." Dull and unprofitable trading, with little demand for rails, continued in the first seven months of the next fiscal year. Inevitably, times were hard times for their investors. Between 1869 and 1873, as it carried the cost of building the new plant, Bethlehem had paid only stock dividends. From 1873 to 1879, neither stock nor cash dividends were declared, operations being conducted at a loss. Adding to the burden, in 1874, a \$1 million bonded debt was created, and three years later more bonds, valued at \$278,000, were issued.<sup>23</sup>

Other firms were suffering, too, especially if they hung on too long to iron rails. When the Lackawanna Iron and Coal Company decided to suspend puddled iron operations in mid-May 1874, its yards were crowded with thousands of tons of iron rails for which it could find no buyers. Next, it too began to make Bessemer rails. Steel rail makers were often in serious trouble. In spring 1874, the Troy steel works and mills laid off its work force for some four months. Both Lackawanna and Troy shared Bethlehem's disadvantage of remoteness

Table 2.1 Prices secured for sales of Bessemer rails by Bethlehem Iron, 1874, 1875, and 1877

Year (autumn)	Amount/type of rails	Price (\$/ton)
1874	3,000 tons of 66-pound rails (sold to LVRR)	80
1875	62.5- to 66-pound rails (small lots)	70-72
1877	2,000 tons of rails (weight unspecified)	41

Source: Bethlehem Iron Company minute books.

from the areas of most active railroad construction, but the experience at the intrinsically much better placed Joliet Iron and Steel Company and the Vulcan Steel Company of St. Louis seemed to show that success or failure owed more to quality of management than to location. Joliet began to make Bessemer rails in 1873, failed and stopped in 1874, and tried and failed a second time, after making investments totaling \$3.7 million. By 1879, when it was sold and began at last to be successful, its original capital had been lost. Vulcan first made steel in 1875, failed soon afterward, ceased production, was revived, and for a long time made serious losses.<sup>24</sup>

Bethlehem's managers tackled their difficulties by emphasizing quality and efficient methods, raising productivity, and attempting to cut costs. As always, Fritz stood out for quality, so much so that at one time even the billets rolled as an alternative product on the rail mill sold at a premium of some four dollars a ton above prices obtained by most other makers.<sup>25</sup> To reduce unit costs, it was essential to increase plant output, and here too there were important successes, as when, on the last night of 1875, one converter turned out what was believed to be the largest heat of steel to date in the United States. The efficiency of Bethlehem operations received warm endorsement in the second half of the 1870s from Andrew Carnegie, though it is not clear how much weight should be given to his words. After a visit, he wrote to thank Fritz for his hospitality and asked for more information about costs: "Nothing during our trip surprised me more than the low cost at which you could handle ores per ton of metal. . . . I might say that everything I saw tended to convince me that, on the Darwinian principle of the survival of the fittest, you have no reason to fear the future."<sup>26</sup> Unfortunately, such a sanguine prediction proved too rosy. The steel operations of the man who made them were a leading cause of the inaccuracy of Carnegie's prediction.

For three years, from late 1874 onward, the prices received for the rails sold by Bethlehem Iron dropped by roughly half, but given the company's circumstances, it was not easy to make comparable cost reductions. One major expense was for purchase of low-phosphorus ores or, alternatively, for iron made from such ores. By 1878, the company operated eleven ironstone mines, in eastern Pennsylvania and New Jersey and extending as far as Staten Island. High-grade ores were imported from North Africa and Spain. A year before it began to produce steel, Bethlehem was also importing considerable tonnages of good-quality pig iron from Britain, in September and October 1872 buying at least 4,500 tons of Bessemer pig from the North West Coast district for between \$55.85 and \$57.87 a ton delivered in Philadelphia. Rail prices in 1873 left more than enough margin to cover such costly supplies, but the next year's rail price was almost 22 percent lower. By 1879, the price was only 40 percent of the 1873 figure, but the company was still buying Bessemer pig iron, some of it from distant suppliers. In five weeks in late 1879, two-thirds of the 9,140 tons purchased was from English works.<sup>27</sup> Remedying such difficulties would involve searching out other suitable ores within the eastern region and outlay for more blast furnace capacity.

A necessity for more capital spending was a recurrent theme at board meetings. By summer 1877, with rail prices falling sharply (though, as subsequent figures showed, demand was in fact strengthening), it was recognized that more outlay was vital for survival: "Supposing the Company to continue operations, receiving cash for sales as fast as expenses accrue, \$200 to \$250 thousand would seem sufficient to put the Company into a reasonably comfortable position, but with little or no reserve resources." Nine months later, as things began to look up, the board was gently prepared for continuing calls for money:

It is not possible, in these times of rapid changes of view as to the superiority of steel over iron for many uses, and the constant demand made for new sizes and shapes in steel, to say when we will be able to cease expenditures for new work, but it will be the aim of the management to make the absolutely necessary improvements from time to time, in such manner as not to embarrass the financial position of the company. In this period of low prices for our product every advantage must be taken of improved machinery and appliances for economizing our work.<sup>28</sup>

As the works expanded and became more complex, it proved difficult to maintain a well-rounded operation. For example, by spring 1879 their annual

consumption of pig iron was estimated to exceed production by about 13,000 to 14,000 tons, and the shortfall was expected to double as a result of improvements then being made to the steel plant. Accordingly, that summer, when all products were reported as being in “good demand”—though at prices of which all that could be claimed was “it is believed [they] will afford a slight margin of profit”—they purchased the Northampton furnace and a furnace at Bingen, formerly operated by the North Run Iron Company.<sup>29</sup> Late in 1881, Holley noted that Bethlehem had installed much new equipment since his account of the works in 1877, even including a new Bessemer plant with a capacity of 3,000 tons a week. In fact, from 1877 to 1882, annual Bessemer bloom and rail capacity increased from 50,000 to 135,000 tons.<sup>30</sup>

At last economic revival began. National rail output in 1878 was at least 100,000 tons more than in 1877, and the next year there was a larger increase. Prices strengthened after five years of steady decline. Bethlehem figures are not directly comparable with national ones because its fiscal and production year ended in June, but at 71,000 tons in 1879, output of rails was almost 88 percent more than in 1878. Despite the fears the board had entertained, the company had survived. In 1875, its first full year of operation, Bethlehem had made 5.2 percent of the nation’s steel rails; in 1879, its share was 11.5 percent. Over the year and a half to mid-1879, the value of its stock advanced from fifteen to forty-five dollars a share.<sup>31</sup> What was now needed was a period of sustained high operating rates to cover the large capital outlays already made. Unfortunately, after a promising start, the business environment of the 1880s would prove no more congenial than that of the 1870s.

Bethlehem Iron shared many of the problems of the other anthracite iron companies, but it had a better balanced operation. By 1890, all other iron making firms in the Lehigh valley had a rated iron capacity of some 735,000 tons but combined rolling mill capacities of only 104,000 tons; at Bethlehem, the respective figures were 160,000 and 285,000 tons.<sup>32</sup> As an integrated operation it escaped reliance on the uncertain outlets for pig iron and had more valuable products to sell. These advantages were counterbalanced by dependence on a more limited choice of raw materials and by the fact that, whereas eastern iron makers competed with merchant iron works on the Great Lakes and in the South, Bethlehem was engaged in a ruthless struggle for business with Bessemer steel makers and rail mills west of the Appalachians, rivals nearer to superior ore and fuel supplies as well as to the main areas of new railroad construction. The company was fortunate to have access to Lehigh Valley Railroad capital.

In the early 1870s, coke furnaces in western Pennsylvania and Ohio could make about double the amount of iron turned out by similar sized furnaces in eastern Pennsylvania. By increasing the pressure of the blast, Fritz managed to make Bethlehem furnaces equal the tonnages produced by western furnaces using low-pressure blast. However, some western ironmasters responded by raising blast pressures at their own furnaces, and given the raw materials with which he was working, Fritz could not follow suit.<sup>33</sup> Holley, who thought highly of Bethlehem, recognized its mineral supply problems. In the mid-1870s, it was using anthracite from mines in the upper parts of the Lehigh valley, but “it cannot be claimed for anthracite that as a smelting fuel it is equal to coke, for the reason that coke is a more porous fuel, and burns more freely, and sustains its burden better than anthracite, which is compact and liable to splinter.”<sup>34</sup> The obvious way of escaping this limitation was to use some coke, or perhaps make a wholesale switch to it, but the Bethlehem furnaces and ancillary equipment had been designed for anthracite. Freight charges on coke would always be a burden. Bethlehem’s ore supply problems proved even more intractable than those for fuel supply.

By embarking on steel making, Bethlehem took on a heavier burden in organizing its ore supply than those eastern firms that remained makers of pig iron or, on a much smaller scale, were involved in rolling finished iron. From the time of Fritz’s visit to Troy to inspect the experimental plant installed there in 1864–1865 to the decision in fall 1868 to go ahead with steel making, and even apparently in the early period of operations, he had serious doubts as to their command of adequate sources of the low-phosphorus ores needed in the Bessemer process.<sup>35</sup> When Holley and Smith visited Bethlehem a few years later, they found that the local hematites with the lowest phosphorus content were about fifteen miles from the plant. Overall about one-eighth of the furnace charge was made up of hematites procured from within four to twenty miles of the works; another eighth (sometimes up to three-eighths) was brown hematite hauled seventy-five miles from Staten Island. The Cornwall ore banks, fifty miles from the furnaces, provided up to half the charge. Magnetite was brought in an average distance of sixty miles from New Jersey and also from the mines of the Crown Point Iron Company in the Lake Champlain district, a three-hundred-mile journey, mostly by water, but ending with a sixty-mile rail haul inland from Perth Amboy. When ice closed the navigation, the ore had to be hauled by rail all the way. Rather optimistically, Holley and Smith added,



“The ores of Lake Superior may also be delivered at Bethlehem at low cost via the Lakes to Buffalo, New York, and thence over the Erie Railway and Lehigh Valley Railroad.”<sup>36</sup> Bethlehem Iron made its ore supply situation worse by failing to organize it effectively. Fritz recalled that the Cornwall ore was good, but they had lost the chance to make long-term contracts for it at favorable prices, preferring instead to purchase in dribs and drabs. Other companies bought their way into this huge reserve to Bethlehem’s disadvantage. Similarly, they let slip an opportunity to develop the Tilly Foster mines in the Hudson valley, which a few years later were being developed to supply the Lackawanna works. Eventually, Fritz felt forced to recommend that his company move into higher grade products because “I could plainly see the end of the acid Bessemer process everywhere, and especially with us, as the company had let every ore property that was available and suitable for the Bessemer process pass beyond their control, and the end was in sight.”<sup>37</sup> Before they reached that extreme situation and point of choice, they had also been trounced by the competition in steel finishing operations and marketing.