Managerial Structure and Technological Style: The Lowell Mills, 1821-1880

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What effect does managerial structure have on technological style? In this paper I will examine the textile mills of Lowell, Massachusetts, to investigate that question. Two aspects of management at the mills are of particular interest: the managerial hierarchy and the accounting systems. Did the management of the mills encourage or discourage technological change? Who was responsible for invention, who for innovation, and how did their background, training, and interests affect the speed and direction of technological change? How did their knowledge about the operations of the machinery of the mill, gained by means of formal and informal accounting, influence their decisions? I hope to show that managerial style was an important determinant of technological style.

Let me start off with a brief description of what I call technological style. Technology, I believe, has a style, just as does painting or writing. Technological style reflects many of the same cultural and social influences that affect style in the arts. A piece of machinery is, after all, the end result of a series of design decisions. While physical law is central in many of these decisions, cultural influences make their presence known as well. Engineering reflects regional and national tendencies and artistic and economic desires as well as physics. Technological style is closely related to, but goes beyond, the economist's notion of factor endowments. While factor endowments help to account for economic influences on technical style, in my definition technological style includes more complicated, less easily measured cultural phenomena. In this paper I examine the effect on technological decisions of one of these cultural phenomena: managerial hierarchies [17; 27].

I shall not argue that management is the only determinant of technological style. Other contexts of technology are undeniably important and play a critical role in technological decisions.[1] I believe, though, that in nineteenth-century America, the business context of technology was of utmost importance. In fact, I would argue that the defining characteristic

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[1] For more on the role of other contexts of technology in the textile and textile machine industry of Lowell -- geographical, legal, political, social, and personal contexts -- see my dissertation, from which this paper is drawn [22].

of "modern" technology is that it takes place within a corporate, or at least a business, context.

The Lowell textile mills were among the largest early American corporations. It has been generally believed that they had a very simple managerial structure. Chandler, for example, following traditional sources, suggests that the wishes of the owners (formulated by the treasurer) were carried out by an agent and a number of overseers, one for each room of the mill [5, pp. 67-72]. On close examination, it turns out that the managerial structure was more complicated than this. The agent was often assisted by a superintendent, a technically trained man, and there were overseers with technical responsibilities that cut across the operations of the mill: overseers of repairs, for example, or of belting.

At the top of a mill's managerial hierarchy was the treasurer. He was the immediate representative of the shareholders and usually a major shareholder himself. Most treasurers had mercantile experience before taking the helm of a cotton mill, though (with a few exceptions) little knowledge of the machinery of the mill. The treasurer was not expected to deal with technical matters, and most did little beyond passing on suggestions from friends or other treasurers. The executive office of the mills of Lowell was occupied by a man whose knowledge and interests were centered on something other than technology. This set the style for technology at the mills.[2]

Treasurers dealt primarily with financial and sales aspects of the mills: buying cotton and, with the help of the mill's sales agents, selling cloth. They were distinguished gentlemen, middle-aged, of good Boston families — in 1830 two Appletons, a Cabot, and a Lyman were treasurers — and were well paid for their exertions, up to $4,000 per annum. Most treasurers of Lowell mills lived in Boston and controlled the financial affairs of the mills at long distance [22, pp. 46-47, 76-85].

An agent, in constant contact with the treasurer, was responsible for the day-to-day running of the mill [22, pp. 47-53]. He was assisted by a paymaster and a clerk (not surprising, considering the amount of bookkeeping to be done) and, in many cases, a superintendent, a technically trained expert [22, pp. 53-63]. The managerial structure of the mill allowed the agent to concentrate on labor (his major concern), supplies, and bookkeeping; the superintendent was responsible for the machinery of the mill. The agent had overall responsibility for running the mill, but he was not expected to have technical expertise. Rather, as a treasurer directed a new agent, he was to "have a general knowledge of the operations to be conducted under your management, so as to be, as far as possible, independent of subordinate advice" [15].

Expertise was supplied by the superintendent, who was usually an outsider, hired for his technical ability. Though superintendents were without question hired to oversee print works and bleacheries, shareholders

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[2] After the Civil War, when the Lowell mills encountered major financial problems, this changed; ability became more important as a credential for managers, family connections less.

always questioned the need for a highly paid manager of the carding, spinning, weaving, and finishing divisions of the mill. One agent used a maritime metaphor to plead for a superintendent to help him:

> Perhaps some of the Directors may think that I might manage without a superintendent of the manufacturing department, for my own part however I deem such an intermediate functionary between the agent and the help employed to be as necessary as is a mate of a merchantman or a first Lieutenant of a Man of War to the proper government & direction of either class of those vessels. [12]

James Montgomery, author of the several of the most important early textile books, applied for this job at the Hamilton Mills. He was turned down; the agent decided he could do almost as well with "a mere overseer" paid less than half the wages Montgomery demanded [9].

The split of technical and production managers is found at the lower level of management also. The typical overseer of a production room had little technical training. He was responsible more for the management of the workforce than the management of machines. Listing the qualities sought in new overseers, an agent put "mechanical ingenuity" after industriousness and trustworthiness [16]. A contemporary observer listed the duties of the overseer:

> [He] has the entire care of the room, taking in such operatives as he wants for the work of the room, assigning to them their employment, superintending each process, directing the repairs of disordered machinery, giving answers to questions of advice, and granting permission of absence [24, pp. 104-5].

Note that the overseer merely directed the repairs of machinery; the mills had machine repairers and overseers of repairs, to do the actual work.

Overseers of repairs were men with technical training. Many started as machinists or woodworkers. Overseers of repairs tended to be slightly younger than overseers of production rooms. On average, they had much lower real and personal wealth — one-tenth the average of production overseers — and few of them lived in company housing, again as compared with production overseers. In short, overseers of repairs were in a lower social and economic class than other overseers; they were more technicians than managers. Overseers of the yard and of the finishing and cloth rooms, for comparison, were older and wealthier than other overseers; their work was the least technical (see Table 1).

Thus, there were two groups of managers at the Lowell mills. One group — the superintendent and the overseers of repairs — was concerned with technology and the other — the agent and the overseers of the production rooms — with day-to-day production, especially labor. This was the case with the large Boston-based textile mills from their very beginning: the Boston Manufacturing Company, the predecessor of the

Lowell mills, wrote into the contracts of its first agent and first superintendent exactly this division of labor [7, pp. 59-60].

Table 1

Social Statistics of Overseers at the Lowell Mills, 1860

Type of Overseers	Number	Mean Age	Mean Wealth	Company Housing
Production	165	42.5	$1278	77%
Finishing, Cloth Room, Yard	22	51.0	2302	73%
Repair	13	41.4	119	23%
Print Works	20	42.9	2285	47%

Source: 1859 Lowell Directory and 1860 Manuscript Census.

This managerial setup had important implications for the technology used at the mills. It meant that decisions about technical matters were not immediately handled by the highest levels of management. It also meant that, often, financial and personnel matters were given larger weight in managerial decisions than were the needs of technology and, thus, that renovation and replacement of machinery was often postponed beyond when it should have been. The questioning of the need for a superintendent can be read as a debate over the importance of technology in the running of the mill — a debate that proponents of new technology often lost. The Lowell mills were not technologically adventurous or even, after the early years, particularly up-to-date [21, pp. 23-24]. Technological change, when it came, seems to have been driven more by managers' whim than economic or technological need.

George Draper, one of the preeminent manufacturers of textile machinery, described the textile machine industry in a way that also fits the large Lowell textile mills:

> I find in all cases, almost without exception, that all of the principal machine shops are opposed to the introduction of improvements for the reason that it is very costly to make the necessary changes, and it takes the personal attention of the leading men to the details that are required, and every point has to be considered, while in order to duplicate machines, they have only to give the order" [6, v. 2, p. 1297].

Draper is describing the inertia of managerial hierarchy. The inertia of the hierarchy of the Lowell mills, in conjunction with the lack of

technological ability of the managers of the mills, helps to explain their technological style.

Accounting practices at the Lowell mills are a second managerial explanation of the mills' technological style. Accounting is one of the ways managers attain knowledge about the operations of their firms. The mills' accounting, like their managerial structure, was rather more complex than historians have given it credit for. I shall look briefly here at their accounting, focusing especially on its effects on technological decision-making.

The first step of any accounting system is bookkeeping, the recording of costs and revenues. The agents and treasurers of the mills invested much effort in accurate bookkeeping. The point of this effort was mercantile — to keep track of money spent and received. The details of the distribution of expenses among accounts were not particularly accurate or consistent — one agent wrote that expenses "are not easily distributed with entire accuracy, nor is it of much importance whether it is so or not, so long as it can be fully documented that their funds have been faithfully applied and correctly accounted for" [13]. The bookkeeping of the mills did keep accurate track of total costs.

It is in the step beyond bookkeeping — evaluating and controlling the flow of funds — that accounting and technology intersect. While it was not necessary to have accurate and complete accounting to evaluate the performance of machinery — experts could evaluate early textile machinery simply by skilled observation [28, pp. 108-25], accounting could have helped evaluate the benefits of using one machine rather than another, helped decide whether to replace or repair old machinery, and helped determine whether labor or capital costs might be more easily reduced. It is at this stage that the accounting at the Lowell mills biased decisions about technology.

Cost accounting began early in the history of the Waltham-Lowell system of textile manufacture. The Boston Manufacturing Company, beginning in 1817, had a rudimentary cost accounting system that allocated overhead to the cost of manufacturing, and, in 1818, a system of "Semi-Annual Accounts" that calculated the cost of cloth by type. By 1822 repair costs, but not depreciation, were taken into account [26]. The Lowell mills, too, had cost accounting schemes. In 1831 the clerk at the Merrimack Company wrote: "The business of the Merrimack Company is so systematized that they know exactly what every yard of cloth costs them" [31, p. 2]. These early accounting systems were ad hoc — they were often found on scraps of paper or in agents' notebooks of miscellaneous information — and were peculiar to each company. They survive only for the Boston Manufacturing Company and the Appleton Manufacturing Company [1; 3].

The cost of cotton was by far the largest single expense in cloth production, accounting for about four-fifths of outlays for materials. It was also the expense over which the agent had the least control. The agent had some control over waste, by speeding up or slowing down the machinery, and so paid more attention to waste than to cotton costs. Agents had the most control over labor costs and paid them the most

attention. Indeed, many production-expense reports included only labor costs. Labor costs were useful to agents both for evaluation of the operation of the mill and for the evaluation of overseers, whose bonuses depended on production [3, p. 43; 8, p. 511].

Repair and depreciation costs, though of the greatest use in decisions about technology, were perhaps the least well kept of any accounts. There was no explicit depreciation in early nineteenth-century textile mill accounting, no fixed percentage subtracted from company assets each year to account for wear and tear, and put aside for the eventual replacement of worn-out machinery and buildings. This does not mean that manufacturers were not aware of depreciation — textbooks for mill managers considered depreciation, giving carefully considered figures for depreciation of buildings and machinery [25]. In the absence of legal requirements or standard accounting rules, though, treasurers depreciated assets when the company was profitable, or when new machinery was installed. The managers were, Paul McGouldrick found, "apparently shrewd in their long-range decisions on how much depreciation to take" [23, p. 116]. That shrewdness was based on elements of a useful system of accounting.

Starting in the 1850s, some of the Lowell mills originated more complete accounting systems [8, p. 469; 26, p. 12]. Curiously though, while rather detailed calculations of overhead were made — fractions like 23/89 are used to divide "waste and general expenses" among the mills of one corporation — these were not done in such a way as to allow agents to determine actual machine use costs, or to evaluate technological alternatives. After the Civil War, agents began to take more of an interest in cost accounting. Indeed, the agent of the Lawrence Company compiled retroactive charts of expense, by room, showing that cost accounting data were available before then, but were not used in managerial decision making [11; 14]. In 1868 the Appleton Company started to use printed forms to record costs of monthly production for each type of cloth [2]. Still, accounting for depreciation remained primitive. When F. A. Leigh addressed the New England Cotton Manufacturers Association on the subject in 1876, his talk was thought a novelty [19, pp. 29-32]. Only in the 1890s did fully useful cost accounting systems catch on in the Lowell mills.

Earlier accounting systems at Lowell, though not so comprehensive, timely, or accurate as they might have been, were of use for a number of purposes. Their first use was simple communication. Because of the separation of management and ownership, the separation of knowledge of technology and knowledge of production, and the geographic separation of levels of management in Lowell and Boston, accounting information was a necessary language of management. In the correspondence between the agent and treasurer, the treasurer is always asking for an explanation of various costs, and the agent responding by comparing the costs of one mill with another. This use is found in many of the industries that developed early cost-accounting schemes, for example, the railroads and the cut nail industry [5, p. 115; 20, p. 43]. Secondly, managers used cost accounting figures to explicate, and justify, production costs to shareholders. Cost accounting figures were used to appraise workers and managers; overseers'

productivity was explicitly calculated, and bonuses given, on the basis of production figures.

Finally, the figures were used — to a small extent — to evaluate machinery, and to decide, more generally, about new investment in the mills. Usually, cost figures are only one of several reasons given for choosing or not choosing a new technology; qualitative considerations almost always outweighed quantitative considerations.

Still, accounting had an effect that was larger than the sum of its parts. Because the Lowell mills' cost accounting underestimated depreciation, it overstated profits. In the short run, the corporations appeared to be more profitable than they really were, encouraging investment and thus the replacement of old machines by new [4, pp. 184-89]. However, the same accounting flaw meant that often reserves were not available to purchase new machinery when it was needed, slowing down the rate of technological change. Not only the rate but also the style of the mill's technology was distorted by the nature of their cost accounting. Because labor was more closely accounted for than capital, managers tended to invest in labor-saving innovations. Indeed, the inventions typical of the Waltham-Lowell mills are labor saving. Innovation is aimed at the perceived bottle-necks of the process of production, and so the known expense of labor received more attention than the largely unknown problems of capital expense [10, p. 190].

Thus, both the managerial structure of the mills and their accounting system had effects on the technology used at the mills. But they also had an effect, albeit an indirect one, on the rate and direction of invention at the mills. Invention at the mills does not show up immediately in the machinery used there — many of the Lowell mills bought the right to use inventions patented elsewhere — but is indicative of the direction of technological change at the mills, for inventors employed at the mills responded to the needs they perceived in their work. Employees of the Lowell corporations received 101 patents between 1837 and 1873. This was 38 percent of all patents awarded in those years to people who lived in Lowell (see Table 2). Considering the overwhelming size of the Lowell corporations (they accounted for more than 90 percent of employees in the city in 1865), this is an unremarkable representation among those who were responsible for new technology in the textile industry.

Patents are very unevenly divided among companies; overseers at the Middlesex Manufacturing Company, which produced woolens, received proportionately many more patents than did those of other companies. Overseers at the woolen mill had a much better technical training than did overseers at the cotton mills, for they were more likely to have been promoted from the ranks — many of the workers at woolen mills were male. At all of the mills, overseers were generally responsible for minor improvements; their patents reflect the technological needs of the mill.

The Lowell corporations made only a half-hearted attempt to promote innovation. They seem to have enforced a strict, but inconsistent, bureaucratic separation of functions: inventors were to invent

Table 2
Occupations and Employers of Patentees at Lowell

Large Textile Companies		
Overseers	45	
Superintendents and Agents	16	
Line Workers	6	
Other	7	
Unknown	27	
TOTAL	101	38%
Small Textile Machine Shops		
Proprietors	42	
Machinists	7	
Other	5	
TOTAL	54	20%
Lowell Machine Shop	13	5%
Small Textile Companies	11	4%
Other	22	8%
Unknown Firms	63	24%
TOTAL	264	100%

Source: (18) and Lowell City Directories

and others were to do their work and not invent. Although the corporations occasionally encouraged invention in their mills and shops, they more often took advantage of operatives by forcing them to surrender patent rights for little or no payment.

One inventor, Moses Marshall, a machinist at the Middlesex Company, "with difficulty" persuaded his employer to furnish him materials, a shop, and tools to work on his loom improvements. His regular job, though, interfered with his ability to perfect his invention, and he had to sell his patent rights to another company [29]. Lewis Cutting, an overseer, got even less support from his employer, the Appleton Mills. He was eventually forced to turn over his patent to the corporation: as his lawyer put it: "I have no doubt ... he was then induced by the influence of the mill owners in their corporate and private capacity to part with his rights at a very inadequate rate" [30]. Hardly the way for the corporations to promote invention!

This lack of interest in encouraging invention is an example of an increasingly rigid managerial hierarchy obstructing innovation. It is also

indicative of the low regard for technological and inventive ability seen in the low social ranking of managers with technological duties, and reflects the lack of interest in accounting for the costs of machinery or the costs of operating different types of machinery.

These aspects of managerial structure of the Lowell corporations helped to define their technological style, their approach to invention and innovation. There are also other aspects of management that go into shaping the technological environment of a company, directing the speed and direction of technological change there. Alfred D. Chandler, in The Visible Hand, has shown that technological changes have had an important effect on the development of managerial structures [5]; I should like to urge business historians to see how far they can push causation in the other direction and find the effects of management on technological change.

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