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ACCOUNTING FOR LABOR IN THE EARLY 19TH CENTURY: THE U.S. ARMS MAKING EXPERIENCE

Abstract: The national armory at Springfield was the largest prototype of the modern factory establishment and its accounting controls were described by Alfred Chandler [1977] as the most sophisticated in use before the early 1840s. In spite of that, armory management did not integrate piece-rate accounting and a clock-regulated workday to produce prespecified norms of output. Hoskin & Macve [1988] have recently suggested that the armory's accounting controls were unable to attain disciplinary power over labor and increase labor productivity until a West Point trained managerial component had been established at the armory after 1840. They called for a reexamination of the historical record from a disciplinary rather than economic perspective to validate this doctrine. The paper presents the findings of this reexamination and indicates that West Point management training was a relatively minor determinant in the evolving nature of accounting. Several economic and social factors are found to better explain why integration did not occur any sooner than it did at the Springfield armory.

The national armory at Springfield was the largest and among the most important prototypes of the modern factory establishment and its accounting procedures and controls were the most sophisticated in use before the early 1840s [Chandler, 1977]. Until that time, however, the armory's accounting system was not designed to integrate piece-rate accounting and a clock-regulated workday.

Hoskin & Macve [1988] have argued that the presence of West Point trained management at Springfield after 1840 was the key factor in the application of accounting to enforce norms of output, attain disciplinary power over labor, and yield significant labor productivity gains. The role of accounting at the Springfield armory and the significance of a West Point trained management component are the main subjects of this study.

OVERVIEW OF THE EARLY U.S. ARMS MAKING INDUSTRY

In response to a severe shortage of small firearms during the Revolutionary War, Congress in 1794 established national armories at Springfield, Massachusetts and Harpers Ferry, Virginia. Because these armories were unable to fully meet the government's needs, 27 private manufacturers in 1798 were awarded two year contracts totalling 40,200 muskets.¹ Contract work was especially attractive because the government made cash-advance payments of between \$.50 and \$2.00 per musket and contract renewals were based on satisfactory performance and were usually automatic.

As a result of the faulty performance of small arms during the War of 1812, the national armories were placed under military oversight and jurisdiction of the Ordnance Department in 1815 to promote "greater systematization and efficiency" [Smith, 1977, p. 106] and to establish clear-cut lines of administrative authority and responsibility [Uselding, 1973]. In order to obtain government contracts, private arms makers had to supply firearms at a price based on the cost figures incurred at Springfield. Accordingly, the contractors were granted full access to armory facilities to examine the cost records and production methods.

Soon after the economic panic and depression of 1837-43, private arms makers were able to increase their customer base and reduce their overall dependence on federal contracts. A number of new and better capitalized arms makers such as Colt, Smith & Wesson, and Lawrence & Robbins also entered the industry. Concurrently, the government changed from an exclusive system of renewable cash-advance contracts to one emphasizing open-market purchases. This policy shift had major financial consequences to marginally profitable and under-capitalized suppliers, forcing the vast majority of them to leave the industry.²

From 1850 onwards, production activities in the small arms industry became predominantly mechanized and machine-directed as the dual goals of parts uniformity and full inter-

¹Eli Whitney received the largest of these initial contracts for 10,000 arms. The contract price was \$13.40 per stand of arms and \$5,000 was paid in advance. The terms of the contract specified total shipment by September 30, 1800, but in fact, Whitney did not fully complete the contract until 1809. See Mirsky and Nevins [1952] for more details.

²Of all the pre-1830 private and government arms manufacturers, only the Whitney and Springfield armories survived through the Civil War.

changeability were achieved. The industry also became dominated by large patent arms makers, several of whom have survived until the present day.

SPRINGFIELD ARMORY'S ACCOUNTING SYSTEM³

The Springfield armory's accounting system was originally designed to summarize financial transactions, to record the movement of goods to and from inventories, and to establish and enforce individual worker accountability for unnecessary loss or waste. Major Dalliba of the Ordnance Department conducted a detailed inspection of the Springfield armory in 1819. Included in his report (referenced under "American State Papers") was a detailed discussion of the armory's accounting policies and their rationales. The armory used a form of "charge and discharge" accounting and maintained detailed records on raw materials, work in progress, and work completed. Monthly payroll accounts contained the name of each workman, the piece-rate for each task, and the type and quality of work performed.⁴

The Springfield armory's accounting system provided the means of controlling and coordinating arms inventories. Until the early 1840s, accounting was not used to obtain greater control over internal production processes or to improve cost efficiency, perhaps because the national armories operated in a guaranteed market having Congressionally authorized and annually stable output levels. Hoskin and Macve [1988] contend, however, that the inability to integrate accountability and work discipline, through a clock-regulated workday and pre-specified norms of output, better explains Springfield's lack of consistent productivity improvements during Lee and Robb's tenure as superintendents (1815-1841).⁵ They then suggest that significant improvements in output and reductions in piece rates that occurred after 1840 were mainly attributable to the infusion of a

³The reader is cautioned from inferring connections between armory production and general manufacturing policies in the first half of the nineteenth century. The two were always different because of the greater accountability to outsiders (the government) involved in armory production.

⁴For specific details of Springfield's accounting methods and procedures see payrolls and accounts of U.S. armories and arsenals, 1816-50, Second Auditor's Accounts, Records of the United States General Accounting Office, Record Group 217, National Archives.

⁵Hoskin and Macve refer to statistics regarding the output of barrel welders as their basis for assessing productivity improvement. See Note 11 for more details on specific production figures.

forceful West Point managerial component. They argue that pre-1840s armory management were untrained and ill-equipped to enforce labor discipline and improve productivity, and thus were unable to fully utilize accounting information and procedures. Other evidence suggests, however, that the armory's accounting system was appropriate to and fully supportive of the needs of armory management, especially during Lee's tenure as superintendent (1815-1833), and that major changes in the use of accounting after 1840 were in response to a dramatically changed social and economic environment.

As mentioned earlier, the Ordnance Department under the leadership of Colonel Wadsworth became the overseer of armory affairs in 1815. Wadsworth was assisted by a group of West Point officers who also believed in the goals of parts uniformity and interchangeability [Hounshell, 1982]. In fact, Wadsworth's motto, "Uniformity, Simplicity and Solidarity," formed the basis of early Ordnance Department policy [Smith, 1977].

In his detailed examination of the Springfield armory in 1819, Major Dalliba indicated that "complete accountability is established and enforced throughout" and the armory's piece-rate accounting system was "the best of all possible plans" [American State Papers, 1823, p. 542]. According to Deyrup [1970, p. 49], the armory "was outstanding for its excellent management and high efficiency" during Lee's superintendency. Springfield armory's accounting controls have also been described as "the most sophisticated used in any American industrial establishment before the 1840s" [Chandler, 1977, p. 74].

Hoskin and Macve [1988] assert that a particular type of management training was needed in order for the role of accounting to change after 1840, but several other factors appear to better explain why piece-rate accounting and a clock-regulated workday were not integrated at the Springfield armory before that time. The following factors are examined regarding this lack of integration: skilled labor shortages and labor's resistance to controls, cooperative knowledge and cost sharing among arms makers, and the absence of significant labor decrafting.

LABOR SHORTAGES AND RESISTANCE TO CONTROLS

Deyrup [1970] indicated that acute shortages of skilled labor were a major factor that contributed to the early business failures of private arms contractors. Because of these shortages,

as well as New Englanders' natural propensity toward independence and mobility [Prude, 1983], employers were precluded from setting piece rates that would extract exceptionally high labor output, and they would be hard-pressed to enforce norms of behavior and work discipline. In his 1819 report, Dalliba described how piece rates were set by Superintendent Lee at Springfield to provide a reasonable wage for reasonable effort, and without contrary evidence, how they were set in the larger private armories as well:

The prices paid for the working of each piece have been settled by the superintendent, upon the result of much experiment. It is calculated that good industrial men will be able to earn \$1.40 per day. Upon this basis the prices have been established. The workmen earn now from \$20 to \$60 per month; such is the difference in the skill, industry, and ambition of men of the same trade. There are, however, but three or four in the 244 (total number of workman) who come up to \$60 per month. [American State Papers, 1823, p. 542]

In effect, skilled-labor cost control was obtained by computing and maintaining a piece-rate system that provided a reasonable wage for reasonable effort. In both the private and the national armories, the majority of laborers were remunerated on a piece-rate basis.⁶ Piece-rate accounting was introduced at Springfield in 1806 and at Harpers Ferry in 1809. It was described in 1819 as "the best of all possible plans" [American State Papers, 1823, p. 542], and still was credited in 1855 as providing "the greatest amount of work at the least cost to the employer" [Rosenberg, 1969, p. 193].

According to several historians, skilled labor shortages in the United States in the early 1800s encouraged technological innovation and stimulated the subdivision of work processes into precise, specialized tasks [Habakkuk, 1962; Smith, 1977]. In the arms industry at least, production tasks were narrowed and simplified not in response to new manufacturing methods, nor to control an unruly labor force [Nelson, 1981], but rather to achieve technical and economic objectives (e.g., greater uniformity and efficiency). At Harpers Ferry, for example, the greatest growth in the number of occupation classes occurred

⁶Dalliba reported that of the 244 workmen employed at the Springfield armory in 1819, all but 52 were paid by the piece. Even in 1850, only 76 of 348 workers were paid exclusively by the day or month.

between 1811 and 1816, a time of severe labor shortages, rather than during the 1820s and 1830s, a period of greater mechanical innovation.

Initially, accounting procedures at Springfield were not integrated with a clocked workday to produce pre-specified norms probably because highly skilled labor would have rejected such a system. In rural antebellum communities, for instance, work time was never precisely defined and little effort was made to control the pace of work [Prude, 1983]. In the early 19th century work culture, farm, craft, and other skilled workers were generally responsible for setting their own pace and work time and were compensated according to task rather than by time. In his 1819 report, Dalliba noted that on-the-job drinking, conversing, and socializing were the norms of behavior in most factories. Faler [1974, p. 379] similarly indicated that workplace drinking was part of the pre-industrial culture that did not stress "the subordination of pleasure to productive labor." Smith has argued [1977, p. 67] that the ability to impose labor discipline at the armories was inversely related to employees' skill level:

Since they were extremely sensitive about their rights and privileges as skilled artisans, particular care had to be taken not to treat them with condescension. No man worth his salt would stand at command or submit to even the most perfunctory regulations unless he was accorded the dignity and freedom that his skilled status deserved.

Until around 1830, the Springfield armory "was outstanding for its excellent management and high efficiency" [Deyrup, 1970, p. 49]. Under John Robb, Lee's civilian successor from 1833 until 1841, management was relaxed, work discipline generally deteriorated, and Springfield's labor and capital costs significantly escalated. The expansion and prosperity of the early 1830s was followed by a period of strikes, union activity, and a reduction in daily working hours. The increase in labor's power vis-a-vis armory management at this time exceeded, but still paralleled the relationship in the private sector. However, the panic of 1837 and the resulting economic depression left workers defenseless against employers seeking to restore long hours [Laurie, 1974]. Clearly the arms-making environment had changed by 1841 when Lt. Col. George Talcott, inspector of armories, reported to the Secretary of War that the practice of allowing workers to fix their own wages, privileges, and working

hours would not be tolerated in a private business and should not be condoned at Springfield [Benet, 1878].

COOPERATIVE KNOWLEDGE AND COST SHARING

The Ordnance Department, under the leadership of Colonel Wadsworth, actively promoted cooperation among the private and national armories in order to achieve uniformity and interchangeability of small parts. For example, Wadsworth conducted a two-day meeting in 1815 to disseminate his uniformity principles and to establish the standards of manufacture for military muskets. The participants at the meeting included Superintendents Roswell Lee of Springfield and James Stubblefield of Harpers Ferry, and Eli Whitney. Whitney was the largest and most influential of the original private arms makers. In addition to his near total dependence on government contracts, Whitney's willingness to share technical information was partially based on the close personal relationships he maintained with Wadsworth and Lee.⁷ Letters written between Lee, Wadsworth, and Whitney between 1815 and 1819 show that Whitney shared technical details and actually offered barrel turning machinery to the Springfield armory.⁸ As a result of frequent interactions among the key members of the arms-making community, trade secrets apparently did not exist, at least during Lee's superintendency.

According to Uselding [1973], Springfield's primary role was to extend arms-making inventions to more technically advanced stages so that production methods and innovations could be rapidly diffused throughout the industry. Armory superintendents were directed by Wadsworth to cooperate with

⁷Smith [1981, p.68] described Wadsworth as "an intimate friend" of Whitney, while Lee had worked at Eli Whitney's private armory and was recommended by him for a position at the Ordnance Department. Mirsky and Nevins [1952] and Deyrup [1970] referred to many of the letters that were exchanged among these individuals. For more details see Letters Sent-Letters Received and Reports of Inspections of Arsenal and Depots in the Records of the Office of the Chief of Ordnance, Record Group 156, National Archives, Washington, D.C.

⁸Whitney had invented the cotton gin in 1793 and was continually seeking judicial relief for patent infringements on this invention. Given his experiences, Whitney's decision to offer Lee a machine for turning barrels is more understandable, since men, materials, costs, and technical information were routinely shared during this time. Regarding his decision, Whitney wrote: "... But the probability is that some person would contract to make barrels & not only take advantage of my invention but entice away the workmen whom I had instructed in the use of the Machine before I could be compensated for the experience of making it."

each other "in all matters related to management and manufacturing on the uniformity principle" [Smith, 1981, p. 71]. To partially fulfill this charge, the national armories were open to all visitors, and skilled workers, raw materials, patterns for machines, and manufacturing processes were regularly exchanged among the national and private armories.

Private contractors were also apprised that future arms contracts would depend on the degree they cooperated with the Ordnance Department in sharing new inventions and other relevant information. Arms making was such a cooperative endeavor that important technological innovations are unable to be traced specifically to particular individuals. Instead they were perceived as evolving "through a remarkable process of cooperation, transfer, and convergence" [Smith, 1973, p. 591]. The full sharing of technical and production cost data also enabled the arms makers to control labor rates and limit wage-motivated turnover within the industry. According to Mirsky & Nevins [1952, p. 268], Lee and Whitney worked together and had "a tight control over the labor market" and thus effectively created an oligopsony for armory workers" [Uselding 1973].

This evidence suggests that during the period of full cooperation, arms makers were able to delay implementation of a comprehensive labor-accounting system due, in part, to their ability to openly, regularly, and completely share all relevant cost information. Gentlemen's agreements and personal discourse would be clearly preferred to a comprehensive labor accounting system that might encounter strong resistance from a work force unacculturated to clock-paced work standards and intrusive labor reporting requirements. Demanding pre-specified norms of output from workers having widely variant skill levels⁹ may also have led to intolerable levels of intra-industry turnover given the shortages of skilled labor that were experienced in New England at that time.

Until the early 1840s, the government's monopoly purchasing power allowed the policy of shared cooperative knowledge to be enforced and sustained. After that time, new and more competitive private arms makers entered an industry that was expanding rapidly and the earlier cooperative spirit naturally broke down. Once the cooperative period ended and a united labor policy disappeared, a more integrative labor accounting system was needed. And only after arms making

⁹See Dalliba's comments in an earlier section.

became highly mechanized and labor had been significantly decrafted would pre-specified norms of output be established.

ARMS MAKING AND LABOR DECRRAFTING

At the time of Major Dalliba's inspection in 1819, arms-making machinery had not developed to the point where labor productivity was independent of the skills of the individual worker. Even though Springfield's production workers were subdivided into more than 86 different occupations by 1820, attaining complete uniformity of work and full interchangeability of parts was both unobtainable and unwarranted given existing cost and quality criteria. According to Dalliba in his 1819 report:

... Different men have different visions; they do not see alike, and they do not feel alike; and as the accuracy of parts depends upon the vision and feeling of the workmen, the parts made by them must vary. [American State Papers, 1823, p. 543].

From its beginning, the Springfield armory followed a policy of paying wages above the industry average in order to maintain a stable force of skilled workers given labor shortages and the limited upward job mobility at the national armories [Deyrup, 1970]. Over time, as the vast majority of arms-making tasks evolved from craft judgement to machine tending, this wage-rate policy became unnecessary. Lt. Col. Talcott's report to the Secretary of War in July, 1841 reveals how dramatically the arms making labor market had changed:

The difficulty of finding good armorers no longer exists; they abound in every machine-shop and manufactory throughout the country. The skill of the eye and the hand, acquired by practice alone, is no longer indispensable; and if every operative was at once discharged from the Springfield armory, their places could be supplied with competent hands in a week. [Benet, 1878, p. 397].

Until the late 1830s, the Ordnance Department gave much greater priority to perfecting the system of interchangeable parts manufacture than to improving cost efficiency. In fact, the Department never really expected significant cost reductions before this time [Hounshell, 1982]. Thereafter, machine capital was increasingly substituted for manual labor and the craft skills of the average arms worker declined significantly. By

1850, all fabrication was carried out by machine except for barrel welding. Once parts uniformity and interchangeability had been achieved, and labor shortages had been eliminated, improving labor efficiency became the new and natural focus of Ordnance Department management.

INCREASES IN LABOR PRODUCTIVITY

Hoskin and Macve [1988] have argued that West Point management methods¹⁰ best explain the major increases in barrel welding productivity that occurred at Springfield armory after 1840 when J. W. Ripley became superintendent.¹¹ They recognize that Decius Wadsworth and George Bromford, Wadsworth's successor as chief of Ordnance from 1821-1842, both came under the West Point influence,¹² but contend that the physical presence of West Pointers trained by Sylvanus Thayer was the key determinant of the productivity increase at Springfield.¹³ Smith [1981] acknowledged that tighter rules, clocked days, regularized procedures, and greater factory discipline all occurred during Colonel Ripley's superintendency. Hoskin and Macve [1988, p. 38] go much further, however, in contending that West Point management methods caused the increase in labor productivity, allowed accounting to be more fully utilized, and were "of crucial significance in business and accounting history."

Ascribing multifarious influences to West Point management methods is alluring, especially when invoking power-knowledge rationales for accounting procedures. In the case of the Springfield armory after 1840, however, several economic factors stand out. The depression that began in 1839 resulted in

¹⁰Hoskin and Macve describe in great detail the human accountability techniques that were introduced at West Point by Sylvanus Thayer during the period of his superintendency (1817-1833).

¹¹Hoskin and Macve (HM) reproduce figures from Deyrup showing a significant rise in average barrels welded per man after 1842. The increase was from a figure no higher than 2,500 before 1840 to an average of 4,000 after 1842. HM reference Uselding [1972] when arguing that this increase was not due to improvements in technical factors. They suggest that the West Point management style and technique is the most likely explanatory factor for the productivity increase.

¹²Wadsworth and Bromford were West Pointers from before Thayer's superintendency.

¹³Until 1841, Congress mandated that the national armories come under civil superintendency. Accordingly, both Lee and Robb were civilians and not career military men.

major price and wage declines in the private sector.¹⁴ Rezneck [1935] noted that there were nationwide givebacks of wages and working hours during this time.

Barrel-welding output probably increased at Springfield because of higher and more regularized working hour requirements and piece-rate reductions of over 50 percent that occurred between 1841 and 1844. The new armory policies resulted from the 1841 War Department examination that identified the incongruity of private and national armory practices regarding work rules, wages, and regulations.¹⁵ Given the economics of the day, armory workers apparently had to accept the new work requirements, and the increases in output and productivity that resulted did little more than restore the real income levels of prior years.

SUMMARY AND CONCLUSION

In the larger, competitive arms-making environment that emerged after 1840, there was far more industrial secrecy and much less opportunity for firms to share information about costs, methods, and innovations. Labor costs that formerly had been regulated by a few key players via tacit agreement and personal discourse, could now be controlled only by managerial pressure, work discipline, and an accounting system that introduced norms of output. West Point training and discipline probably helped managers perform their work, but this particular background should not be given undue credit for increasing productivity and bringing fundamental change to accounting and accountability systems. Economic and social forces appear to be far more significant.

The depression that ended in 1843 was followed by 14 years of phenomenal growth and westward expansion [Taylor, 1951]. During that time, private sector demand for small arms increased and private arms makers were no longer dependent on

¹⁴During this period, wholesale prices fell between 25 and 50 percent [U.S. Department of Commerce, 1960].

¹⁵In September 1841, a three-man board appointed by the Department of War conducted a detailed examination of conditions and management at the Springfield armory. They confirmed Talcott's earlier comments about high wages and slack work rules. In their report to Congress in 1841, the War Department examining board indicated that "in all the private establishments which were visited by the board, the hours of labor are fixed by regulation" and "In looking into the prices of labor, the board became satisfied that the workmen on the different parts of the musket are very unequally paid" [Benet, 1878, p. 401].

government contracts for continued viability. The trend toward fuller labor accountability at Springfield that occurred under Ripley appears to parallel procedures that existed in private manufactories in light of comments made in the 1841 War Department report. More research on this aspect of accounting history is needed to uncover private industry practices and to better assess the impact of particular management methods and techniques on the development of accounting.

In her study of 19th century business practice, McGaw [1985] concludes that accounting has been supportive of technological change and has supplied owners with the information they needed to manage. This suggests that an integrated labor accounting and accountability system was not needed at the Springfield armory much before 1841. Until that time, a comprehensive piece-rate system supplemented by shared cooperative knowledge of current costs and production methods may have elicited all the accountability that arms workers would have tolerated and probably furnished all the labor cost information that armory management expected or could use.

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