From Chaos to Systems: The Engineering Foundations of Organization Theory, 1879–1932

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This paper traces the genesis of the systems paradigm in the study of organizations in the United States back to nineteenth-century engineering practices. The empirical analyses for the period 1879–1932 are based on primary data collected from three journals in which the study of organizations was first codified and crystallized: the *Engineering Magazine,* the *American Machinist,* and the *ASME Transactions.* The evolution of the systems paradigm was found to be a product of at least three forces that form one interacting gestalt: (1) the efforts of mechanical engineers who sought industrial legitimation and whose professional paradigm spilled over into the organizational field; (2) the Progressive period (1900–1917) and its rhetoric on professionalism, equality, order, and progress; and (3) labor unrest, which was perceived as a threat to stable economic and social order. The paper provides a cultural and political reading, rather than a functional and economic one, to the emergence of managerial thought and the evolution of organization theory.•

Several academic disciplines have devoted considerable attention to the study of organizations, most notably management, economics, sociology, political science, and psychology. Despite this massive attempt to produce scientific knowledge about organizations, researchers have done little to understand the historical origin of organization studies and its cultural and political context (for the few exceptions, see Waring, 1991; Barley and Kunda, 1992; Guillen, 1994). This paper traces the initial efforts to produce theories of organizations as "systems" during the period 1879–1932 in the United States. The study has two objectives: first, to demonstrate that the systems perspective has an intellectual history that predates general systems theory and, second, to show that the rise and evolution of this perspective should be understood as a product of professional, cultural, and political forces, not necessarily of functional and economic needs. The main argument is that the systems perspective in the management of organizations was crystallized within mechanical engineering during the last decades of the nineteenth century and was institutionalized as a legitimate canonical discourse during the Progressive period (1900–1917). Three factors were instrumental in facilitating this process: (1) The professionalization of mechanical engineering; (2) the political culture of Progressivism; and (3) the politics of labor unrest.

THEORETICAL BACKGROUND

The ascendance of industrial capitalism in the U.S. after the Civil War was evident in the integration of markets, the consolidation of production, the professionalization of engineering, the concentration of labor in large firms, and industrial unrest (Sklar, 1988). By the late 1920s the organization of production was characterized by multi-unit, large-scale, and complex bureaucratic firms supervised by professional managers (Chandler, 1977; Fligstein, 1990). Concurrent with these processes were efforts to produce literature about organizations. Emerging from the rhetoric

0001-8392/95/4004-0557/$1.00.

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and practice of mechanical engineering, these efforts gradually turned into an intellectual project with the deliberate aim of establishing a scientific body of organizational knowledge.[1]

The Roots of Systems: The Professionalization of Mechanical Engineering and the Movement for Standardization

As early as the 1860s, machine builders and engineers aspired—for different reasons and with different degrees of success—to standardize and systematize machines and machine tools (Noble, 1977; Sinclair, 1980). These attempts became more salient between 1880 and 1920, with the rapid industrialization of the economy. During this period, the number of engineers increased by 2000 percent, from 7,000 to 136,000 (Layton, 1971; Stark, 1980). By 1900, the United States had the highest proportion of engineers among industrial employees of any country, and the gap with its main competitor, Germany, widened. In the course of the incorporation of engineers by industry, engineering was transformed from a craft to a profession (Calvert, 1967). Furthermore, the civil engineer, who in the early nineteenth century performed all engineering-related tasks (Calhoun, 1960), was overshadowed by the mechanical engineer, who benefited most from industrialization. By 1900, college enrollment in mechanical engineering outnumbered that in civil engineering three to two (Noble, 1977). Compared with the 2000-percent average growth rate of all engineering fields, the number of professional mechanical engineers (i.e., members of the American Society of Mechanical Engineers) increased during this period by 6000 percent.

From the early stages of professionalization, mechanical engineers attempted to achieve legitimacy and establish their distinct role of expert. Corporate capitalism was congruent with these attempts. Trained and credentialed mechanical engineers were, for the most part, industrial employees. The growth of corporations did not threaten to displace them but, rather, opened up new possibilities for their careers. Most of them accepted without objection the structure, power, and ideological principles of industrial corporations. They believed that progress could be achieved without government control, through better management and greater efficiency. In their attempts to claim expertise, they determined, for example, that nations need "fertile land" and a "capable body of professional engineers" in order to prosper (*American Machinist,* April 12, 1894: 4). They also praised the "new hegemony of the engineer" (Haber, 1964: 43) and suggested that engineers dominated civilization and the progress of the world (*Engineering Magazine,* February 1892: 675). The movement for standardization described below was congruent with these attempts to establish a distinct domain of engineering expertise.

During the first twenty years of its existence (1880–1900), the American Society of Mechanical Engineers (ASME)—the professional society for mechanical engineers that exists to this day—encouraged the government to support the systematization of experimental activities in industry.

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Most historians agree that there was little literature on organizations in the United States before the 1870s (e.g., Bendix, 1974; Chandler, 1977; Nelson, 1975). An exception is the literature that emerged in the railroad industry since the 1850s (Yates, 1989). This literature, however, was not readily accessible until the first decade of the twentieth century (Jenks, 1961).

Judging by the content of the *Transactions of the ASME* (*TASME*) during this period, standardization occupied a substantial portion of its agenda. In ten of the first twenty years, discussions of codes and standards took up more than 10 percent of their annual volumes. The papers are full of engineers' pleas for order and uniform codes for recording procedures in a properly indexed form. As Calvert (1967: 178) put it, they desired "rationalized standards of measurement, nomenclature, fittings, screws, nuts, bolts, and everything else with which they came in daily contact." Robert Thurston, president of the ASME, declared in his inaugural address in 1880 that "we are to endeavor to hasten the approach of that great day when we shall have acquired a complete and symmetrical system of mechanical and scientific philosophy" [*TASME* 1880 (1): 15]. A year later, one of the society's central figures, Oberlin Smith, envisioned a day when "system shall replace chaos" (Calvert, 1967: 171).

In a series of articles published both in the *Transactions* and in the *American Machinist,* Smith pleaded for standardized nomenclature and symbolic representation of machine details for systematic manufacturing (e.g., *TASME,* 1882: 360; *American Machinist,* October 31, 1885: 1; *American Machinist,* November 17, 1888: 2). In 1889, James W. See, a correspondent for the *American Machinist* known by the pseudonym "Chordal," gave a paper before the ASME in which he pointed out to ASME members that the "arts are full of reckless things that had better be standardized" (Sinclair, 1980: 145). He attacked the lack of standards for such items as carriage clips, washers, bricks, picture frames, needles, and files. Naming over one hundred items, he called for the creation of a government bureau that would record all standards. Likewise, letters to the editors of the *American Machinist* over a long period of time called for an end to "mechanical provincialism" and encouraged a broad systematization in industry. Sinclair (1980: 144) aptly characterized this period: "formal codes and standards of industrial practice seem the ideal expression of that drive for system that dominated American life in years after 1880."

The creation of systems and standards was expected to yield predictability and regularity in production and greater control over anomalies. As William Kent, chairman of the committee on standard methods of conducting steam boiler tests, argued before the ASME, standardization would transcend the biases of different testers and enhance objectivity in engineering work (Noble, 1977; Sinclair, 1980). He explained that, in the absence of standards, "every engineer who makes a boiler test makes a rule for himself, which may be varied from time to time to suit the convenience or interests of the part for whom [*sic*] the test is made" (Sinclair, 1980: 51).

When the movement for systematization emerged, the notion of "systems" did not have the meaning that scholars attribute to it today. As Hounshell (1984: 16) put it, early users "did not consciously endow 'system' with great significance or with transcendent qualities."[2] The term "system" in the mechanical engineering literature was commonly used to refer to any method of ordering

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Hounshell described the origin of the expression "system," albeit in a different context. It was first applied to the tangible and physical aspects of manufacturing and was used in relation to the "American system" of production, famous in Europe for its interchangeable and uniform parts (Hounshell, 1984).

engineering ideas and practices. As one writer stated in 1904, "system is neither more nor less than method" (*Engineering Magazine,* November 1904: 211).

This is not to say that everyone agreed with this professional ideology. There was considerable opposition within the ASME to the attempt to enforce standards and systems arbitrarily. Many members of the ASME criticized the movement, arguing that very few individuals are competent enough to judge a standard, that standardization implies taking a stand in business competition, and that standardization may produce unforeseen hazards for those forced to adopt standards. Others, who sided with owners of small shops, argued that standardization constrains free trade, is costly, and interferes with the freedom of industrial producers and the principle of laissez faire. Still others criticized systematization as rigid and antithetical to the ideals of spontaneity and innovation in engineering. In a controversial article entitled "Wake up America!," Louis Bell warned the engineering community that there are dangers "lurking in over-confidence in system" and that workmen become "mere belts, wheels, and oil-cans" where "one can hardly find an artisan" (*Engineering Magazine,* September 1906: 801–808).

This opposition failed for at least two reasons. First, there were frequent accidents that were attributed to the lack of standards. In 1904 Baltimore's entire business district was destroyed by fire, despite there being an ample water supply, because the screw threads on the fire hydrants did not fit couplings on the hoses of fire engines that arrived from other towns (Sinclair, 1980). Such incidents verified engineers' claims for the urgent need to standardize. Second, the effort toward standardization was partly driven by large firms as a response to the antitrust movement. As Haber (1964) and Hounshell (1996) explained, Progressive activists (such as Louis Brandeis) demanded that monopolistic firms increase their efficiency. Standardization seemed to eliminate duplication, lower costs, and therefore be congruent with this demand. Noble (1977) partly corroborated this explanation in his observation that standardization was a more straightforward affair in industries that were dominated by large firms. The standardization program at Westinghouse, for example, was adopted throughout the electrical industry. Likewise, standards for the telephone industry were developed at AT&T and adopted by the Federal Communication Commission. This led to a symbolic justification for the need to adopt a system, given that respectable manufacturers had done so (see *American Machinist,* July 3, 1913: 15), a logic that is in line with the mimetic isomorphism argument of institutional theorists (e.g., DiMaggio and Powell, 1983).

The Extension of the Movement to Organizations

Beginning in the late 1880s, parallel to the attempts to standardize and systematize mechanical matters, the movement was extended more explicitly to organizational and administrative issues. Dexter Kimball, Dean of Engineering at Cornell University and later a president of the ASME, suggested "the extension of the principles of standardization to the human element in production'' (Noble, 1977: 83). An editorial in the *American Machinist* suggested that ''the advantages of standards are so vital in connection with material things, and are so well recognized by manufacturers that we wonder that so little standardization has crept into the mechanism of business. We believe that in this field, at least, business can learn from the engineering profession'' (*American Machinist,* August 22, 1908: 212).

The extension of technical principles to social and commercial endeavors was based on the assumption that human and nonhuman entities are interchangeable and can equally be subjected to engineering manipulation. One writer suggested that ''One of the most important, if not the most important, and at the same time most elusive, difficult to handle and fickle materials the mechanical engineer has to deal with is the human material, the man behind the lathe, miller and planer'' (*American Machinist,* January 1909: 900). Furthermore, including organizational design within the jurisdiction of engineers was justified by their claim that the analysis of organizations ''is to the enterprise what the engine diagram is to the designer'' (*Engineering Magazine,* April 1908: 83–91). Along this line, engineers argued that the manager ''is to the enterprise what the skilled engineer is to the engine'' (ibid.). Mechanical engineers viewed organizations as technical systems and the problems posed by their management as an integral branch of mechanical engineering. As Church held, ''scientific accounting is a kind of engineering'' (*American Machinist,* September 2, 1915: 431). Likewise, Lewis Slater reserved the role of designing organizations to the engineering profession, which he referred to as: ''not a mere amateur . . . but a carefully-thought-out method, based on the advice of an expert in this particular branch of work'' (*Engineering Magazine,* October 1899: 59).

These ideas traveled in professional circles and in U.S. industry. Individuals such as Alexander Hamilton Church, John Dunlap, Horace Arnold, or Harrington Emerson—who were labeled by historians as ''systematizers''—applied mechanical engineering methods to the administrative restructuring of firms (Calvert, 1967; Layton, 1971). The rise of this group marks the origin of management as a distinct phenomenon. In the late 1890s, an editorial in the *Engineering Magazine* acknowledged that there was ''an awakening'' in everything that was related to workshop systems and management (*Engineering Magazine,* March 1899: 1001). Elsewhere, Charles Carpenter suggested that ''one can but admire the wonderful systems of organization and management by which the enormous business interests of the United States are governed'' (*Engineering Magazine,* February 1902: 693–702). He further offered that ''if the system of organization is founded upon the correct principles, the perfection of the details will follow as a natural sequence.'' Or, as another writer celebrated, ''systems inaugurate themselves, for where there is an established line of work to be turned out facilities must be provided to do it at the lowest possible cost'' (*Engineering Magazine,* November 1904: 219).

The systematizers praised the value of systematic organizations, promoted methods to advance systematization, and criticized improper systematization. They constructed organizations as machines (Haber, 1964) and suggested that "confusion," "oversight," and "neglect" could be eliminated through the use of organizational "systems" such as cost accounting, production control, standardized communication, and administrative procedures (Litterer, 1961a, 1961b, 1963, 1986; Yates, 1989). They linked systems to efficiency and argued that efficiency could be maximized by replacing "individual idiosyncrasy with system, individual memory with organizational memory, and personal skills with firm specific skills" (see Jelinek, 1980; Yates, 1989: 12).

Thus, alongside the development of mechanical engineering as a profession and its mission to systematize technical matters, an engineering-based social ideology was formed. In this view, the same method that had proved fruitful in material affairs should be applied to social and organizational issues. Engineers were thus able to enhance their centrality within industrial firms and to extend the boundaries of their expertise. As the professional group expanded, the ideology of systems—composed of a series of maxims rather than one coherent theory—became more widespread, particularly in large firms such as Du Pont, AT&T, and Standard Oil of New Jersey (Jenks, 1961; Litterer, 1961a; Haber, 1964; Noble, 1977).

The efforts to view organizations as systems culminated in the work of Frederick Taylor and his followers. Most textbooks regard his "Shop Management" (1903) and "Principles of Scientific Management" (1911) as the first chapters in the theory of organizations (e.g., Scott, 1992). Taylor's theory of industrial bureaucracy—the extension and codification of mechanical engineering—involved an explicit attempt to systematize the firm and rearrange its division of labor. His suggestions for transferring production knowledge ("guild secrets") to the planning department—by using flow charts of production or measuring time and motion—were made under the banner of "social physics," "a science of production" that was supposed to be "objective," "systematic," and "rational" (Merkle, 1980; Nelson, 1980). The "planning department" staffed by professional engineers was a perfect example of how engineers created niches for themselves and enhanced their status by reconstructing industrial bureaucracy. Taylor argued that installing scientific management was a lengthy process, requiring two to four years, and he used time to his advantage. He insisted that during this period engineers be given complete authority.

Unlike the governments of other countries, such as Germany and France, the U.S. government was not a strong actor in the diffusion of systems (McCraw, 1984; Hamilton and Sutton, 1989; Dobbin, 1994; Guillen, 1994; Hounshell, 1996). In the U.S., the rhetoric and practice of organizational systems emerged essentially as a professional project. The Progressive movement at the beginning of the century played a pivotal role in providing legitimacy to this endeavor.

The Progressive Period

Progressivism was not one coherent scheme but, rather, an amalgam of ideas and ideals that converged under a single label (Hofstadter, 1955; Hays, 1957; Kolko, 1963; Haber, 1964; Kloppenberg, 1986). The movement, led by middle-class, well-to-do intellectuals and professionals (Hays, 1957), was stimulated by the power of giant industrial corporations and by corruption in politics. Progressives demanded redistribution of wealth by means of welfare legislation and rebalancing economic power through antitrust legislation (Hays, 1957). The Progressive period was advantageous to the development of systems for at least two reasons. First, it provided legitimation to the roles for professionals, including engineers, as experts. Second, it was congruent with the agenda of systems, which seemed, on the face of it, to promote progress and equality.

Progressivism and professionalism. The Progressive period was the golden age of professionalism in America (Larson, 1977; Abbott, 1988). During this period, "only the professional administrator, the doctor, the social worker, the architect, the economist, could show the way" (Wiebe, 1967: 174). These experts "formulated their interests in terms of continuous policies that necessitated regularity and predictability" (Wiebe, 1967: 165). In turn, professional control became more elaborated. It involved measurement and prediction and the development of professional techniques for guiding events to predictable outcomes (Hays, 1959). The experts "devised rudimentary government budgets, introduced central, audited purchasing, and rationalized the structure of offices" (Wiebe, 1967: 168).

This type of control was not only characteristic of professionals in large corporate systems. It characterized social movements, the management of schools, roads, towns, and political systems. Hays (1959), who examined the political culture of the Progressive Era through the prism of the conservation movement, argued that loyalty to professional ideals, and not close association with the grass-roots public, set the tone for the movement. Furthermore, the Roosevelt administration maintained close relationships with all engineering societies, including the ASME, and the societies supported Roosevelt's attempts to bring efficiency and rational management into government. Hays (1959) concluded that "efficiency," "expertise," and "system" infused the entire social order of Progressivism. This was congruent with the general trend of "anti-chaos" reforms labelled by Wiebe (1967) as "the search for order" and was characterized by "bureaucratic vision" and a desire for "perfect systematization."

The professional tools developed by Progressives were perceived to be objective and rational and above the give and take of political conflict. The struggle of Progressives to find a common ground for society as a "whole" generated a pragmatic culture in which conflicts were diffused and ideological differences resolved. To them, science and engineering provided the "assurance that from the same set of facts men will come approximately to the same conclusion" (Kloppenberg, 1986: 383). At the end of the

Progressive period, business philosophy was crystallized around secular engineering ideals rather than around religious, philanthropic, paternalistic, or social Darwinist ones (Barley and Kunda, 1992; Guillen, 1994). With the engineering ideology, resorting to politics was no longer needed, since political conflicts could be redefined in technical terms. Social, political, and ideological problems were often cast in terms of efficiency. Engineering expertise seemed appropriate to solve them (Larson, 1977).

Progressivism and systems. The legitimacy of organizational systems during the Progressive period was supported by two additional ideals: progress and equality. Images of progress, often expressed with the logic of efficiency and productivity, emphasized technology, production, machines, and the rising demands of coordination given the growth of industry (e.g., *American Machinist,* January 7, 1904: 35; April 1911: 97). They were represented by engineers, managers, scientists, and economists who identified industry as the proper arena for reform. Images of equality, often expressed in moral terms, focused on the redistribution of wealth by means of welfare legislation, and limiting economic power through antitrust laws and unionism. Their locus for reform was the public sphere (Jacoby, 1993).

Despite the fact that themes of progress and equality often clash (Meyer, 1994), the development of rational and efficient organizational systems, in both industry and government, seemed to provide a perfect vehicle for reforms acceptable to both camps. In organizational systems, progress and equality were harmonized. Systems were perceived as a safeguard for the morality of organizations, of managers, and of employees (Kloppenberg, 1986). They bind individuals in mutual relations of responsibility and accountability, depersonalize these relationships, and thus eliminate favoritism, nepotism, and other unethical practices. In systems, the trajectory of progress can be charted both for individuals and for the organization as a whole. Authority is no longer derived from privileged social positions but "is grounded in the facts and techniques needed to perform and coordinate interdependent tasks" (Miller and O'Leary, 1989: 255). Systems, therefore, were perceived to be objective, coherent, democratic, and progressive. As Wiebe (1967: 170) argued, systems promised to bring "opportunity, progress, order and community" through which "all men would enjoy a fair chance for success."

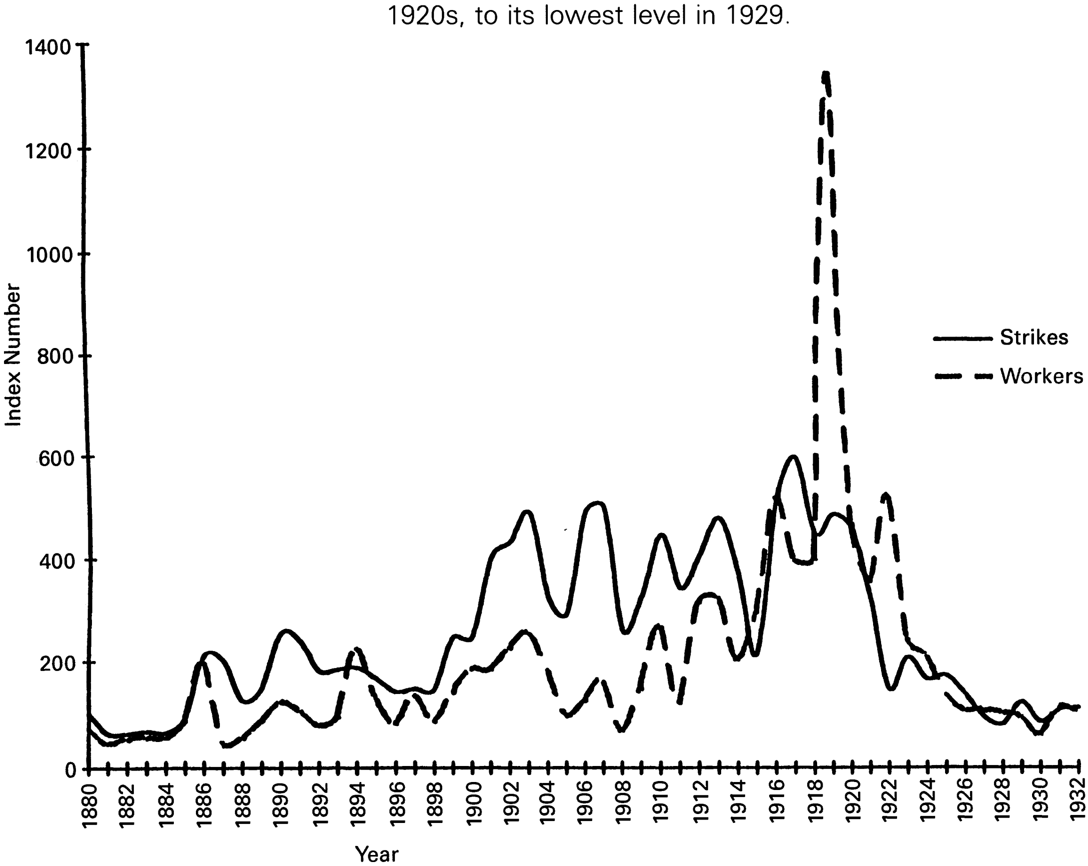
On the basis of the mechanical engineering literature, the systems perspective was institutionalized as a canonical discourse about organizations during the Progressive period. In this discourse, the concept of organizational system assumed coherence and autonomy and became an object of independent inquiry. As the editors of the *American Machinist* suggested, "there is not a man, machine, operation or system in the shop that stands entirely alone. Each one, to be valued rightly, must be viewed as part of a whole" (*American Machinist,* March 3, 1904: 294–296). In 1912, the study of organizations was defined as a separate scientific field, "a smaller sister of sociology as a science of human nature" (*Engineering Magazine,* January 1912: 481–487). In 1915, John Dunlap, the editor of the *Engineering Magazine* documented what he labeled as the "historic events in the development of a new science" (*Engineering Magazine,* May 1915: 163–166), and in 1916, he inaugurated *Industrial Management*. This old-new magazine was devoted to issues of organizational systematization and became a professional outlet for organizational engineers. Sociologically, the institutionalization process of organization science resembled a typical Weberian "iron cage" case: As the discussion of organizational systems was established, the social forces originally behind it were discarded (for processes of institutionalization, see DiMaggio and Powell, 1983; Scott and Meyer, 1994).

Despite this blossoming of "organizations as systems" in the engineering literature and in professional circles, in practice, many employers were apprehensive about adopting a systems approach. Shop owners, particularly those with smaller shops, viewed systematization as a strategy employed by engineers to expand their professional territory. To them, systems were costly and superfluous. As Charles Carpenter observed, "in the mind of the old-time manufacturer the word 'system' is indissolubly linked with that of horror of 'extra clerks' " (*Engineering Magazine,* April 1902: 15; see also *Engineering Magazine,* January 1907: 481). Or, as one foreman testified, describing the work of the systematizers, "they had every man in the place running around with a pencil over his ear, and we didn't get the work done" (*American Machinist,* April 29, 1915: 750). Likewise, Dunlap acknowledged in an editorial that employers and managers perceived systematization as "fantastically theoretical and highly impractical" (*Engineering Magazine,* May 1916: 272).

The fact that shop owners were not enthusiastic about the introduction of systems troubled mechanical engineers. In their attempts to persuade these owners that systems were necessary, they turned to one of the most disconcerting social problems of the period: labor unrest. During these years, wage labor and employers engaged in severe unrest, yielding one of the bloodiest and most violent labor histories of any industrial nation (Taft and Ross, 1969). The fear of unrest was common to manufacturers, politicians, and the public at large and threatened the very essence of the American republican heritage: private property, the state, civil order, and the free market (Goldstein, 1978; Wunderlin, 1992). Given the significance of the unrest to employers, mechanical engineers mobilized the events to their advantage. They conceptualized labor unrest in technical terms, argued that engineers should "serve as arbiters in settling the strife between labor and capital," and suggested that, under a perfectly rational and mechanical system, labor unrest would be rendered unnecessary (Layton, 1971). Taylor's (1895) first paper sketching his ideas on systematic management, "A piece rate system: Being a step toward partial solution of the labor problem," touched on these very issues. Mechanical engineers had taken industrial unrest as given and used it as a strategy to promote the agenda and necessity of systems. Nelson (1974, 1980) supported this argument. He maintained that rather than being a "partial solution" to the labor problem "the Taylor system was a comprehensive answer to the problem of factory coordination, a refinement and extension of systematic management . . . [and] a thinly concealed effort to attract attention to scientific management by exploiting interest in labor unrest" (Nelson, 1974: 480, 486). This rhetoric of systems intensified as labor unrest increased.

Industrial Unrest

The United States is a peculiar case in the history of industrial conflict. Despite the fact that its labor movement has been among the least radical, its strike rate and the intensity of violence have been very high compared with other countries (Taft and Ross, 1969; Edwards, 1981). The intensity of the struggle peaked during the Progressive Era. While serial data on violence are unavailable, official records on strikes and the number of workers involved in strikes have been kept in the U.S. since 1880. A comparison of the annual frequency of strikes (standardized for the number of nonagricultural employees) suggests that the figure gradually rose during the 1880s, fell in the 1890s, and then rose to peak levels in the early years of the twentieth century. The strike frequency remained high throughout the Progressive Era (until 1918–1919) and then saw a dramatic decline in the 1920s, to its lowest level in 1929.



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Source: Peterson, 1938.

Figure 1. Trends in labor strikes, 1880–1932.

While the frequency of strikes gauges the number of disputes between labor and employers, the average number of strikers per strike indicates their scope and severity. The historical figures reveal that after a period of a relatively constant level of worker involvement in strikes during 1880–1909, this number began to increase around 1910 and reached its highest level during the years 1919–1922. Like the frequency of strikes, the number of workers involved was at its lowest level around 1929 (Peterson, 1938), as shown in Figure 1.

Barley and Kunda (1992) attributed shifts in managerial discourse to upswings and downswings of economic long waves. Although they concluded that labor unrest does not provide a consistent explanation of surges of rational and normative managerial ideologies over the course of the twentieth century, they acknowledged that scientific management, which they accurately consider a rational ideology, "flowered when strikes were more common than any other time" (p. 389). Since my argument addresses neither the distinction between normative and rational ideologies nor developments in managerial thought after 1930, I cannot assess Barley and Kunda's general conclusion. I do argue that in the decades surrounding the turn of the century, rational rhetorics of the systems paradigm—including accountancy, production control, and organizational structure, as well as scientific management—initially emerged and intensified during periods of labor unrest and that the rise of the systems paradigm cannot be understood except in this context.

There is ample evidence in the engineering literature that mechanical engineers offered rational systems as a solution to unrest. In 1893, the *Engineering Magazine* published a debate on the causes of "labor troubles." In addition to listing a variety of other solutions, the link between labor troubles and the necessity of systems was established: "what really is the principle underlying the relation of employer and employed, whether or not the employed know it, or the employer means it? . . . The system, the exacting rules . . ." (*Engineering Magazine,* January 1893: 569–576). The logic that prompted the necessity for organizational systems was made even clearer two years later by Frederick Taylor. Taylor (1903: 183, 185) explicitly said that his differential piece-rate system could put an end to labor unrest:

> . . . there has never been a strike by men working under this system, although it has been applied at the Midvale Steel Works for the past ten years; and steel business has proved during this period the most fruitful field for labor organizations and strikes . . . the moral effect of this system on the men is marked. The feeling that substantial justice is being done renders them on the whole much more manly, straightforward, and truthful. They work more cheerfully, and are more obliging to one another and their employers.

Taylor further suggested that the laws of management systems would be impartial and above class prejudice. Subsequent articles in the engineering literature substantiated the link between "systems" and the so-called "labor problem" (e.g., *Engineering Magazine,* March 1897:

994–1000). Charles Carpenter made the argument rather clearly in 1903: "The 'labor problem' now confronting us cannot be solved until the same principles of organization that have been such great factors in commercial success are brought to bear upon it" (*Engineering Magazine,* April 1903: 1–9). Or, as Dunlap put it, "Strikes are a disease, hence curable" (*Engineering Magazine,* August 1916: 748). The cure was in the standardization of work: "Look where you will, labor troubles and unstandardized working conditions are concomitant phenomena."

According to this engineering rhetoric, the properties of the machine-like system were expected to transform chaos into order, ambiguity into certainty, and irrational into rational behavior, as the following typical quote suggests:

> The difference between music and noise, between an army and a mob, between a wagon-train and a stampeding herd of cattle, between righteousness and wickedness, is that *standards and schedules* have been evolved for music, for an army, for a wagon-train, for righteousness; none, for noise, for a mob, for a stampede, for wickedness. (*Engineering Magazine,* April 1911: 23–32; *emphasis mine*)

This rhetoric minimized the political significance of unrest, since the solution "is simply a question of method, the application of a few simple rules" (Litterer, 1961a: 473). The mechanical model was expected to replace "the old set of rules, . . . which have served their day," and to establish the modern principle that order is "the first law of the universe" (ibid.). Apparently, "the nearer our approach to it, the more harmonious will our arrangement work" (Litterer, 1961a: 475). It follows therefore that if engineers used labor unrest to justify the introduction of systems, this rhetoric will be more intense when labor unrest intensifies. This hypothesis is tested empirically below. While some historians have neglected labor strife altogether (e.g., Chandler, 1977), and others have acknowledged the linkage between industrial systems and the labor struggle (Bendix, 1974; Braverman, 1974; Marglin, 1974; Stone, 1974; Edwards, 1979; Litterer, 1986; Barley and Kunda, 1992; Guillen, 1994), no quantitative evidence has yet been offered to support this hypothesis.

In this study, I focus on the rhetoric of systems rather than on their practice (e.g., Hounshell, 1984), because the systems perspective became a landmark in the study of organizations, and its fundamentals shaped the thinking of scholars for several generations. The data for the empirical analyses are based on primary sources—rather than on reinterpretation of secondary materials—which are often missing in otherwise interesting studies of nineteenth-century management practices. The data were compiled from three elite engineering periodicals in which knowledge about organizations was first codified: the *American Machinist,* the *Engineering Magazine* and the *Transactions of the ASME.* Despite the acknowledged salience of these periodicals, and despite the widespread reference to them, there are no systematic quantitative analyses of them. Using the data, I attempt to test three hypotheses suggesting that the use of the systems perspective for organizations (1) grew concomitantly with the number of professional mechanical engineers; (2) flourished particularly during the Progressive Era, even though it existed in engineering circles since the early 1880s; and (3) intensified as labor strife increased in intensity.

METHOD

Data

In the period following the Civil War there were hardly any mechanical engineering periodicals. Most of those that existed prior to the professionalization of the field disappeared by mid-century. For example, when the *Engineer,* a short-lived Philadelphia magazine, was founded in the 1860s there were hardly any competitors, and those that did exist were in the railroad industry (Calvert, 1967; Ferguson, 1989). When the *Engineer* disappeared, the mechanical engineering field remained ''without a voice or a conscience in print'' (Calvert, 1967: 135). It was only in the 1870s that more long-lived, widely circulated technical journals were founded.

The first to emerge, in 1877, was the *American Machinist.* As Calvert (1967: 136), who studied mechanical engineering in the United States, suggested, it was the ''first in quality and scope among the post-1876 journals.'' The next periodical to emerge was the *Transactions of the ASME,* following the establishment of the American Society of Mechanical Engineers in 1880. The *Engineering Magazine* started ten years later, in 1891. All three periodicals captured the rise of modern management and provided (often generous) outlets for the formation of organization analyses. A number of historians and social scientists have referred to them as central sources for the documentation of management practices during the period under study (Mott, 1957; Jenks, 1961; Nelson, 1975; Chandler, 1977; Jelinek, 1980; Jacoby, 1985; Montgomery, 1987; Guillen, 1994). The analyses in this study are based on data collected from the three periodicals. Together, the data cover a time span of 54 years, between 1879 and 1932, which captures the years of intense industrialization (the 1880s and the 1890s), the Progressive Era (1900–1917), the peak of industrial violence in the early 1920s, and the decline of labor unrest in the late 1920s.

Ferguson (1989: 53) warned researchers about using technical journals as sources for nineteenth-century practices, pointing out that they ''often know surprisingly little about the circumstances surrounding those articles, news items, or editorials.'' While convincing, this criticism is less relevant in the context of the current study because I am less interested in the reliability of these articles or editorials than in the discourse that the community of writers manufactured and elaborated. It is my contention that this discourse was stimulated by cultural and political variables. Since the three periodicals I examined were main players in the institutional milieu of the profession, their value for this study goes beyond their contribution as empirical sources. The systematizers themselves acknowledged the ''excellent service'' and ''the efforts of the *American Machinist* and other journals'' in the dissemination and diffusion of systems (see *American Machinist,* July 8, 1915: 62).

The *American Machinist.* The *American Machinist* was a weekly magazine published in New York, with Horace Miller as first president and publisher and Jackson Bailey as first editor (1877–1887). Subsequent editors were Frank Hemenway (1887–1895), Fred J. Miller (1895–1907), Fred H. Halsey (1907–1911), Leon P. Alford (1911–1917), John H. Van Deventer (1917–1919), and, finally, Fred Colvin and Kenneth Condit (1921–1938), who served as co-editors. Most of these figures belonged to the inner circles of the mechanical engineering profession. For example, the editors of the *American Machinist* played a role in the attempts to form the American Society of Mechanical Engineers (ASME). In 1896, John Hill became publisher of the magazine, and McGraw-Hill took over in 1917. During the 56 years between 1877 and 1932 the *Machinist* published approximately 2000 issues. Articles about shop methods varied from "Cutting a coarse pitch screw," "Making thin threaded brass rings," or "Making large holes on a small driller" to "Compensation of skilled labor" and "Hanging workmen's coats." For this study, I used all the issues of the periodical during the period 1879–1932. On average, 10 percent of the annual volume was devoted to management issues. Of the 10 percent, 26 percent was devoted each year to discussing organizational systems.

The *Engineering Magazine.* The New York monthly, *Engineering Magazine,* was a general purpose engineering periodical. It was founded in 1891 by John R. Dunlap (a British edition was published from 1896 onward), who was perhaps the most active journalistic sponsor of the management movement (Jenks, 1961). Dunlap had several co-editors, including Charles Going, Henry H. Suplee, Charles E. Funk, and Leon Alford. Dunlap's interest in machine-shop management began in October 1894 with the publication of Oberlin Smith's paper, "Modern American machine tools—A factor in our industrial growth," W. H. Wakeman's paper, "Management of men in mills and factories—Rational methods vs. brute force," and James Brady's "Economy in machine-shop management." During the same year, Dunlap started a regular section on "industrial sociology," which presented reviews of sociological subjects from other newspapers and magazines. In January 1896, six months after Taylor's presentation at the Detroit meeting of the ASME, Dunlap published his paper. In April 1896, he invited Horace L. Arnold to write a series of six papers on "Modern machine-shop economics." In January 1901, he devoted the entire issue to "the works of [the] management movement." In 1904, his magazine carried an annotated bibliography of several hundred titles on management and organization, edited by Hugo Diemer. In 1915, Dunlap documented the "Historic events in the development of a new science." The *Engineering Magazine* was transformed in 1916 into a journal devoted exclusively to management concerns to become *Industrial Management.* John Dunlap remained editor until 1927, when *Industrial Management* merged with *Factory* to form *Factory and Industrial Management,* a joint venture of the McGraw-Shaw and the

McGraw-Hill publishing companies. At that point, John M. Carmody was appointed editor of the new magazine. For this study, I examined issues for all years between 1891 and 1932, except four volumes (each covering six months) that were missing and could not be examined: vols. 20 (1900), 26 (1903), 43 (1912), and 61 (1921). Because the magazine gradually became a management magazine, however, I did not compile data from it on management after 1918. On average, 13 percent of the annual volume was devoted to management issues, of which 45 percent concerned organizational systems.

***Transactions of the ASME* (*TASME*).** The American Society of Mechanical Engineers was established at the editorial office of the *American Machinist* in February 1880 and held its first organization meeting at the Stevens Institute two months later. The council that was elected in that meeting planned, among other activities, the society's transactions and professional meetings, the first of which was held in November 1880. The society met twice a year, in winter (in New York) and in spring/summer, and published, in most years, two proceedings that constituted a volume. The annual size of the *Transactions* (*TASME*) grew over time, from less than 300 pages in 1880 to more than 1000 pages per year in the mid-1890s. The average number of pages was 1080 (s.d. = 310). Ten percent of the annual volume was devoted to nontechnical issues such as the history of engineering, management, education, or labor market issues. Two percent, on average, was devoted to discussions of organizational systems. Some of the publications in the *Transactions* became landmarks in the history of management. In 1915, John Dunlap recollected that the origin of the science of organization can be traced back to the 1886 volume of the ASME *Transactions.* He referred particularly to Henry Towne's presidential address, entitled "The Engineer as an Economist" and two additional papers presented in that meeting by Henry Metcalfe and Oberlin Smith (*Engineering Magazine,* May 1915: 163–166; Chandler, 1977).

There were two major differences between the *TASME* and the other two periodicals. First, while the *TASME* was the official publication of the society, the *American Machinist* and the *Engineering Magazine* were independent trade publications. This does not mean that they were marginal to the profession. The *American Machinist,* in particular, took an active role in the professional life of mechanical engineering. Its editors participated in the formation of the ASME in 1880 and took numerous roles within the society in the years to come. In the first years of its establishment all ASME professional and administrative matters were handled from the *American Machinist's* offices, which also served as the society's headquarters. For example, the magazine's treasurer, Lycurgus Moore served the society as well. Furthermore, people involved with the three periodicals were part of the same network. Several editors of the *American Machinist* served as presidents of the ASME. Also, a number of people wrote simultaneously for all three periodicals, and two people, Leon Alford and John Van

Deventer, served as editors for both the *American Machinist* and the *Engineering Magazine* (Colvin, 1947; Jaffe, 1957).

Second, there were differences between the *TASME* and the other two in format and in frequency of publication. The *American Machinist* was a weekly magazine, contained on average 8–10 pages per issue, and included editorials (two or three), short articles (mainly about machine tools), regular columns, news from the industrial world, and letters to the editors. The *Engineering Magazine* was a monthly periodical, included an editorial, several articles, and sections reviewing newspapers, magazines, and books in areas such as engineering, economics, sociology, and political science. This section provided the material from which the *Engineering Index,* a compilation of information for the service of engineers, was published by Dunlap. In contrast, the *TASME* printed proceedings from society meetings and contained mainly articles. It appeared only twice a year and contained no editorials, news columns, or letters to the editors. The *TASME* was thus less sensitive to current events, particularly given the rich coverage of strikes, politics, and economic changes in the other two periodicals. Because of this incompatibility between the two magazines and the *TASME,* I decided to test the hypotheses twice: once for all three journals and once excluding the *TASME*.

Dependent Variable

Systems perspective (*system*). To operationalize interest in systems thinking, I used the yearly cumulative volume (number of pages) of items published on systems as a percentage of the volume devoted to management issues. The division by *management* (the proportion of pages devoted to the discussion of management) was introduced to capture the growth of systems net of the growth of management. This measure was repeated for each periodical and was averaged for each year. To be included, items had to address the term "system" directly either in the title or in the text. In coding "organizational system," I collapsed all categories (cost-accountancy systems, production-control systems, wage systems, and hierarchical systems) into one. Here I assume that uses of "system" can be aggregated across writers and over time. By so doing, I do not imply that all systems look alike or that systems do not change. I do suggest, however, that all systems have certain common properties, an assumption made by Nelson (1975) as well. The percentage of the text on systems (out of the literature on management) is presented in the Appendix, showing an average figure of 26 percent per year (s.d. = 0.16).

Independent Variables

Professionalization of mechanical engineering (*ASME*). The professionalization variable was measured using the annual membership in the American Society of Mechanical Engineers (mean = 6585; s.d. = 6858). Data on annual membership were compiled from the ASME's archive and are described in the Appendix. In the regression equations below, I introduced the variable with two lag effects: one year and two years.

Progressive period. Progressivism is a dummy variable coded 1 for the years 1900–1917 and 0 otherwise.

Labor unrest (*strikes*). I used the customary measure, the number of strikes, as a measure of the level of labor discontent. Data on the annual frequency of strikes during the period 1880–1932 were compiled from the official publication of the United States Department of Labor (Peterson, 1938) (mean = 1876; s.d. = 1111). The analyses also include a squared term for *strikes*. The rationale for this inclusion is based on a close examination of the texts produced by the systematizers. There were periods in which there was a realization that the introduction of systems caused strikes rather than eliminating them. During such periods, systems were perceived as a means to control labor and generated resistance and unrest. Such was the case, for example, with the strike at Watertown Arsenal. I therefore hypothesized that the number of strikes would increase the discourse on systems. At high levels of strikes, however, the effect of strikes on publishing items on systems would be the reverse: a retreat from recommending the introduction of systems to solving the labor problem. The squared term provides an opportunity to capture such a curvilinear effect.

Edwards (1981) attempted to evaluate the reliability of data on strikes. For example, he asked to what extent the arousal of public interest in unrest after the upsurge of strikes in 1886 may have caused newspapers reporting on strikes to become more thorough. He also asked to what extent the founding of state bureaus of labor statistics may have increased the likelihood of recording strikes. Although Edwards found no evidence for any systematic bias, during the period 1906–1913 no official statistics on strikes at the national level were collected. This is even more surprising, given the significance of these years in the history of labor and the rising interest in social statistics in the midst of the Progressive Era. It is fairly plausible that this neglect has to do with the intensity of labor unrest, but it has yet to be investigated. To complete my analysis, I relied on proxy statistics provided by Griffin (1939) for the missing years. Griffin's method was evaluated by Edwards (1981), who found that the predicted trend was generally valid. In an attempt to validate this argument, I calculated the correlation coefficient between the national level as estimated by Griffin and the data for the state of Massachusetts as published by its bureau and found a correlation of 0.88.

Control Variables

Average number of workers that participated in strikes (*workers*). This variable was included as a control variable, since the meaning of strikes is not consistent across the years if the number of workers involved varied over time. For example, some strikes are widespread and include many workers at the national level (as was the case in the great telegraphers' strike of 1883), and others are local. Furthermore, it is possible that a few strikes with many participants catch the public's attention more easily than many strikes with a smaller number of participants and have a better chance to be registered in the media. I used the average number of workers per strike to control for such variation. The data were compiled from publications of the United States Department of Labor (Peterson, 1938) (mean = 338.4; s.d. = 224.8). Because I introduced the squared term of *strikes,* I also included the squared term of *workers.*

Management and business literature (*management*). To operationalize this variable, I used the proportion of annual items that were devoted to management and business. All items that concerned the supervision of workers, recruitment, payments, organization and administration, economic issues, production control, cost accounting, finance, inventory control, office control, labor relations, efficiency and productivity, labor market, training, and apprenticeship were included. The yearly average volume devoted to management was 10 percent (s.d. = 0.05). This variable reflects the growth of management within mechanical engineering. I introduced the control for *management* (which was standardized by the annual volume capacity of each magazine in pages) because the growth of management itself could stimulate the discourse on systems.

Growth of labor force participation (*LFP*) was measured as the change in labor force participation from the previous year. Data on labor force participation were compiled from the *Historical Statistics* published by the U.S. Department of Commerce (1975). The variable measures the annual change in the number of nonagricultural workers in thousands of employees (mean = 631; s.d. = 265.7). The control for growth in labor force participation is based on the assumption that the probability of strikes (and of workers' involvement in strikes) and the rise of systems are linearly related to growth in labor market size. It would be ideal to control for average firm size, but unfortunately such data do not exist for the period covered by the study.

RESULTS

Figure 2 presents changes in the discourse on organization systems over the period 1879–1932. The figure, based on all three periodicals, reveals two surges, in 1881 and 1886, and a steady increase toward the end of the nineteenth century. It remained high until 1913, when it started to decline, with two additional peaks around 1924 and 1926. The figure suggests that the discourse on systems flourished during the Progressive Era.

Table 1 summarizes the means, standard deviations and zero-order correlations between the variables.

Simple correlations support at least two of the hypotheses presented above. Systems discourse was positively related to the number of ASME members (.12), the Progressive Era (r = .47), and the number of strikes (r = .32). While the first coefficient was not significant, the other two were statistically different from zero. Growth in labor force participation was also positively related to the rise of systems (r = .13), but the coefficient was not significant. The table also shows that management literature was positively and significantly related to the number of professional engineers (r = .26), increased during the

Table 1

Means, Standard Deviations, and Zero-order Correlations ($N = 53$)

Variable	Mean	S.D.	1	2	3	4	5	6	7	8
1. System	.256	.162	–							
2. ASME	6585	6858	.125	–						
3. Progressivism	.333	.475	.469•	.247	–					
4. Strikes	1876	1111	.318•	−.103	.702•	–				
5. Workers	338.4	224.8	−.088	.467•	−.317•	−.100	–			
6. Strikes²	4733748	4996811	.281•	−.071	.666•	.977•	−.074	–		
7. Workers²	164116	326920	−.069	.354•	−.207•	−.027	.950•	−.015	–	
8. Management	.102	.054	.063	.261•	.294•	.379•	.096	.443•	.039	–
9. LFP	631	265.7	.132	.075	.133	−.027	−.495•	−.036	−.474•	.050

• $p < .05$.

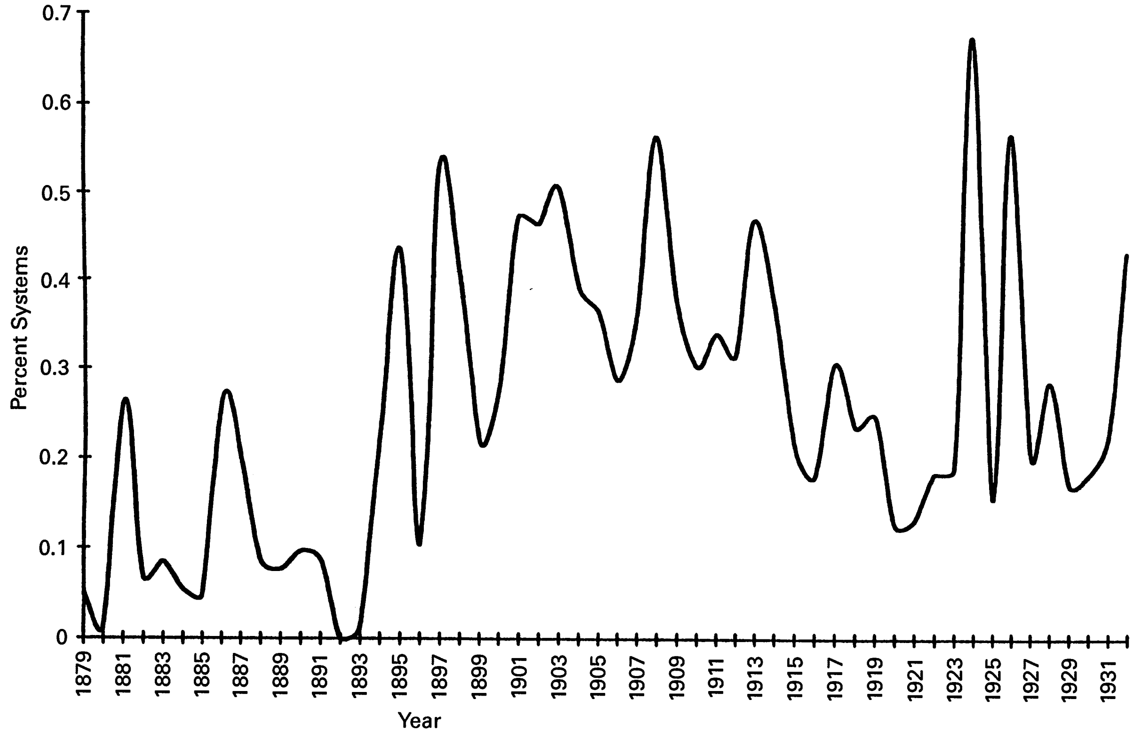
Progressive period (r = .29), and increased in volume as the number of strikes increased (r = .38).[3]

Table 2 presents the time-series regression analyses in which system is the dependent variable, and all variables are simultaneously included in the analysis. The results presented in the first column (*TASME* included) support two of the hypotheses. The amount of discourse on systems was significantly higher during the Progressive Era. It was also significantly related to the professionalization of mechanical engineering: the greater the number of ASME members, the higher the proportion of systems thinking. In using this measure, I assume that the new engineers joining the ASME over the years were increasingly convinced of the need to emphasize systems thinking. Note that the

3

Although I report significance tests, I am not fully convinced that they are appropriate for this analysis. First, this study is not based on a sample but, rather, covers the entire population (of items) during the period under investigation. Second, the small number of cases means that even strong relationships could be rejected at the .05 level (see Stepan-Norris and Zeitlin, 1989, for a similar argument). I therefore conducted the significance test, not to find out whether there is an effect or not but, rather, as an indication of the stability of the coefficients (i.e., the ratio of the coefficient to its standard error). The same logic is applied to the regression analyses below.

Figure 2. Organization systems in three periodicals: the *American Machinist,* the *Engineering Magazine,* and the *Transactions of the ASME* 1879–1932.



coefficient for ASME was obtained with a one-year time lag.[4] The coefficients for strikes or strikes squared were not significant.

Figure 3 presents the appearance of systems in the *American Machinist* and *Engineering Magazine* only. The figure clearly shows that the first decade of the Progressive Era was the golden age of systems, with an additional surge around 1923–1924 and then a decline between 1924 and 1927. The second column in Table 2 (*TASME* excluded) presents the regression coefficients for the two magazines only. In addition to the number of engineers (ASME) and the Progressive Era, the number of strikes had a significant effect on the appearance of organizational systems. The relationship between strikes and the publications of items on systems had an inverted-U shape. This can be inferred from the fact that the coefficient for strikes is positive and significant, and the coefficient for strikes squared is negative and significant. The maximum value of this inverted-U shape is at a level of 2816 strikes.[5] The interpretation of this finding is that more strikes resulted in more items on systems, up to a level of 2816 strikes. Beyond this level, more strikes resulted in fewer items on systems. In 41 years out of the 54-year period that the study covers, the level of strikes was below 2816. In these years, strikes had a positive effect on the publication of items on systems. The years in which that level was surpassed were 1901–1903, 1906–1907, 1910, 1912–1913 and 1916–1920. The average level of strikes (1876 strikes per year, see Table 1), however, falls within the range of a positive relationship between strikes and systems.

Figure 3 also shows that there was a decline in the discourse on systems beginning in 1913–1917. There are

Table 2

Regression Results on Factors Affecting the Coverage of Organization Systems in *American Machinist,* the *Engineering Magazine,* and the *TASME,* 1879–1932 (N = 53)*

Variable	*TASME* included	*TASME* excluded
ASME	.764•	.974•
	(.394)	(.374)
Progressivism	19865•	24835•
	(6503)	(5596)
Strikes	3.506	16.946•
	(9.502)	(7.95)
Workers	21.337	−.879
	(36.67)	(31.2)
Strikes^2	−.0006	−.003•
	(.002)	(.002)
Workers^2	−.153	−.007
	(.223)	(.019)
Management	−74070	−8001
	(46580)	(24702)
LFP	1.299	5.325
	(9.520)	(8.248)
Constant	13528	−3329
R-squared	.33	.57
Durbin-Watson	1.83	1.31

• $p < .05$.
* Standard errors are in parentheses. Dependent variable is multiplied by 100,000.

4
Similar results for ASME were obtained for the analyses with no time lag (coefficient = .726; S.E. = .30) and with a two-year time lag (coefficient = .882; S.E. = .40). No time lags were included for strikes, since I assumed that the effect of strikes should register immediately, as they occurred.

5
This was calculated by taking the first partial derivative and setting it equal to zero. It is thus the ratio of the coefficient of strikes to twice the coefficient of strikes squared (16.9/.006). I thank an anonymous reviewer for a useful comment on this interpretation.

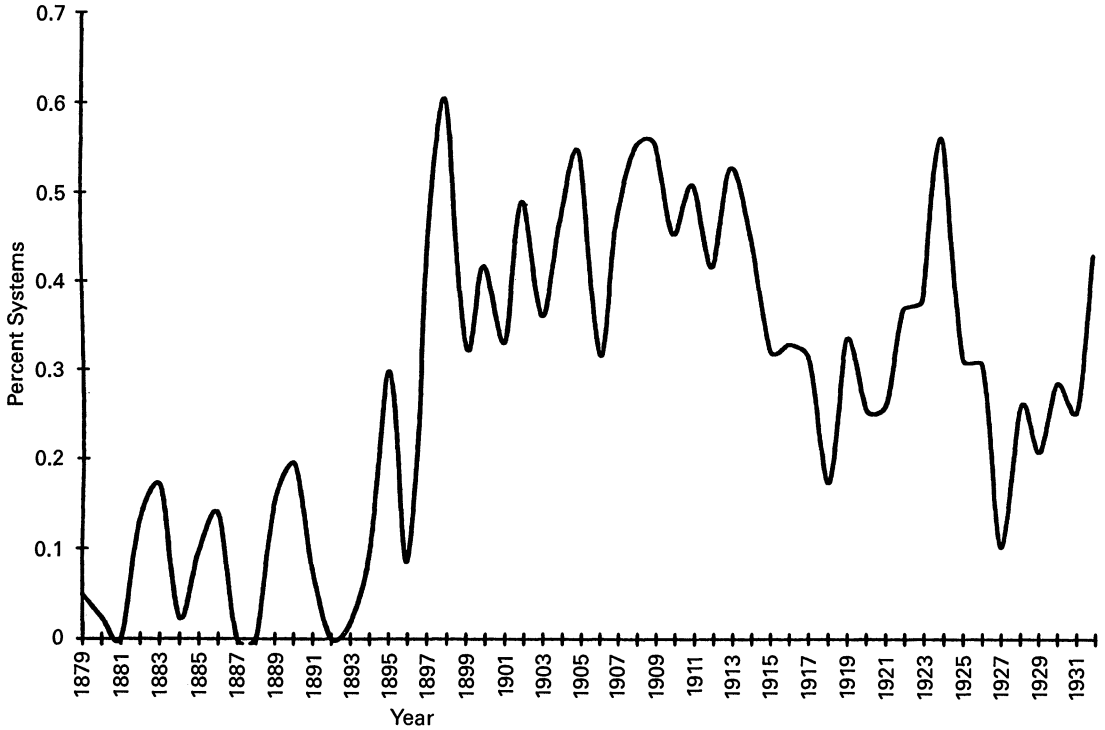


Figure 3. Organization systems in the *American Machinist* and the *Engineering Magazine* 1879–1932.

two interpretations for this decline. First, it might be an artifact of the data sources. During this time, another engineering spinoff journal, *System: The Magazine of Business,* was started. It is possible that the overall count of articles appearing in the three journals with the addition of this magazine would yield a steady state or perhaps even an increase in the proportion of articles on system rather than a decline. The decline can also be understood in terms of the rise of industrial psychology. Until this period, engineering, accounting, and economics were the only bodies of knowledge relevant to systematic management. If considerations of the "human factor" were at all involved, they were based on philosophy, ethics, and religion (see Jenks, 1961; Noble, 1977; Guillen, 1994). Before and during World War I, however, the literature on industrial psychology proliferated (Baritz, 1960; Bendix, 1974; for examples, see *Engineering Magazine,* September 1915: 801–808; *American Machinist,* May 31, 1917: 934). A closer examination of the *American Machinist* reveals that the percentage of items associated with industrial psychology was ten times larger during 1913–1920 than in the earlier period, 1879–1912. As for *Engineering Magazine,* there were no items on industrial psychology prior to 1916. In 1916, the percentage was approximately 2 percent and rose to 22 percent in 1917 and to 35 percent in 1918. These findings suggest that industrial psychology might have replaced (at least temporarily) the logic of systems as a solution to the "labor problem." A similar observation was made by Noble (1977: 263). The interplay between the language of systems and industrial psychology is discussed thoroughly by Barley and Kunda (1992).

DISCUSSION AND CONCLUSIONS

The results of analyses with and without the *TASME* showed that the number of engineers had a positive effect on publishing items on organization systems. The Progressive period also had a positive effect (compared with other periods) on the discourse on systems. The results on the effect of strikes was contingent on the analysis. The analysis that included the *TASME* was based on data collected from all three magazines. The effect was positive but insignificant. The results of the analysis that excluded the *TASME* show that the level of strikes had a positive, significant effect on publishing items on systems. Separate analyses for each of the three journals (not shown here) support that same pattern: The results for the data obtained from the *American Machinist* and the *Engineering Magazine* are significant, and the results for the *TASME* data are not.

In evaluating the divergent results one should bear in mind that in the early days of its existence (approximately until 1905), there was a controversy within the mechanical engineering profession between the so-called "shop-oriented" and "school-oriented" groups (see Calvert, 1967; Sinclair, 1980). The first group was more likely to rely on shop experience, while the others relied on engineering and scientific knowledge obtained through formal schooling. The *American Machinist* represented, for a long time, the shop-oriented engineers, while the *TASME* and the *Engineering Magazine* were more oriented toward school-based efficiency and scientific management. This should suggest that including the *TASME* is important to cover the heterogeneity within the profession, but there is also a good reason to exclude the *TASME* from the analysis.

Although the *TASME* was the official publication of the society of mechanical engineers within which Taylorism and scientific management first appeared (Chandler, 1977), it was a vehicle for the publications of the professional papers presented in the ASME's annual and semiannual meetings and, as such, was less sensitive to topical events than the other two publications. It therefore was not timely in responding to specific incidents of labor unrest, nor did it participate in the political debates around them. This suggests that the *TASME* should not be part of the analysis. Of major concern here is the effect of labor unrest on the evolution of systems thinking. I believe that whether we include or exclude the *TASME,* there is another good reason to give credibility to the effect of unrest. This is because it is not entirely clear that one needs a significance test to evaluate the coefficients of the regression analysis, since the study was based on the entire population of items rather than on a sample. This being the case, labor unrest has a positive effect on the systems discourse in both analyses, and all three hypotheses are supported.

Organizations as Systems

That organizations are systems is an idea with strong roots in organizational theory (Scott, 1992). Of the several recurrences of the systems perspective in the study of organizations, the most influential one emerged in the 1950s. It was a natural spinoff of a widespread scientific movement that dominated the period following World War II (Waring, 1991; Barley and Kunda, 1992). Most broadly, this perspective suggested that because organizations resemble many physical, mechanical, and biological entities, they can be categorized under the rubric of general systems (Lilienfeld, 1978; McKelvey, 1981; Scott, 1992). One of the most commonly used applications of general systems theory to organizations was the machine analogy (e.g., Morgan, 1986). This image was supposed to approximate the features of a perfect bureaucracy: stable, efficient, precise, orderly, and hierarchical (e.g., Burns and Stalker, 1961).

In this study, I singled out the image of organizations as mechanical systems and situated it within its own engineering breeding ground to trace its carriers and to determine the political and cultural context within which it developed. The analysis goes back to the formative years of the discipline and attempts to follow the relations between organizational practices and the production of knowledge about organizations. The systems perspective on organizations began as an engineering-based professional ideology. Its first explicit appearance in the engineering literature occurred in the 1880s. A community of mechanical engineers focused on organizational unity, on the interdependency between parts, and on accountability of operation (e.g., *American Machinist,* January 1, 1891: 7). This definition was later extended to include an array of methods and organizational tools developed by the systematizers, such as accountancy techniques, wage plans, production control, and communication devices. Over time, systems were defined less concretely. It was suggested that system is "the triumph of mind over matter," "a network of intangible ties—that holds the executive together, defining their functions, responsibilities, authorities and requirements for cooperation" (*American Machinist,* April 29, 1915: 750). Along these lines, the systems perspective stressed the ahistorical and enduring nature of organizational constructs: "the object of records is to annihilate time, to bring back the past, to look into the future, to annihilate space, to condense a whole railroad system into a single line . . ." (*Engineering Magazine,* January 1911: 496).

These features of organizational systems were congruent with the transcendental characteristics of the machine: uniform, detached from a particular time and place, and reproducible in numerous organizations and situations. It was based on the assumption that human and nonhuman entities are interchangeable and can be equally subjected to engineering manipulation. This study shows, however, that the emergence, proliferation, and consolidation of this discourse needs to be put in context, as a product of at least three forces. First, it was the results of efforts of mechanical engineers who carried a professional and ideological claim about the nature of organizations, work relations, and the methods by which they should be viewed and structured. Second, the Progressive culture, with its emphasis on professionalism, equality, and progress, contributed to systems discourse. The emphasis on professionalism helped to legitimize the role of engineers as independent and objective actors. The ideals of equality and progress made their claim for systems plausible and desirable. The third force was labor unrest. It was perceived as a source of chaos, as a barrier to proper organization, and as a menace to the stability of society and its economic order. The systems perspective was marketed as a response to the threat and as a progressive solution to social disorder.

Labor Unrest and the Rise of Management

Historians of management can be categorized into roughly three types. First are those historians who overlooked industrial strife, such as Chandler (1977) and Waring (1991). Chandler attributed the rise of management to technology and market needs and neglected the politics of labor altogether. Second are those neo-Marxist historians (e.g., Braverman, 1974; Marglin, 1974; Edwards, 1979) and neo-Weberian historians (e.g., Bendix, 1974; Guillen, 1994) who have claimed that labor unrest is relevant to the development of management but who provided no consistent quantitative evidence to support their argument. In the third and more ambiguous category are Barley and Kunda (1992). While they argued that labor unrest was related to the rise of scientific management and the efficiency movement, they restricted the rise of the movement to the years 1900–1923. The period prior to 1900 is reserved to industrial betterment, whereas the year 1923 marks the beginning of human relations. Furthermore, they described no variations in the extent of this ideology within the period 1900–1923. My study differs from Barley and Kunda's in at least two aspects. First, I examined general systems thinking (rather than only scientific management) during a broader period, 1870s–1930s. Secondly, I examined variations in the extent of this ideology within this longer period of time. I believe that my study provides the first consistent quantitative evidence that the volume of labor unrest stimulated the adoption of the systems paradigm in the United States during this period. Moreover, Barley and Kunda concluded that the phenomenon of labor unrest does not explain the rise of general systems and its associated ethos after World War II. While I did not consider this period, the evidence regarding the close association between labor strife and systems thinking earlier in the century casts reasonable doubt on their interpretation of the relevance of civil disorder to rational managerial rhetorics after mid-century. To resolve this issue will require applying the sort of fine-grained content analysis used in this paper to the managerial literature written after 1930.

All in all, this study offers a cultural and political reading of the rise and evolution of organizational and managerial thought. It should complement and broaden those studies that portray the emergence of this thought as a sole product of employers' attempts to increase the efficiency of the firm (e.g., Chandler, 1977) or to control the labor process (Braverman, 1974; Edwards, 1979).

Two more issues require further elaboration. First, the empirical study focused on the ideology of systems as a professional project of mechanical engineers, not on the practice of systematization in industry. I was concerned with the ideology rather than the practice, since this ideology traveled from the technical field of engineering to social and economic domains and eventually became the most persuasive and enduring paradigm in the literature on organizations. I argue that the analytic category of organizations as mechanical systems is a cultural image advocated by a professional group and that it was adopted by a large organizational audience (see Meyer, 1988, for a similar argument about mechanical images in sociology).

Second, the study suggests that to understand the rise of a specific body of knowledge—in this case, knowledge about organizations—one should study the idiosyncratic factors that were at work in a particular society in the specific period. These differ from one society to another. For example, it is clear that the U.S. government was not a strong actor in the diffusion of systems, standards, or other industrial models, as were the governments of France and Germany (Bendix, 1974; McCraw, 1984; Hamilton and Sutton, 1989; Dobbin, 1994; Guillen, 1994). Guillen (1994), for example, showed that in contrast to the U.S. government, the German government was instrumental to industrial rationalization through the National Board of Efficiency (RKW) and the German Normalization Committee. Dobbin (1994), who described variations in strategies for railroad policies in France, England, and the United States, argued that the French government took an active role in organizing national monopolies and in nationalizing the railroad industry, while in the U.S. the Interstate Commerce Commission was paralyzed for years. Dobbin suggested that distinct polities and institutional resources account for the different patterns of state involvement in industry. Even those who make a case that the U.S. government's role was stronger (Kolko, 1963; Goldstein, 1978) suggest that the government was manipulated by employers or employers' associations rather than having an independent and active role of its own.

These arguments suggest that organizational systematization started as a professional project, mainly since state control was weak (Hamilton and Sutton, 1989), and then served as an ideology, sometimes decoupled from actual practices (Nelson, 1975). It was eventually accepted by industrialists and by government agencies, however, and was often applied in industry. It peaked around World War I, with America's war mobilization and the efforts to coordinate industry, eliminate waste, and remove organizational inefficiencies. To be sure, engineers rarely advocated government regulation. On the contrary, they suggested that the state's role be limited. But the spirit of Progressive systematization encouraged the emergence of a "visible hand" in industry. The macro-management philosophy of the war experience was replicated to resolve problems of productivity, unemployment, and class conflict. It resulted in a system of public and private linkages in which the government (particularly President Hoover and the Commerce Department) encouraged private business, engineers, and social science technocrats to undertake industrial planning (Hawley, 1974; Alchon, 1985). This system was welcomed by proponents of modern management. It was also in accord with the interests of the large industrial establishments founded by such people as Carnegie, Edison, Westinghouse, Bell, and Ford. Systematization and standardization were developed along with their product lines and allowed them to increase control over their respective industrial segments (Noble, 1977). Systems provided greater rationality in production and served as means of labor control, particularly as the level of industrial violence increased. Consequently, there was a substantial increase in systematization and in the number of system-related technocrats, such as personnel administrators, corporate lawyers, accountants, and industrial engineers.

The results of this study have implications for the sociology of knowledge. I suggest that texts about organizations, as well as their authors, a network of scholars, researchers, and research technologies, need to be studied as a distinct sociological topic. These academic and nonacademic texts should not be read as external to the practice of organizations but, rather, as discursive practices that are intertwined with organizational practices. The study further suggests that the institutionalization of academic research about organizations has reified and glorified the distinction between theory and practice as two separate domains. As I have shown elsewhere, analyzing the ideological premises in using the concept of "uncertainty" (Shenhav, 1994), the theory and practice of organization share the same epistemological assumptions, and both traditions can be traced back to the same origin: the systematization project during the period of the 1880s–1930s. The systematizers—the first professionals to formulate maxims about organizations—were engaged in activities that were both descriptive and prescriptive, with very little discrimination between the two. But as the paper showed, for a particular professional project to be successful, one needs a supportive social climate and ideology, an important political or economic problem to be solved, and a growing presence of a professional group that is willing to provide the solutions.

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APPENDIX: Data on Strikes, Workers per Strike, the Number of ASME Members, and Coverage of Systems in the *American Machinist,* the *Engineering Magazine,* and the *ASME Transactions,* 1879–1932

Year	Strikes	Workers/strike	ASME members	Percent systems (*AM, EM, TASME*)	Percent systems (*AM, EM*)
1879	NI	NI	NE	0.049	0.049
1880	762	299	191	0.012	0.024
1881	477	273	222	0.263	0.000
1882	476	334	311*	0.067	0.135
1883	506	336	401	0.085	0.169
1884	485	341	440	0.055	0.023
1885	695	371	558	0.048	0.096
1886	1572	388	621	0.269	0.138
1887	1503	292	715	0.194	0.000
1888	946	172	813	0.086	0.000
1889	1111	234	985	0.077	0.154
1890	1897	197	1049	0.097	0.194
1891	1786	185	1344	0.087	0.075
1892	1359	176	1500	0.000	0.000
1893	1375	209	1675	0.011	0.017
1894	1404	491	1699*	0.232	0.091
1895	1255	324	1723*	0.433	0.297
1896	1066	233	1748	0.104	0.086
1897	1110	375	1867	0.528	0.399
1898	1098	240	1898*	0.402	0.603
1899	1838	235	1929	0.217	0.326
1900	1839	309	2129	0.278	0.416
1901	3012	187	2325	0.469	0.329
1902	3240	213	2419	0.462	0.488
1903	3648	216	2573	0.505	0.359
1904	2419	237	2740	0.390	0.466
1905	2186	138	2929	0.362	0.543
1906	3655	105	3040	0.286	0.315
1907	3724	135	3366	0.358	0.463
1908	1957	107	3455	0.562	0.551
1909	2425	186	3832	0.369	0.554
1910	3334	247	3978	0.301	0.452
1911	2565	145	4115	0.338	0.507
1912	3053	318	4542	0.315	0.416
1913	3574	279	5394	0.466	0.527
1914	2736	229	6142	0.371	0.452
1915	1593	569	6931	0.213	0.319
1916	3789	422	7704	0.179	0.328
1917	4450	276	8720	0.305	0.313
1918	3353	370	10189	0.235	0.173
1919	3630	1146	11882	0.246	0.334
1920	3411	429	13251	0.127	0.254
1921	2385	461	15227	0.131	0.261
1922	1112	1450	17210	0.184	0.368
1923	1553	487	17452	0.189	0.379
1924	1249	524	16666	0.670	0.561
1925	1301	329	16749	0.156	0.312
1926	1035	318	17036	0.563	0.305
1927	707	467	17489	0.206	0.102
1928	604	520	18295	0.284	0.259
1929	921	313	19437	0.172	0.208
1930	637	287	20011	0.182	0.284
1931	810	422	20009	0.223	0.254
1932	841	386	20079	0.428	0.428

Note: *AM* = the *American Machinist, EM* = the *Engineering Magazine,* and *TASME* = *Transactions of the American Society of Mechanical Engineering;* NI = no information, NE = journal did not exist, and an asterisk indicates extrapolated information.