




The Evolution of Management Models: A Neo-Schumpeterian Theory

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Abstract

In the last century and a half, U.S. industry has seen the emergence of several different management models. We propose a theory of this evolution based on three nested and interacting processes. First, we identify several successive waves of technological revolution, each of which prompted a corresponding wave of change in the dominant organizational paradigm. Second, nested within these waves, each of these organizational paradigms emerged through two successive cycles—a primary cycle that generated a new management model making the prior organizational paradigm obsolete, and a secondary cycle that generated another model that mitigated the dysfunctions of the primary cycle's model. Third, nested within each cycle is a problem-solving process in which each model's development passed through four main phases: (1) identification of a widespread organizational and management problem, (2) creation of innovative managerial concepts that offer various solutions to this problem, (3) emergence and theorization of a new model from among these concepts, and (4) dissemination and diffusion of this model. By linking new models' emergence to specific technological revolutions, we can explain changes in their contents. By integrating a dialectical account of the paired cycles with an account of the waves of paradigm change, we can see how apparently competing models are better understood as complementary pairs in a common paradigm. And by unpacking each model's phases of development, we can identify the roles played by various actors and management concepts in driving change in the models' contents and see the agency behind these structural changes.

Keywords: management model, organizational paradigm, technological revolution, neo-Schumpeterian

Even in more-advanced industrial economies, it was less than two centuries ago that the internal organization of business enterprises, until then essentially

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"primordial" and traditionalistic, became the object of deliberate organization design efforts (Pollard, 1965; Coleman, 1993). These efforts have often been informed by management models: distinct bodies of ideas that offer organizational managers precepts for how best to fulfill their technical and social tasks. We see the sequence of such models running from line-and-staff, industrial betterment, scientific management, human relations, strategy-and-structure, and quality management to what we call the business process model and the knowledge management model.

Though there are growing bodies of research on the rise and fall of specific models and on the generic dynamics of innovation, fads, and fashions in management models, efforts to explain the models' longer-term evolution in the history of American management are sparser. The main contributions—Barley and Kunda (1992), Abrahamson (1997), Kunda and Ailon-Souday (2005)—have been impressive in their scope and creativity but leave us with a frustratingly thin account of this historical development. Their limitations can be stated succinctly. Barley and Kunda (Barley and Kunda, 1992; Kunda and Ailon-Souday, 2005) have argued that this sequence can be understood as a pendulum swinging between cultural antinomies of "rational" and "normative" approaches reflecting long Kondratiev waves of economic growth. Though we agree with much in their account, it gives us no way to explain how or why one rational model differs from another or one normative model differs from another. Abrahamson (1997) enriched their account by showing the effects of labor movement activity and labor turnover rates on each model's persistence and discussing factors that affect the timing of the pendulum swings, but he offered no further insight into the models' contents.

To understand the changing contents of these models beyond their classification as rational versus normative, we need to bring into the foreground the role of technological innovation, rather than leaving this factor in the background as prior scholarship has done. We build on recent work in the neo-Schumpeterian tradition of technology studies and on Bodrožić's (2008) synthesis to advance a new theory of the evolution of management models. A more-robust theory of longer-term evolutionary development can better explain the causal dynamics of specific historical episodes, enhance our capacity to interpret the organizational changes currently underway, and provide a fuller answer to one of the big and "largely unresolved" questions of our field: "Where do new organizational forms come from?" (Suddaby and Greenwood, 2005: 35). We focus on the U.S., because it was increasingly central in the world economy over the past two centuries and served as the main locus of innovation in management models for most of the period.

PRIOR RESEARCH ON MANAGEMENT MODELS

Distinguishing Models, Paradigms, and Concepts

The concept of a management model has not received much scholarly attention, and terminology has been loose. Management models were referred to as both "rhetorics" and "ideologies" by Barley and Kunda (1992) and Abrahamson (1997). Guillén (1994) called them equivalently "models" and "paradigms." We define a management model as a distinct body of ideas that

offers organizational managers precepts for how best to fulfill their technical and social tasks.

These models are the organizational analogues of what neo-Schumpeterian scholars of technology call “generic all-pervasive technologies” (Perez, 1994) or “general purpose technologies” (Bresnahan and Trajtenberg, 1995). If, following Griffith (1999: 474), we define technology as the “tools, machines, and/or techniques for instrumental action,” then general-purpose technologies can be defined as higher-order families of technologies (such as those pertaining to water power, steam power, electricity, or computers) from which lower-order, more-specific technological applications derive. We thus distinguish management models from lower-order management concepts. A given management model often includes multiple management concepts, sometimes competing for preeminence, sometimes complementary, but sharing common themes (see Davenport, Prusak, and Wilson, 2003, for a partial list). We use two criteria to differentiate management models from management concepts: (a) generality—management models open up entire new fields of application, whereas concepts are implemented in more-specific situations; and (b) pervasiveness—management models are applicable in a wider range of industries than concepts.

We also differentiate management models and concepts from a higher-order construct, the organizational paradigm, a term used in passing by Djelic and Ainamo (1999) and Höllerer et al. (2014) and treated more in depth in Simsek and Louis (1994). Adapting Kuhn’s (1970) concept of a scientific paradigm, we define an organizational paradigm as a set of ideas that characterize the essential features of the enterprise as an organization. While management models specify managers’ key tasks, organizational paradigms are more abstract, articulating an understanding of the organizational context within which managers work.

The Historical Evolution of Management Models

Scholars generally agree on the identity of the main management models, and a considerable literature is focused on individual models as they emerged in the U.S. In the Online Appendix (<http://journals.sagepub.com/doi/suppl/10.1177/0001839217704811>), we list a number of the key sources. These and other studies show that the models under discussion were not only discursive constructs in the management literature but had wide-ranging impact on management practice.

Prior scholarship has also made important progress in understanding the evolution of these models. For Barley and Kunda (1992), the main factor explaining the content of successive models is the pendulum swing between rational and normative cultural antinomies. A rational model (e.g., scientific management) is associated with and supported by a surge of rational rhetoric, before being challenged by a normative model (e.g., human relations) and a surge of normative rhetoric. The subsequent lifecycle of each rhetoric resembles the evolution of a social movement (e.g., Blumer, 1969; Macionis, 2012). Barley and Kunda (1992) argued that this alternation is driven by long, Kondratiev waves of economic growth, which according to some accounts are in turn driven by waves of technological revolution (Schumpeter, 1939). As Abrahamson (1997: 501–502) argued, “Engineers and scientists need

management techniques to fit employees to new technological innovations, and they are receptive to the machine and system metaphors used in rational rhetorics to describe and justify the use of techniques that could serve this purpose." Surges of normative rhetoric, by contrast, occur because "when returns on capital begin to decline, managers should show greater interest in rhetorics that focus on the utilization of labor, industry's second factor of production" (Barley and Kunda, 1992: 391). This account, rich as it is, leaves us without any explanation for the differences between the ideas expressed in one rational rhetoric and another, or between one normative rhetoric and another. Each model is classified as either rational or normative, but we cannot further differentiate their contents.

A NEO-SCHUMPETERIAN FOUNDATION

Building on and extending Chandler's (1962, 1965, 1977, 1990) historical research, we argue that technology is a powerful factor shaping the evolution of management models' contents. Chandler showed how radical technological innovation provided the impetus for organizational and management innovation, which stimulated the growth of innovators' firms. These exemplary firms contributed to the growth and shaping of new leading industries, which helped transform the entire U.S. economy and society (Chandler, 1977). Chandler, however, did not develop an explicit theory of these causal connections (as noted by Nelson and Teece, 2010). To try to do so, we bring in Schumpeter's (1934) analysis of technological revolutions, which was sometimes invoked as a background factor by the scholarship we reviewed. In so doing, we shift the focus from long Kondratiev cycles of economic growth to one of these cycles' main antecedents, following the path traced by a neo-Schumpeterian generation, most notably Freeman (Freeman, 1994; Freeman and Soete, 1997; Freeman and Louçã, 2001; Freeman, 2008) and Perez (2002, 2007, 2010); see also Murmann (2003, 2013), Nelson and Winter (1982), and Winter and Szulanski (2001). We discuss these influences, especially that of Perez, more in the Online Appendix.

Bringing technological innovation to the foreground involves several trade-offs: they are all aspects of the choice we have made in favor of generality over simplicity and even more so over accuracy (using the classic trilemma articulated by Thorngate, 1976; see also Weick, 1999). First, when we shift the focus from macro-economic conditions to their technological antecedents, we substitute a complex, multidimensional, and hard-to-measure construct for a relatively simple, quantitative one such as GDP growth rate. Second, although this move promises greater insight into some aspects of management models' evolution, it will inevitably downplay the role of contingencies of history such as wars or legislation. Third, we do not attempt to take the next step further back in the causal chain, where the interplay of science, technology, politics, and culture would explain the content and timing of technological revolutions themselves. Finally, we focus on the emergence of new management models and thus pay less attention to their persistence or the subsequent emergence of related management concepts in the later phases of a model's life.

Technological revolutions are based on general-purpose technologies, whose appearance portends massive changes in the industrial landscape. Neo-Schumpeterians see technological revolutions generating "clusters"—reprising a term used by Schumpeter (1939: 167)—of interrelated revolutionary products,

production processes, and infrastructure (e.g., highways for automobiles, Internet for computers), giving rise first to new core industries and then diffusing to older industries. Table 1 summarizes Perez's chronology of these revolutions. In the first two, the UK was the locus of the original technological breakthroughs, and the U.S. took the lead in the last three.

The effective use of the revolutionary new technologies in the new core industries and their diffusion to older industries require change at both the broader institutional level and the firm level. We focus on the latter, where the uptake of the new technologies is accelerated by the emergence and adoption of a new techno-economic paradigm—"a best practice model for the most effective use of the new technologies within and beyond the new industries" (Perez, 2010: 185). Perez (2002) and Freeman (2008) sketched some of the key technological and economic elements of these paradigms but said little about the organizational and managerial elements.

Neo-Schumpeterians divide the lifecycle of these technological revolutions into distinct periods (Perez, 2002). Future core technologies emerge during a gestation period. This period is highly variable in duration, which makes it

Table 1. Timeline of Technological Revolutions (adapting Perez, 2002)

Technological revolution	Examples of dominant U.S. companies (and year founded)
1st wave: Water power and iron Incubation: 1750s–1770 Installation: 1771–1793 Crisis/turning point: 1793–1797 Deployment: 1797–1829 Exhaustion: 1830–1840s	
2nd wave: Steam power and railways Incubation: 1790s–1829s Installation: 1829–1848 Crisis/turning point: 1848–1850 Deployment: 1850–1873 Exhaustion: 1873–1890s	Baltimore & Ohio Railroad (1827) Erie Railroad (1832) Pennsylvania Railroad (1846)
3rd wave: Steel and electric power Incubation: 1850s–1875 Installation: 1875–1893 Crisis/turning point: 1893–1895 Deployment: 1895–1918 Exhaustion: 1918–1940s	Bethlehem Steel (1857) Midvale Steel (1867) Carnegie Steel (1872) (part of U.S. Steel as of 1901)
4th wave: Automobile and oil Incubation: 1880s–1908 Installation: 1908–1929 Crisis/turning point: 1929–1944 Deployment: 1944–1974 Exhaustion: 1974–1980s	Ford (1903) General Motors (1908) Chrysler (1925) (predecessor Maxwell founded 1904)
5th wave: Computers and telecommunication Incubation: 1950s–1971 Installation: 1971–2001 Crisis/turning point: 2001/2008 Deployment: ? Exhaustion: ?	IBM (1911) Hewlett Packard (1939) Microsoft (1975) Apple (1976) Google (1998)

difficult to select a clear start date for each revolution; thus studies such as by Freeman and Perez (1988) and Tylecote (1992) refer to a starting period rather than a specific year. At some point, the installation period begins, during which new industries and a new facilitating infrastructure begin to take shape around the most successful new technologies. The beginning and duration of this period are affected by technological, economic, and social circumstances. Radical innovations are embodied in successful exemplary products, which spark the imaginations of entrepreneurs and draw attention from investors—for example, Ford's model T in the 1910s and Intel's microprocessor in the 1970s. Corresponding new process and infrastructure technologies emerge and cohere around new core industries, and a new techno-economic paradigm begins to emerge. But the full exploitation of the technological revolution's developmental potential across the rest of the economy is still limited, because the context—both the broader political-economic institutional structures of society and the dominant economic, organizational, and management practices of firms—was formed under the impact of the previous technological revolution and is ill-suited to the new technologies. This tension eventually provokes institutional and organizational change, opening the way for the deployment period, during which the revolution diffuses beyond the lead industries into older industries. This diffusion is uneven: some industries and firms adopt the new paradigm and are thoroughly revolutionized in both their technologies and organizational forms—they experience “de-maturity” (Abernathy, Clark, and Kantraw, 1983)—while others may find a niche for themselves in the new order, proceeding unchanged or adapting and implementing only elements of the new paradigm.

Finally, the revolution enters a period of exhaustion. The paradigm can no longer drive productivity or stimulate innovation and growth because the developmental potential of the new technologies is largely fulfilled, and innovations are increasingly incremental (for the distinction between radical and incremental innovation, see Abernathy and Utterback, 1978; Dosi, 1982). Whereas the automobile revolution initially gave the U.S. the combustion-engine-powered vehicle, later it offered incremental refinements such as air conditioning or automatic transmission. This exhaustion of a revolution, according to the neo-Schumpeterians (i.e., Perez, 2007, 2010), energizes technological innovation efforts in new directions.

A PRELIMINARY HISTORICAL SKETCH

Starting from this account of technological revolutions, we trace the corresponding shifts in organizational paradigms, management models, and management concepts. We offer a compressed narrative for the major waves of technological revolution and situate the major management models within them, which is summarized in table 2. This narrative provides the empirical foundation for the theorization we propose in the subsequent section.

The Water Power and Iron Revolution

The technological revolution based on water power and iron was incubated during the 1750s, took off in the 1770s, and was exhausted by the 1840s. It launched the larger period known as the Industrial Revolution and predated the

Table 2. Technological Revolutions, Models, and Concepts

Technology revolution	Organizational paradigm	Dominant management model and key elements	Management concept search terms	Emergence *
Steam power and railways	Professionally managed firm: The rationalized management of a geographically dispersed enterprise	Revolutionizing cycle: Line and staff	Staff and line Line and staff	1861 1869
		The establishment of specialized line and staff managers, unrelated to the owner, who would responsibly administer a large, complex firm	Organization chart	1889
		Balancing cycle: Industrial betterment	Employee benefit† Industrial betterment	1895 1899
		The addition of a social function among the staff responsible for improving workers' living and working conditions	Welfare work Welfare secretar†	1906 1913
		Revolutionizing cycle: Scientific management	Scientific management	1896
		Time and motion study, incentive wages, and workflow analysis as ways to optimize and accelerate production in a facility	Taylorism Standardization of methods	1900 1914
		Balancing cycle: Human relations	Human relations Group dynamics	1929 1945
Steel and electric power	Factory: The unitary, centralized organization structure	Making line managers and staff specialists responsible for responding to the alienation induced by rationalized workstation operations	Personnel counseling	1945
		Revolutionizing cycle: Strategy-and-structure	Profit center† Operations research	1955 1956
		Differentiating internal structure and strategy so as to support the production, marketing, and sales of differentiated products to different types of customers	Corporate strateg† Multidivisional Matrix structure† Divisionalization Management by objective	1965 1965 1969 1971 1972
		Balancing cycle: Quality management	Job enrichment Quality circle†	1972 1979
		Deploying a management system to involve personnel at all levels in continuously improving product and process quality	Corporate culture† Organizational learning Total quality management Continuous improvement Lean production	1980 1981 1986 1988 1992
		Revolutionizing cycle: Strategy-and-structure	Profit center† Operations research	1955 1956
		Differentiating internal structure and strategy so as to support the production, marketing, and sales of differentiated products to different types of customers	Corporate strateg† Multidivisional Matrix structure† Divisionalization Management by objective	1965 1965 1969 1971 1972

(continued)

Table 2. (continued)

Technology revolution	Organizational paradigm	Dominant management model and key elements	Management concept search terms	Emergence*	
Computers and telecommunication	Network: Linking and rationalizing processes across internal and external boundaries	Revolutionizing cycle:	Business process redesign	1991	
		Business process	Outsourcing	1991	
		Redesign of business processes up and down the value chain, redrawing and bridging internal and external boundaries	Horizontal organization†	1991	
			Process improvement	1991	
			Business process reengineering	1992	
			Core competencies	1993	
			Business model†	1994	
			Interfirm network†	1995	
			Supply-chain management	1996	
			Balancing cycle:	Knowledge management	1996
			Knowledge management	Intellectual capital	1997
			The cultivation of communities of practice in order to regain, retain, or improve the innovation capacity of dispersed employees.	Knowledge repositort	1998
				Communitt of practice	1998
				Agile ("NEAR/5 software")	1998
		Scrum ("NEAR/5 software")	2005		

* Emergence date represents the year in which the frequency of the concept's use first accelerates, based on a search of ABI/INFORM complete, Hoover's Company Profiles, ProQuest Historical Annual Reports, American Periodicals, and ProQuest Historical Newspapers collection.

† Denotes wildcard in management concept search term.

emergence of deliberate organization change efforts. The British engineer John Smeaton was a key player, improving the design and efficiency of water wheels by using iron instead of wood. He was also a consulting engineer for large iron producers that used water as a power source (Freeman and Louçã, 2001). Smeaton focused exclusively on the technological challenges of this new paradigm. In contrast, his contemporary, British engineer and pottery entrepreneur Josiah Wedgwood, was an innovator both in technology and management, being one of the first industrialists to give sustained attention to enterprises' organizational forms (Pollard, 1965; Langton, 1984).

Wedgwood established some of the first principles of factory organization, most notably in moving from a craft form of organization to extensive task specialization to ensure efficiency and quality for large-batch production (Langton, 1984; Freeman and Soete, 1997; Freeman and Louçã, 2001). He was guided by a machine metaphor: "to make such machines of the Men as cannot err" (quoted in Freeman and Louçã, 2001: 169). Wedgwood's ideas, however, diffused very little across industry, in part because water-power-based production depends on streams and local topography (Seidel, 1976; Rosenberg and

Trajtenberg, 2004), which kept owner–inventors' development and optimization efforts focused on technical, environmental, and local political challenges rather than organization principles. Most owner–inventors relied on their own intuitions and on traditional craft models in organizing their businesses, so no widely shared professional management model was established in the UK during this revolution (Pollard, 1965; see also Landes, 2003: 337, on the "amateurism and complacency" of British entrepreneurs in this period). In the U.S., the situation was similar: though some more self-reflective approaches to management and organization could be found in the plantations, water-powered textile industry, and armories, such examples had little impact on other industries (Chandler, 1972, 1977).

The Steam Power and Railways Revolution

This revolution spanned the 1790s through 1890s. In its first decades, the British inventor James Watt was a key actor, creating an effective and widely applicable power source by developing a fuel-efficient and profitable model of the steam engine (Seidel, 1976; Nuvolari, 2004). With the entrepreneur Matthew Boulton, he started a small consulting business, which marketed his patent-protected engine and sold it to Cornish copper and tin mine entrepreneurs (Seidel, 1976). After Watt's patent expired, Cornish mine entrepreneurs established a network among themselves and used a monthly journal to exchange knowledge, triggering innovations improving the efficiency of steam engines in their mines (Nuvolari, 2004). Watt and the people around him focused mainly on technology, so this period, like the preceding one, yielded no widely shared management model.

American entrepreneurs were initially much slower in deploying steam engine technology than their British counterparts. From the late 1820s onward, however, the availability of inexpensive anthracite coal and iron permitted more-rapid adoption of steam engine technology in the U.S. (Chandler, 1972). Nowhere was the U.S. catch-up and overtaking more visible than in the vast expansion of its railway industry in the mid-1800s, creating and using the infrastructure for moving goods and people (Chandler, 1977, 1990).

Steam power's use in railway locomotives brought organizational and managerial issues into the limelight. The steam locomotive provided fast, regular, and dependable transportation and radically lowered the unit cost of moving goods, especially where locomotives could run on geographically expansive railroad networks. The railroads received a powerful assist from the telegraph, which provided fast and dependable long-distance transmission of information. But full utilization of the new technologies was limited by the absence of a management model that would help firms cope with the size and complexity of single-track networks. Lacking such a model, railways experienced diseconomies of scale and major train accidents (Chandler, 1965, 1977).

The main actors involved in solving this problem were civil engineers such as Benjamin Latrobe at the Baltimore & Ohio Railroad, Daniel McCallum at the Erie Railroad, and J. Edgar Thomson at the Pennsylvania Railroad (Ward, 1975; Chandler, 1977), who became examples of a "new type of businessman" (Chandler, 1977: 95)—the salaried manager who advanced to the highest leadership positions without the benefits of ownership or family ties to the owner. To deal with the railways' scale and complexity, and a resulting need for

coordination, these professional managers developed new organizational and operational principles, specifically a structure in which divisional superintendents had considerable autonomy from headquarters staff, as well as an organizational chart to illustrate the relations of authority and communication among managers (Chandler, 1965, 1977). These innovations were integrated in the "line-and-staff" model.

As Chandler noted (1977: 105), earlier texts on the management of large-scale enterprises focused entirely on the control of workers; with the railways, we see the first model of the control of line managers by a corporate staff down through several layers of management. This model encompassed and synthesized several more-specific management concepts regarding accounting, functional differentiation, and clear principles of delegation and reporting (Chandler, 1977). The new management model expressed a new paradigm of organization, which we call the "professionally managed firm," which differed qualitatively from the prevailing traditionalistic paradigm based on a combination of owner-entrepreneur, family enterprise, and craftsman-apprentice.

The new management model and organizational paradigm emerged in large companies such as the Erie Railroad in which the need for professional managers was particularly pronounced, and then it diffused across and beyond the railroad industry. Driven by the challenge of coordinating rail operations among the distinct companies spanning the U.S., middle managers from these companies cooperated in developing new technical and operating standards, and the model diffused via meetings, industry magazines, and books, becoming standard practice by the 1870s. A key part of the new model was codified and diffused in the form of an organizational chart for railway company management that was developed by McCallum (Chandler, 1977; Yates, 1989). The business editor Henry Poor published and popularized this innovation in his *American Railroad Journal* (Chandler, 1956, 1965). Railroad managers who moved to other industries brought the model with them. Andrew Carnegie, for example, was a manager at the Pennsylvania Railroad before he applied the line-and-staff model to the steel industry (Wren and Greenwood, 1998).

The professionalization of management was one factor that enabled U.S. railway companies to become the largest business enterprises in the world (Chandler, 1977) and led to high profits and vast power for their stockholders and managers (Ward, 1975) but also to a "growing gap between the management and the worker" (Nelson, 1995: 121). Management paid scant attention to employees' working and living conditions (Tolman, 1909; Kaufman, 2008). Railroad-mania years were followed by years of crisis when workers' salaries were reduced even while stockholders' dividends remained high (Ward, 1975), and violent strikes erupted, including one at the Erie Railroad in 1857 (Wren and Greenwood, 1998) and the Great Railroad Strike of 1877 (Kaufman, 2008).

Shaken by these disruptions, some railway shareholders and executives sought ways to avoid future outbreaks by initiating efforts in what was later called "industrial betterment" or "welfare work" (Rudin, 1972; Brandes, 1976). In the last three decades of the nineteenth century, these efforts gave rise to the creation of numerous Young Men's Christian Association (YMCA) centers at major railroad stations across the country, offering railroad workers food, shelter, baths, libraries, athletic facilities, classes, and religious meetings. "The underlying theory was that well-housed, well-fed, clean, properly educated Christians do not strike" (Brandes, 1976: 15). By 1890, several other industries

had adopted industrial betterment programs (Brandes, 1976). If the line-and-staff model inaugurated a revolution in the dominant organizational paradigm, these programs were an effort to stabilize the new paradigm—aiming not to undo the line-and-staff model but to mitigate its lack of attention to employees' working and living conditions (Tolman, 1909). The main actors developing this paradigm-balancing model were the new "welfare secretaries" (Brandes, 1976; Kaufman, 2008): social counterparts to the technical- and business-oriented professional managers. As staff members, welfare secretaries were incorporated into the line-and-staff model. In some firms, their focus was entirely on the workers' lives outside work, a form of social work; in other firms, they played roles that prefigured those of the later generation of personnel managers (Tolman, 1909; Kaufman, 2008). Three organizations were particularly significant in delineating the function of welfare secretary and the practice of welfare work and in diffusing them across different industries: the YMCA, the National Civic Federation, and the New York City-based Institute of Social Service (Kaufman, 2008). These organizations educated welfare secretaries, sponsored conferences, published success stories, and gave advice to clients. The welfare secretary function would evolve and become one of the starting points of personnel and human resource management (Kaufman, 2008).

The Steel and Electric Power Revolution

Before about 1860, steel was expensive, its use reserved mainly for tools, luxury cutlery, and swords. The steel and electric power revolution (approximately 1850s–1940s) began with replacing the traditional crucible process of making steel with the Bessemer and open-hearth processes, which produced much larger volumes at much lower costs. Demand exploded, because steel is significantly stronger than iron and became the material of choice for railroads, bridges, city infrastructures, buildings, and military equipment. Machine tools' effectiveness was often considerably improved by incorporating steel materials, which allowed them to operate at much higher speeds even under steam power. Electric power for such machine tools and other production equipment soon allowed machinery to be used far more effectively and factories to be laid out far more efficiently, no longer constrained by the central location of a steam-power generator (Devine, 1983). The arrival of a more-efficient factory organization allowed a qualitative jump in productivity (David, 1990; on this revolution, see also Devine, 1983; Freeman and Louçã, 2001; Perez, 2002).

During the installation period of this revolution, the organizational challenges posed by new technologies became the focus of sustained attention. Exploitation of the new technologies was initially limited by industry's widespread reliance on craft-like variants of traditional management (Aitken, 1960; Nelson, 1980). Factory operations were typically led by multiple, independent internal contractors, each of whom hired and managed their own crews (often from their extended families), contracted with the owners to supply a given amount of output for a given price, and relied on their own traditional methods to achieve that output. Thus the typical factory functioned as "a loosely organized cluster of operations" characterized by "chaotic conditions" (Nelson, 1995: 35; see also Litterer, 1963). The dramatic growth in demand for steel enabled by the new technologies highlighted the need for more-scientific planning of workstation operations, of workflows between workstations, and of

machine and tool maintenance (Freeman and Louçã, 2001: 232–236; for an example of the interrelation between technological and organizational innovations, see Aitken, 1960: 102–103). The professionally managed firm paradigm had formalized management functions, but that paradigm and its associated line-and-staff and industrial betterment models did not offer an answer to this new type of problem.

In the late 1800s, Frederick W. Taylor was a key figure in the community of mechanical engineers and engineering consultants who identified and addressed this problem and suggested various new management concepts as solutions (Nadworny, 1957; Aitken, 1960; Nelson, 1980, 1992; Guillén, 1994). From the competition and cooperation among these actors, Taylor eventually emerged as preeminent. He attacked the underlying problem both technologically and organizationally. Through an unprecedented program of systematic engineering experimentation, he discovered a new way of tempering steel and invented a new high-speed cutting tool that used this steel to increase the machine-tool's speed from 90 to 250 revolutions per minute (Kanigel, 2005). The same spirit of systematic experimentation guided his organizational innovation efforts, resulting in time-and-motion studies, new principles in plant layout, and rationalized incentive payments (Nelson, 1975), whose synthesis became known as "scientific management."

This new scientific management model inaugurated the "factory" as a new organizational paradigm based on the exemplars of Midvale Steel and Bethlehem Steel (Nelson, 1980). This new paradigm was characterized by the unitary, centralized organization structure with a workflow designed to optimize and accelerate production across an interdependent set of operations—a radical shift from the prior paradigm's focus on the rational design of the management superstructure. Taylor disseminated scientific management through books (Taylor, 1911), lectures, and consulting for companies. After failing to mobilize the American Society of Mechanical Engineers (ASME) to diffuse this approach, he brought together a community of like-minded reformers in the Society to Promote the Science of Management (later renamed the Taylor Society), which became an important forum for discussion and publication of management concepts and tools for efficiency-oriented consulting (Aitken, 1960; Kaufman, 2008). Scientific management also got a major boost from industrial planning efforts during World War I (Bruce, 1995).

Taylor worked mainly in companies associated with the core new industries of this technological revolution, in which the dominant organizational and management problem—how to accelerate operations beyond what was possible under the traditional craft form of work organization—emerged earlier than in other industries. The historical novelty of the motivating problem explains the need for time-consuming experiments in Taylor's early organization change efforts at Midvale Steel. Taylor's version of the scientific management solution preserved something of this spirit of experimentation and exploration: his work as a change agent typically involved lengthy phases of analysis and experimentation, and he was hostile to those who sought to distill scientific management into a set of standardized solutions (see Aitken, 1960). This type of organization change process severely limited the speed and extent of scientific management's diffusion.

The new model's diffusion was greatly accelerated by larger consultancies such as Charles Bedaux's (Nelson, 1995). Bedaux, born 30 years after Taylor,

became part of the wider scientific management network in the early 1910s. By then, the economic crisis of the 1890s had been resolved, socio-economic circumstances had stabilized, and the macro-economic conditions for a broad diffusion of scientific management were more favorable. The dominant organizational and management problem was defined more narrowly as the “efficiency problem,” and scientific management was accepted as its solution (Nelson, 1992). The number of companies that asked for external help in implementing the first new management model of this age was much higher than in the age of the railways (Nelson, 1995), which led to the birth of the consultancy industry, with the Bedaux consultancy as its first leading company (Kreis, 1992; Kipping, 2002). Bedaux applied a very simplified variant of scientific management methodology that led to relatively quick results. It focused on time studies to identify bottlenecks and set production standards, and it installed an incentive wage system that pressured workers for greater output (Nelson, 1995). Some other consultants employed approaches more faithful to Taylor’s approach, but all of them confronted the need to simplify in order to grow their businesses profitably. Bedaux and his employees used their approach for a large number of clients from a wide circle of industries and later in different countries (Guillén, 1994). The difference between Taylor and Bedaux exemplifies the early phase of a deepening division of labor within the overall network of actors involved in the development and diffusion of new management models: between the innovator–theorist and larger consultancies that focus on dissemination to grow their businesses.

The wider application of scientific management frequently had dysfunctional side effects, particularly in the form of high turnover and low worker morale (e.g., Lewin, 1920; Gillespie, 1991) and vociferous (although not unanimous) union opposition (see Aitkin, 1960; Jacoby, 1983). Many of Taylor’s disciples argued that scientific management was not hostile to workers or unions (Nyland, 1998), but it was often implemented in ways workers resented and resisted (Bendix, 1956: 274–287; Aitkin, 1960). The source of this strife was different from that experienced by the railroads in the previous period. The earlier line-and-staff model had focused on the management structure rather than on workers’ tasks; the labor troubles that ensued were attributed to management’s ignorance of the deterioration of workers’ living and working conditions; and the industrial betterment remedy primarily added a social function among the staff responsible for improving the quality of workers’ lives. By contrast, scientific management aimed directly at the wage–effort bargain, and the ensuing strife was fueled by workers’ reactions to management’s efforts to take control over how and how fast workers would execute their tasks.

From among the various management concepts that developed in response to these problems, Elton Mayo’s and Fritz Roethlisberger’s “human relations” approach emerged as the dominant model.¹ The main actors involved in human relations were social scientists and personnel managers (see Guillén, 1994). In the 1920s and early 1930s, social scientists Mayo and Roethlisberger developed and conceptualized personnel counseling as a remedy to scientific management’s dysfunctions at a Western Electric factory. Supervisors tried to influence individual workers’ attitudes so as to (re-)create greater harmony and

¹ The most prominent alternative, focused on action research and group dynamic concepts, was created by the researcher Kurt Lewin (1947).

sense of community in the company (Roethlisberger and Dickson, 1939; Bendix, 1956: 308–319; Gillespie, 1991). Human relations theorists sought to counterbalance what they saw as the alienating effects of scientific management's time-and-motion regimentation and incentive payment systems.

Both the scientific management and human relations models eventually diffused widely across U.S. industry, aided considerably by the Training Within Industry (TWI) program conducted during World War II (War Manpower Commission, 1945; Gillespie, 1991; Robinson and Schroeder, 1993; Breen, 2002). TWI was a government-subsidized, nonprofit network that brought together several actors and organizations to train supervisors from over 16,000 plants with the goal of rapidly adapting U.S. industry to wartime production needs. TWI did not treat human relations as incompatible with scientific management; it sought to integrate the two approaches and facilitated their respective tools' adoption with standardized training programs and materials. TWI's "job methods" module was based on scientific management, and its "job relations" module was a simplified and codified version of the human relations "personnel counseling" method. A second strand of explicit synthesis was proposed by the sociotechnical systems approach, which started as an attempt to integrate "technical" scientific management and "social" human relations (see Trist and Bamforth, 1951; Emery and Trist, 1969; Cummings, 1978).

Notwithstanding some rhetorical gestures suggesting a more radical goal, and notwithstanding the declared hostility of some human relations advocates to scientific management, the human relations model did not displace scientific management but rather helped to reconcile workers to the new organizational paradigm inaugurated by the scientific management model (see Mayo, 1924). Industrialists such as John D. Rockefeller, Jr. exerted significant influence in Mayo's human relations network and strongly supported this role for it (O'Connor, 1999; Bruce and Nyland, 2011; Hassard, 2012). Human relations was thus a paradigm-balancing model rather than a paradigm-revolutionizing one. Whereas scientific management represented an effort to adjust the organization to a radical technological change—reestablishing what organization theorists call environmental or external fit—human relations represented an effort to realign organizations' elements to better fit each other—reestablishing internal fit (Miller, 1992).

The Automobile and Oil Revolution

The subsequent wave of technological revolution (approximately 1880s–1980s) introduced the automobile powered by an internal combustion engine; the development of assembly-line technology in that industry and then in others; the use of oil as a core input; the resulting explosion in demand for automobiles by both industry and households; and the creation of networks of highways as part of the new transport infrastructure (Perez, 2002).² But this generalization of mass production and consumption was out of sync with the inherited context at both the societal and organizational levels, so it led to increasing market

² This revolution also saw a generalization of the use of electricity, a general-purpose technology that was important in several successive technological revolutions. We should also note that the final period of the steel and electric power revolution overlapped with the installation period of the automobile and oil revolution, and as a result, human relations and strategy-and-structure also overlapped in time and often in organizations too.

instability in the 1920s and 1930s (see Fligstein, 1990). The unitary functional organization structure of the factory paradigm, with its inherited orientation toward single product lines, could not respond effectively to the growing diversity of expanding consumer needs. Firms needed a more flexible and market-focused organizational form geared toward changing markets, rapid product development, and manufacturing and marketing on an increasingly global scale.

The main actors involved in identifying and resolving this challenge were managers, management theorists, and management consultants associated with the automobile industry and other industries in the core of this technological revolution (see Guillén, 1994). Managers such as Alfred Sloan at General Motors (GM) recognized the inadequacy of the inherited organizational paradigm and searched for solutions in their companies, resulting in a variety of new ideas. Sloan's search was based on the expectation that the diffusion of automobiles was "creating a new transportation system" (Sloan, 1964: 43) that would involve many more, and more-diverse, consumers. His solution, developed in the 1920s, was a radically new management model in which differentiated market segments would be assigned to distinct, more or less self-contained, business divisions—the "strategy-and-structure" model. This model allowed GM to pursue a strategy of product differentiation and shared parts, and thereby to overtake Ford as the preeminent auto firm (Chandler, 1962). It also inaugurated a new organizational paradigm: the multi-divisional "corporation" replaced the unitary factory as the paradigmatic frame of reference.

This model's diffusion across the new core industries helped to unleash rapid productivity increases and contributed to the dynamism of the 1920s; but the institutional framework was out of sync with these dynamics, and (with several other factors contributing) the Great Depression ensued (Perez, 2002). Though Sloan's organizational innovation occurred before the Great Depression, it was only after the radical institutional reforms of the New Deal and World War II and after the stabilization of the post-war economy that the strategy-and-structure model diffused beyond the core industries. The management theorist Peter Drucker (1946) was among the first to generalize and elaborate the innovative solution developed at GM, articulating and theorizing its core concepts. Drucker helped to disseminate the model through publications and as a consultant. He also led training sessions for junior members of the management consultancy McKinsey in the late 1940s and early 1950s (Edersheim, 2004). Like Taylor, however, Drucker saw organization change as an exploratory process (Drucker, 1954), and this type of practice yielded only slow diffusion.

Management consultancies took up the challenge of further codifying the new model, and firms such as McKinsey eventually came to dominate its diffusion (Kipping, 2002; McKenna, 2006). Treating the underlying organizational and management problem as basically resolved by these solutions, they disseminated the results of the prior innovation and theorization efforts in the form of best-practice templates to many corporations that faced similar problems. McKinsey recruited new employees from prestigious business schools, developed an elaborate internal hierarchy of consultants, and cultivated a network of repeat-business clients. This system enabled the multiplication of interventions with clients in many industries and, increasingly, in many countries (Bhide, 1996; Edersheim, 2004). The development and diffusion of the new model involved a division of labor among the problem articulator and innovator (Sloan),

the guru–theorist (Drucker) who transformed Sloan’s solution into a management tool, and larger consultancies that further simplified the tool to grow their businesses.

For a long period, the strategy-and-structure model, enhanced by management concepts such as operations research, “marched from victory to victory” (Womack, Jones, and Roos, 1990: 43), and the success of U.S. companies in the world market distracted enthusiastic proponents of the model from its limitations (Dertouzos, Lester, and Solow, 1989; Womack, Jones, and Roos, 1990). Despite the development of management concepts such as matrix management, and despite efforts to match organizational structure to “contingency factors” (Burns and Stalker, 1961; Woodward, 1965; Lawrence and Lorsch, 1967), these limitations led to poor quality and service, low worker involvement, and lack of cooperation and political gamesmanship in the management ranks. When global competition intensified as Japan and Germany rebuilt after World War II and reasserted their industrial strength in the 1970s and 1980s, these problems could no longer be ignored (see Dertouzos, Lester, and Solow, 1989).

Various and partially intertwined problem-solving efforts emerged, each addressing one or more of the dysfunctions. Alongside concepts such as the “learning organization” (Argyris and Schön, 1978) and “organizational culture” (Schein, 1985), the most popular effort was associated with the quality movement (see Cole, 1998, 1999). The new “quality management” model, with total quality management (TQM) as the key concept, borrowed extensively from Japanese competitors. When the quality improvement problem came to the fore in the U.S., it had already been addressed in Japan (Cole, 1998; Winter, 2000). After World War II, the Japanese automobile industry was in a deep crisis. A series of organizational innovations led to the emergence of what was later called the Toyota Production System. In the course of defining and resolving the challenges Toyota faced, its chief engineer Taiichi Ohno (1988) criticized management practices that led supervisors and shop-floor personnel to prioritize production over quality. Fearful of negatively affecting productivity, workers and foremen typically passed errors downstream rather than call attention to them—a practice that was ultimately wasteful. Mobilizing shop-floor personnel for eliminating waste and improving quality became a core element of the Toyota Production System and its associated management system (Ohno, 1988; Liker, Fruin, and Adler, 1999).

In contrast, U.S. firms had long relied on staff experts to track quality and set quality targets, whose optimal levels were based on the assumption that quality and productivity were in a trade-off relationship. Japanese competition brought an awareness that competitive advantage could be derived from shifting this trade-off, and, to effect this shift, primary responsibility for quality could be moved from staff to line personnel. Quality theorists argued that prioritizing quality was the secret of Japanese manufacturers’ success (Cole, 1999). Acting as bridges between Japan and the U.S., they developed a set of management tools aimed at quality improvement, later popularized as TQM (Hackman and Wageman, 1995). These change-agents’ efforts were constrained by the arrogance of established (U.S.) industry leaders when faced with upstart (Japanese) challengers (Cole, 1999). Over time, however, the quality movement developed a broad following impressed by its capacity to address the key dysfunctions of the strategy-and-structure approach while

leaving intact its basic elements: the divisionalized firm, with financial and strategic but not operational controls over the operating divisions.

The quality management model shared some features with the human relations model, notably a concern with employees' attitudes, but the differences are also striking. Whereas human relations was focused on individual employees and motivated by concern with their alienation and resistance to task control, quality management was motivated by process and product quality and focused on teams and their engagement with this dimension of their work.

One of the main mechanisms for diffusing the model was the Malcolm Baldrige National Quality Award (for others, see Cole, 1999). Created in the U.S. in 1987 by the government, scholars, and leading companies (Garvin, 1991; Cole, 1998), the Baldrige system synthesized the overlapping principles and techniques of a host of theorists and quality gurus. When a growing number of U.S. industries came under intense and global competitive pressure in the 1980s and 1990s, Baldrige offered them an iterative process of learning, implementation, and practice that promised superior performance (Cole, 1998). It spread from core manufacturing industries to the service sector, including finance, schools, hospitals, and government. The division of labor here was similar to that in the human relations case. Innovators contributed to creating a solution, and theorists conceptualized TQM as a management tool. The Baldrige system established a network that linked actors from government, science, and industry in disseminating this tool. The network of actors involved in developing the system, however, was considerably more diverse than in TWI, and the result was a whole family of best-practice exemplars rather than a single standardized set of procedures.

The Computers and Telecommunication Revolution

The 1970s saw the beginnings of a new wave of technological revolution, which had incubated during the 1950s and 1960s and then took off as the previous revolution moved into its exhaustion period. Successive innovations in microelectronics, computers, the Internet, and eventually mobile telephones provided opportunities for new industries, a new infrastructure of digital and wireless networks, and much wider and cheaper access to information and communication pathways. Identifying computers and telecommunication as the next technological revolution in the sequence is not particularly controversial, but identifying the corresponding organizational and managerial transformation is riskier. Efforts to put the more-recent past in historical perspective always run the risk of premature assessment (Chandler, 1990: 628). With that caveat, we offer the following working hypothesis.

The new technologies enabled the emergence of more-complex and dispersed organizing structures and relationships (networks, internal markets, outsourcing relationships, etc.), and the resulting organizational complexity called for some kind of rationalization. A variety of concepts emerged to fill that need and to simplify and transform the way work was done. Conversely and simultaneously, the new technologies represented solutions looking for bigger problems to solve, and the implementation of new computer-based technologies initially yielded frustratingly limited improvement in organizational performance (see, e.g., Zuboff, 1988). A host of economic indicators showed a disturbing lag in productivity gains during the 1970s and 1980s relative to the massive wave

of investment in information technology (IT)—the so-called “productivity paradox” (Solow, 1987; Short and Venkatraman, 1992). Effectively exploiting the new opportunities offered by IT would require expanding its role beyond support functions and expanding its functionality beyond the automation of stand-alone technical or administrative tasks. The key organizational and management problem was therefore how to use IT to rationalize operations across broader spans and higher levels of decision making and to adapt accordingly organizational strategy, structure, systems, and processes (Venkatraman, 1991).

Resolving this problem led to the emergence of a paradigm-revolutionizing management model that we call the “business process” model, which was initially dominated by two competing management concepts: business process reengineering (BPR) (Hammer, 1990; Hammer and Champy, 1993) and business process redesign (Davenport and Short, 1990; Davenport, 1993). The common core was their “process orientation” (Davenport, 1995), which encouraged firms to rationalize not only the processes that linked activities but also the location of the organizational boundaries that separated those activities.

The centrality of the business process model was buttressed by the emergence of the concept of “supply chain management” (Cooper, Lambert, and Pagh, 1997). IT tools were created to standardize interfaces and linkages and thus to facilitate the flow of information across boundaries both within and between firms (Lambert and Cooper, 2000; Sturgeon, 2002; García-Dastugue and Lambert, 2003). Along with this change in organizational structure, strategy shifted its focus from “corporate strategy” to “core competencies” and “strategic alliances” (e.g., Gulati, 1998; Gulati and Singh, 1998; Ireland, Hitt, and Vaidyanath, 2002; Lavie, 2006).³

The business process model thus inaugurated a radically new organizational paradigm, which we call the “network” (Langlois and Robertson, 1995; Sturgeon, 2002).⁴ This paradigm focused attention on network ties—work and information flows—across units within the enterprise as well as between the focal enterprise and other enterprises up- and downstream (see Short and Venkatraman, 1992). The main actors helping to establish the new model and paradigm were IT specialists in companies, academia, and consultancies. BPR had its origins in a collective research project known as PRISM. In a series of case studies, the PRISM project brought together theorists such as Thomas Davenport and Michael Hammer; practitioners such as Charles Sieloff at Hewlett Packard (HP), Charles McCaig and Keith Glover at Mutual Benefit Life, and others at American Express and IBM; and consultants such as James Champy to define the problem, capture and theorize solutions, and develop

³ Kunda and Ailon-Souday’s (2005) characterization of “market rationalism” covers much the same conceptual terrain as we associate with the business process model but without linking this new “rational” pendulum swing to the emergence of IT.

⁴ Of course, networks of organizations existed before the IT revolution, for example in form of the pre-industrial European putting-out system (e.g., Mendels, 1972; Mokyr, 2001), nineteenth- and early twentieth-century industrial districts in the UK (e.g., Marshall, 1919), and the late twentieth-century interlinked microfirms in the Italian Emilia-Romagna region (Piore and Sabel, 1984; Lazerson, 1995). But all these examples depended on strong local ties. Other networks, such as hawala, the Muslim world’s money transfer system (El Qorchi, Maimbo, and Wilson, 2003), span larger geographies without advanced technology but rely on strong ethnic/religious ties. The establishment and worldwide diffusion of global supply chains became possible only on the basis of IT and telecommunication tools and infrastructure (Sturgeon, 2002).

dissemination approaches (Davenport and Short, 1990; Davenport, Prusak, and Wilson, 2003). The companies involved were often in the revolution's core industries. Hammer, Champy, Davenport, and Short theorized the organization innovations advanced by the IT practitioners and transformed them into a management model, reaching guru status when they published their respective articles and books (Davenport and Short, 1990; Hammer, 1990; Davenport, 1993; Hammer and Champy, 1993). The guru-theorists were further involved in supporting the practical dissemination of the business process model: Hammer created his own consultancy, and Davenport has directed research centers of Accenture and other IT consultancies.

Large IT consultancies such as Champy's CSC Index and subsequently Andersen Consulting/Accenture played a key role in the model's diffusion (Fincham, 1995; Fincham and Evans, 1999). Andersen/Accenture developed an elaborate, standardized consulting process to support this line of work, relying on sophisticated IT support for conducting intervention steps and on modules of ready-made solutions. This standardization allowed consultants to conduct industrial-scale business process projects, profitably leveraging less experienced (and less expensive) consultants (Nanda, 1995; Thompson, 2004; Falk, 2005). Eventually, enterprise-systems vendors such as SAP also came to play key roles in disseminating the model, relying even more than large consultancies on generic best-practice exemplars that abstracted from companies' specific needs (Davenport, Prusak, and Wilson, 2003).

We acknowledge that it is not self-evident that the business process model should be classed as a management model comparable in generality and pervasiveness to scientific management or strategy-and-structure. Its initially dominant concept, BPR, had a faddish quality, pushed aggressively by consultancies and then rapidly abandoned as a consulting product. Yet this model's process orientation lived on and was widely diffused, assisted by concepts such as supply chain management. Davenport (1995: 74–75) seems to support this interpretation:

The most profound lesson of business process reengineering was never reengineering, but business processes. Processes are how we work. Any company that ignores its business processes or fails to improve them risks its future. That said, companies can use many different approaches to process improvement without ever embarking on a high-risk reengineering project.

BPR was contested from very early on. Through the 1980s and 1990s, one of the IT specialists involved, HP's Sieloff (1999: 47), argued that "knowledge management" was more critical than the IT infrastructures emphasized by BPR proponents. Sieloff's point of view was captured in the aphorism, "If only HP knew what HP knows." Davenport himself (Davenport, Prusak, and Wilson, 2003) criticized Hammer and Champy's version of BPR for ignoring Sieloff's point and overselling and oversimplifying BPR. Critics argued that BPR had become an excuse for massive layoffs, and the failure rate of big BPR projects was distressingly high (see Champy, 1995; Davenport, 1995). These failures typically occurred when large consultancies designed radically new work processes without consulting the front-line practitioners who knew most about these processes and without taking the time to redesign work processes that would fit the client organization's specific needs (Davenport, Prusak, and

Wilson, 2003). Critics said the factor driving this short-sightedness was exacerbated competition for profit and growth among the consultancies (see Davenport, 1995; Davenport, Prusak, and Wilson, 2003).⁵

The dysfunctional side effects of the business process model were addressed by various and partially intertwined problem-solving efforts, perhaps the most prominent of which was the one anticipated by Sieloff and known as "knowledge management" (e.g., Nonaka and Takeuchi, 1995; Davenport and Prusak, 1998; Brown and Duguid, 2000). A fundamental goal of knowledge management was to mitigate the risk that business process-related reengineering, downsizing, and outsourcing programs would destroy the fabric of collective tacit knowledge shared among experienced employees both within and across interdependent firms. The key to accomplishing this was to reestablish, strengthen, and deploy the collective knowledge-generating and -sharing capacity of geographically and organizationally dispersed personnel working in related domains. Knowledge management's focus was thus broader than the focus on individuals or teams found in prior secondary model-development cycles. It was now on more-diverse and extended collectivities, labeled by Lave and Wenger "communities of practice" (Lave and Wenger, 1991; Wenger and Snyder, 2000; see Brown and Duguid, 1991).

As with prior paradigm-balancing models, knowledge management did not lead to a new organizational paradigm but instead rebalanced the network paradigm by mitigating the dysfunctional side effects of the business process model. Compared with the prior cycles, however, the business process model's innovation and dissemination phases were more intertwined, and the dissemination of this model provoked much sooner a corresponding paradigm-balancing effort in the form of knowledge management.

The main actors in the development and diffusion of knowledge management were IT practitioners, IT theorists, IT consultants, and HR managers (see Scarbrough and Swan, 2001). One strand of development involved many of the original actors of the business process network, leading from innovative knowledge management practices developed in U.S. companies such as HP by IT specialists such as Sieloff (1999) to scholars such as Davenport and Prusak (Prusak, 1997; Davenport and Prusak, 1998; Davenport, Prusak, and Wilson, 2003) who theorized and elaborated these innovative practices. A second strand led from innovative practices created in Japanese companies such as Honda, Canon, and NEC to the theorization of Nonaka and Takeuchi (Takeuchi and Nonaka, 1986; Nonaka, 1991, 1994; Nonaka and Takeuchi, 1995) and in particular to Nonaka and Toyama's (2003) concept of "ba," which seems close to that of community of practice (as suggested by Choo and Alvarenga Neto, 2010). We understand knowledge management here in a broad sense, as the cultivation of knowledge-creating and knowledge-sharing communities of practice. Various management concepts might be arrayed under its umbrella, such as the Scrum and agile methods of software development, "coworking spaces" (Johns and Gratton, 2013), and "open innovation." Knowledge management is thus more general and pervasive than it seems and perhaps

⁵ We thank one of our reviewers for suggesting that BPR was so focused on cost reduction and more effective "exploitation" of IT's potential that it was bound to provoke a response aimed at supporting industry's "exploration" efforts (using March's, 1991, exploitation/exploration distinction).

warrants status as a management model. Our argument is that knowledge management was ultimately driven by the computers and telecommunications revolution but was deeply marked by its role as a (secondary-cycle) response to the deficiencies of the business process model, which was the prior (primary-cycle) response to that revolution. This interpretation is consistent with the history offered by Koenig and Neveroski (2008), but it is a hypothesis that needs further testing.

Concepts and methodologies related to knowledge management were diffused by larger IT consultancies (Davenport and Prusak, 1998; Scarbrough, 2002) but also by many smaller consulting businesses such as Prusak's (1997), by academic institutions (Davenport, Prusak, and Wilson, 2003), and by intra- and inter-organizational networks of the model's proponents (see Scarbrough and Swan, 2001). IT consultancies often focused on the IT infrastructure, while the other actors increasingly focused on establishing and cultivating the social networks and shared values that supported communities of practice (Hansen, Nohria, and Tierney, 1999; Wenger, McDermott, and Snyder, 2002).

Some observers claim that the implementation of knowledge management techniques and tools did not live up to the promises made by guru-theorists and consultancies (Rigby, 2001; Scarbrough, 2002; Spender, 2005), and many large consultancies abandoned knowledge management as a product line soon after its boom in the second half of the 1990s (Grant, 2011). Whereas major business process IT infrastructure projects may have yielded disappointingly few benefits for the clients, projects aimed at implementing communities of practice yielded even less profit for the larger consultancies. Yet proponents have continued advocating knowledge management and hold out hope for its future development (see Grant, 2011).

The IT revolution is far from exhausted as of this writing. The bursting of the Internet bubble in 2001 and the financial crash of 2008 revealed major institutional misfits that would need to be resolved before IT could be deployed effectively across wider swaths of industry, and in vast regions of the economy its deployment has been as yet limited. IT has the potential to de-mature, for example, the automobile, transport, and logistics industries, sparking new developmental trajectories in the leading industries of the prior wave. The emergence of autonomous vehicles and the more-general idea of an "Internet of things" (e.g., Atzori, Iera, and Morabito, 2010; Hui, 2014) underscore the massive untapped potential for IT to revolutionize many more parts of industry and everyday life. We have barely begun to see full-scale deployment in health-care or education.

Notwithstanding this uncertainty, one feature of the current wave of technological change is noteworthy: it has brought challenges, first to the role of gurus with oversimplified best-practice theorizations (see Abrahamson, 1996; Kieser, 1997) and second to the profit-driven diffusion of these models and tools by large consultancies (see Clark and Fincham, 2002; Kipping and Engwall, 2002; Kipping and Clark, 2012). Such criticisms have already inspired the exploration of alternatives to guru- and consultancy-dominated processes of creating and diffusing management models. Some have argued for a new role for scholars, such as in the engaged scholarship proposed by Van de Ven and Johnson (2006) and Van de Ven (2007). Others have argued for new forms of action research, such as the Finnish methodology Developmental Work Research developed by Engeström (2005), which uses interventionist research to

stimulate organizations' innovation capacity. And there has been a proliferation of "collaborative" forms of mutual learning among practitioners (Kilo, 1998; Øvretveit et al., 2002; Schouten et al., 2008; Devers, Foster, and Brach, 2013). The criticism of consultancies and the exploration of alternative organizational innovation and change mechanisms seem to have further intensified since the most-recent financial crisis (e.g., Hodgkinson and Starkey, 2011; Alvesson, 2013).

THREE NESTED, INTERACTING PROCESSES

The evolution of management models can be theorized as the result of the interplay of three nested and interacting processes driven by successive waves of technological revolution. We present these processes here, zooming in from macro to micro. We understand these processes as relatively autonomous yet interdependent and interacting. In this characterization, we take inspiration from Freeman and Louçã's (2001) approach to historical analysis and evolutionary theories that allows for both bottom-up and top-down innovation and selection; a similar approach was adopted by Geels and Schot (2007).

Four Major Waves of Paradigm Change

Our sketch of almost two centuries of management models emphasizes long waves of technological revolution that prompted the emergence of new organizational challenges. We are certainly not the first to identify a long-wave pattern in management history, but there is debate over how to interpret it. By shifting our focus from the Kondratiev waves of GDP growth emphasized in prior scholarship to waves of technological revolution, we can see that each revolution posed radically new problems in industry, which in turn prompted the emergence of radically new organizational paradigms in each wave as part of the process of "creative destruction" (Schumpeter, 1942: 83).

In the first period of each of the last four major technological revolutions, new technologies emerged and became the basis for the growth of new core industries (railroads and steam power, steel and electrical power, automobile and oil, computers and telecommunication), in which organizational and management problems were acute enough to prompt substantial and disruptive organizational innovation. Each revolution generated a qualitatively new paradigm: professionally managed firm, factory, corporation, and network. Companies emblematic of progress in one paradigm—such as the Erie Railroad, Bethlehem Steel, and General Motors—appeared in the subsequent waves as "dinosaurs" (Perez, 2010).

Two Model-development Cycles in Each Wave

Moving down to the next nested level, we observe two model-development cycles in each major wave of change. Where Barley and Kunda (1992) and Kunda and Ailon-Souday (2005) saw the alternation between rational/technical and normative/human cycles as a pendulum movement between incommensurable antinomies reflecting a deep dualism in our culture, we argue that these cycles are better understood as poles of a dialectical contradiction finding expression in primary and secondary model-development cycles. The second

pole in the pair opposes the first but also presupposes it, and the two do not simply oscillate as a pendulum but are eventually synthesized before a new technological revolution renders that synthesis obsolete.

Consider the sequence of models across the four main waves of technological revolutions. The first primary model-development cycle (sparked by the steam power and railways revolution) yielded the line-and-staff model and contributed to the establishment of a new organizational paradigm, the professionally managed firm. But this cycle led also to a degradation of working and living conditions for workers, which provoked conflicts that led to a secondary cycle that gave rise to the industrial betterment model. Industrial betterment did not undo the line-and-staff model but added a counterbalancing social function in the form of welfare secretaries.

The second primary cycle (sparked by the steel and electric power revolution) yielded the scientific management model and contributed to a new organizational paradigm, the factory, but led also to high turnover and low worker morale due to close control over how and how fast tasks were performed. These problems provoked a secondary cycle that yielded the human relations model, which built on some of industrial betterment's ideas but also introduced new management concepts to deal with the distinctive features of problems introduced by scientific management. Human relations did not undo scientific management but rebalanced the factory paradigm.

The third primary cycle (sparked by the automobile and oil revolution) yielded the strategy-and-structure model and contributed to the establishment of a new organizational paradigm, the corporation. But it led to poor quality and service, low worker involvement, lack of cooperation, and political games among managers, which provoked a secondary cycle aimed at quality, organization culture, and organization learning. The resulting quality management model did not undo the strategy-and-structure model but remedied its dysfunctions and stabilized the corporation paradigm. Quality management inherited some ideas from human relations and industrial betterment and introduced novel concepts motivated by the distinctive problems arising from the strategy-and-structure model, which focused on the team and its responsibility for improving quality.

Our analysis of the most recent wave was more tentative, but we suggested that the fourth primary cycle (sparked by the computers and telecommunication revolution) yielded the business process model and contributed to a new organizational paradigm, the network. Here IT was deployed to outsource all non-core activities and to rationalize the management of both internal and supply-chain processes. But this cycle led to the neglect of human involvement and weakened the innovation-generating capacity of firms, provoking a secondary cycle that led to the knowledge management model. There is some continuity of knowledge management with prior paradigm-balancing models, but we see conceptual innovation around the idea of community of practice.

Generalizing across these four waves, we see that each primary cycle focused on developing a model that facilitated the exploitation of the new possibilities generated by a new technology—overcoming the limitations in this new technological context of the paradigm inherited from the prior revolution, and leading to the emergence of a new organizational paradigm. The secondary cycles responded to unanticipated problems created by the limitations of primary-cycle models and aimed to rebalance the new paradigms. Our historical account offered some evidence for this interpretation, and table A1 in the

Online Appendix offers further textual evidence for it in the words of proponents of each of the secondary-cycle models who explicitly referenced this rebalancing goal.

The paired models reflect a contradiction—with the second simultaneously opposing and presupposing the first—rather than a cultural antinomy. Beneath the appearance of alternation, the two models eventually give way to a dialectical synthesis. Industrial betterment's welfare secretaries evolved into personnel managers—specialized staff managers who were integrated into and enhanced the effectiveness of the line-and-staff model in professionally managed firms. Although human relations proponents often portrayed their efforts as opposing scientific management, in reality the two models were often used in conjunction, and under TWI they were explicitly synthesized. Similarly, quality, culture, and learning approaches were often portrayed as opposed to the mechanistic bureaucracy of strategy-and-structure, but in practice these normative and rational approaches were typically combined (see e.g., Bate, Khan, and Pye, 2000; Beer and Nohria, 2000). More recently, theorists such as Davenport have sought a synthesis of the business process model and knowledge management (Davenport, 2010).

Four Problem-solving Phases in Each Cycle

To avoid an excessively mechanical account of this evolutionary process, we zoom in one more step to account for the actors who contribute to the birth of new management models and their diffusion. This process unfolds in four inter-related, overlapping, and non-linear phases: (1) various efforts are made to articulate a widespread organizational and management problem, (2) competing management concepts offer innovative solutions, (3) a management model emerges from among these concepts as a theorized solution, and (4) the management model is diffused.⁶ Each phase is typically dominated by different actors, and the different pressures and opportunities they face influence the successes and failures of diffusion of any given model.

These four phases and their constituent moments are often discussed separately in the management literature. Many studies focus on problem articulation (e.g., Cowan, 1986, 1990; Landry, 1995; von Hippel and Tyre, 1996), management innovation (e.g., Damanpour, 1991; Van de Ven, 1999), theorizing management concepts (the literature on management fashions, e.g., Abrahamson, 1996; Kieser, 1997; Suddaby and Greenwood, 2001, 2005), or diffusing management concepts (the literature on consultancies, e.g., Clark and Fincham, 2002; Kipping and Engwall, 2002; Kipping and Clark, 2012), but our understanding is deepened if we see their interconnection. Birkinshaw, Hamel, and Mol (2008) showed the way in an account that addresses the first three phases.

The cycle characterized by these four phases parallels, as Barley and Kunda (1992) demonstrated, the evolution of successful social movements (e.g., Blumer, 1969; Macionis, 2012); we argue that it also parallels the trajectory followed by individual technological innovations (e.g., Utterback and Abernathy,

⁶ Though both sequences might be represented as S-shaped logistic curves, the four phases are different from the four periods of a technological revolution: the former are notional and in reality they are interrelated, overlapping, and non-linear; the latter are distinct historical periods in the trajectory of a given cluster of technologies.

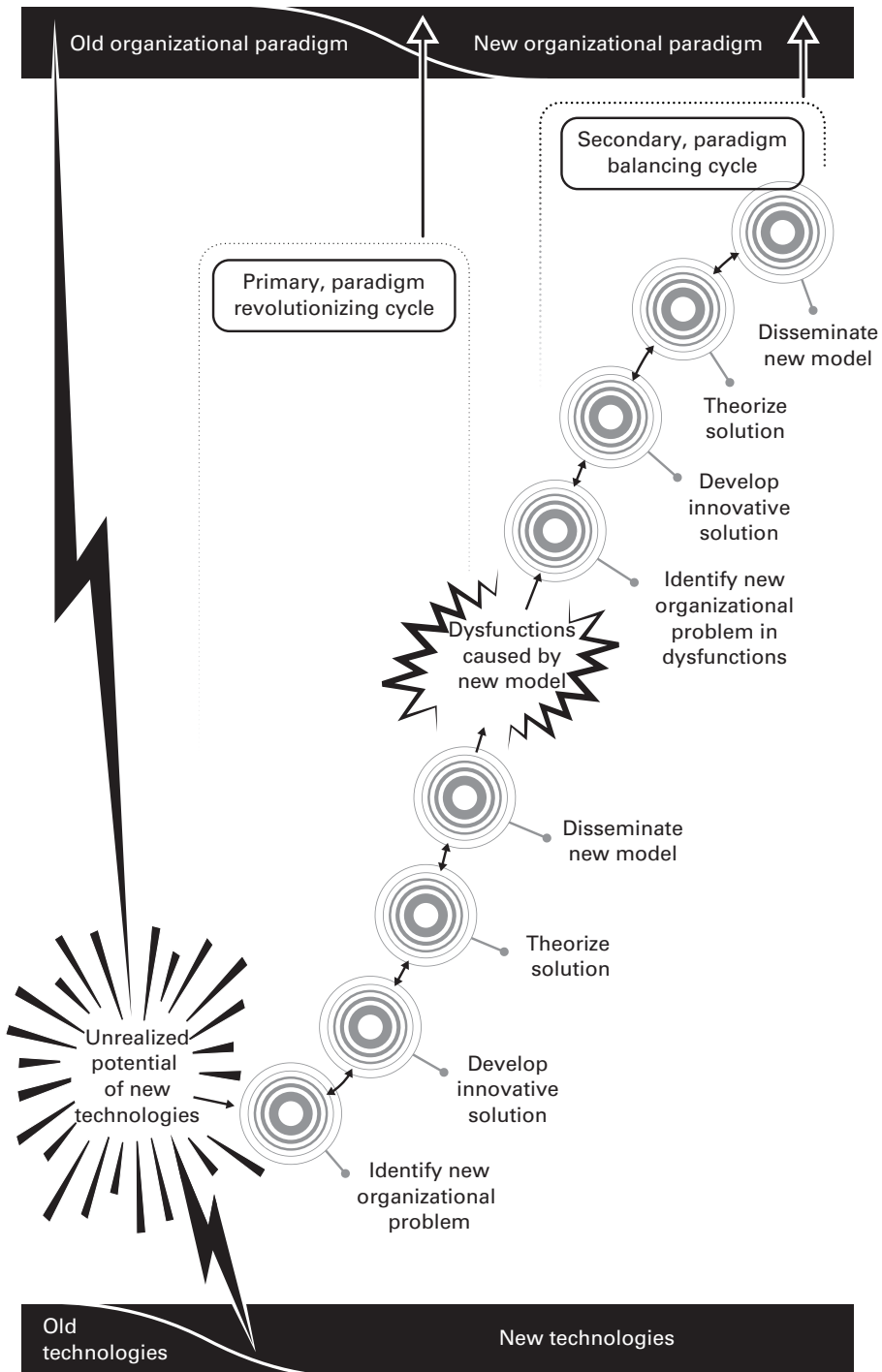
1975; Dosi, 1982; Nelson and Winter, 1982; Freeman and Louçã, 2001; Perez, 2002; Murmann and Frenken, 2006). Such a trajectory starts with a technological discontinuity and the identification of “reverse salients”—the parts of the emergent new system that lag the advancing performance frontier and hamper its progress (Hughes, 1993). Various actors address these reverse salients through experimentation (Abernathy and Utterback, 1978; Perez, 2010), and as they are overcome, there emerges a “dominant design” (Utterback and Abernathy, 1975; Utterback and Suárez, 1993), “technological paradigm” (Dosi, 1982), or “technological guidepost” (Sahal, 1981). A dominant design functions like a technology standard: technological innovation can now focus on improving the processes for implementing that design (Abernathy and Utterback, 1978). This opens the diffusion and adaptation phase, when process innovation efforts come to the fore (Nelson and Winter, 1977) along with incremental product innovations compatible with the dominant design (Utterback and Abernathy, 1975). The diffusion process is further accelerated by mechanisms such as bandwagon effects and network externalities (Arthur, 1988).

Consider the phases of managerial innovation in light of what this literature has taught us about the phases of technological innovation. In the first phase, innovators articulate a widespread organizational and management problem—an organizational reverse salient. For primary-cycle, paradigm-revolutionizing models, this reverse salient is the inadequacy of prevailing models of management relative to the potentialities of the new technologies. One indicator of such a reverse salient is “productivity paradoxes” such as the one observed in the 1980s (Solow, 1987; see also David, 1990). For secondary-cycle, paradigm-balancing models, the reverse salient is the disruption caused by the inadequacy of the primary-cycle model. In a primary cycle, the salient is encountered first by actors in the new core industries, such as McCallum at the Erie Railroad, Taylor at Midvale Steel, Sloan at GM, and Sieloff at HP. In the secondary cycles, the salients are felt more diffusely. Figure 1 offers a simplified visualization of both reverse salients, the cycle each sparks, and the eventual impact on management models and organizational paradigms.

The second phase of this cycle—creating innovative solutions to the problem—typically involves considerable experimentation in a cyclical movement of “reflective thought and action” (Dewey, 1910) or of “expansive learning” (Engeström, 1987, 2005). As in the cases of Taylor, Mayo/Roethlisberger, and Ohno, such processes often take many years, during which multiple management concepts emerge, compete with, and complement each other.

In the third phase, a new model emerges from among the promising concepts and offers a theorized solution, which facilitates diffusion to other companies and industries. The challenge in this phase is to find what Davydov (1990) characterized as a “theoretical generalization”—the simplest conceptualization of a phenomenon that captures all its relevant elements and relationships and provides the methodological means for relating different variants of the phenomenon to each other, so it can apply in different contexts. Winter and Szulanski (2001: 731) characterized this challenge as identifying the innovation’s “Arrow core”—“knowledge of which attributes are replicable and worth replicating, together with knowledge of how these attributes are created.” This process is advanced by theorists (Taylor, Mayo/Roethlisberger, Drucker, Deming/Ishikawa/Juran, Hammer/Davenport, Nonaka/Takeuchi) who are typically connected to companies in which the innovations are developed and are

Figure 1. Primary and secondary cycles.



knowledgeable about the respective new technologies or the social problems following their implementation.

In the fourth phase of this cycle, the successful theorists' ideas are popularized in articles and books and sold as products by larger consultancies (Bedaux, McKinsey, CSC/Accenture, etc.) and public-sector organizations (TWI, Baldrige), which further codify the models to maximize their utility for industrial-scale implementation of solutions in many client companies.

A Multi-layered Evolution

As depicted in figure 1, the interaction of these three processes—waves, cycles, and phases—operates along the lines suggested by Giddens (1984) in his characterization of the mutual constitution of structure and action (see also Barley and Tolbert, 1997). When actors are confronted with a technological revolution that radically transforms the structure of technological constraints and affordances, they also face the inadequacy of existing management paradigms, models, and concepts. The resulting structural tensions prompt actors to create, theorize, and spread organizational innovations that contribute to resolving these tensions by the formation of new management concepts. Through trial and error, some concepts eventually cohere as a robust new management model, which first revolutionizes and then rebalances a new organizational paradigm that fits the new technological conditions.⁷

Once a paradigm, model, or concept achieves a dominant position, it functions as a new "structure" in Giddens' (1984) sense, exercising "downward pressure" that shapes subsequent action by creating a taken-for-granted frame of reference, associated routines and artifacts, and new interests vested in the new status quo. Paradigms, models, and concepts are thus all structures "stretching across time-space" (Giddens, 1984: 377), but they vary in their generality, pervasiveness, and durability: paradigms are more durable than models, and models more durable than concepts. As a result, management innovation progresses—via the mutual constitution of agency and structure—from concepts to models to paradigms, challenging and eventually changing those structures.

DISCUSSION

We have argued that the evolution of management models can be understood as the result of the interplay of three interacting processes. Here we explore whether this account helps us make sense of emerging new management concepts and longer-term trends.

Emerging New Concepts

The present is always difficult to see in historical perspective. This difficulty cannot be completely avoided, but we can manage it better if we are armed with a more-robust theory of the forces shaping change. Our theory suggests that in aiming to interpret any given management innovation, we should ask: Is it responding to a technological revolution? Is it associated with a specific

⁷ In parallel with this process, other actors, working in other spheres of activity, are developing ideas and artifacts that will eventually manifest as a new technological revolution.

paradigm? Is it associated with a specific management model? But our theory also suggests that there is no quick way to arrive at a convincing answer to such questions: we need to parse carefully the four phases of the management innovation's development; examine the problems and opportunities that motivated an innovation's originators; and identify where in the industrial landscape those problems and opportunities arose most forcefully and where the emerging solutions found most enthusiastic reception. We also need to explore the similarities and differences with existing concepts and models. Only through such a multi-dimensional study can any innovation be characterized with much confidence. Not surprisingly, the study of present-day innovations in progress is particularly difficult.

With that huge caveat, let us see what light we can shed, first, on the concept of "open innovation." As we read the available research, it seems that the downsizing, outsourcing, and focus on core competences associated with business process initiatives in the 1990s had the unintended side effect of potentially limiting a company's innovation-generating capacities to those available within. To overcome this limitation required a broader view of the communities of practice that could contribute to innovation generation (Fjeldstad et al., 2012). The success of open-source software (e.g., Linux or Apache) served as inspiration for companies in the IT industries to adopt a new approach—open innovation (Chesbrough, 2003a, 2003b; Gassmann, 2006; Chesbrough and Appleyard, 2007). In contrast with prevailing "closed innovation" strategy, open innovation aimed to develop systems for linking internal and external communities of knowledge workers in inbound and outbound innovation activities (Huizingh, 2011). New IT facilitated communication and collaboration across these boundaries (Dodgson, Gann, and Salter, 2006; Huizingh, 2011), and the publicity given to exemplary cases further contributed to the diffusion of open innovation beyond high-technology industries in which innovation was the primary driver of competitiveness (Chesbrough and Crowther, 2006), to industries such as machinery, medical equipment, consumer goods, food, architecture, and logistics (Gassman, Enkel, and Chesbrough, 2010). Thus we might see open innovation not so much as part of the primary, business process cycle but as a management concept that belongs under the secondary, knowledge management cycle. Yes, open innovation encourages the dispersion of activity across organizations and embraces the network paradigm, but its proponents are acutely aware that social ties of a community-of-practice type are critical to organizational effectiveness in that new paradigm.

Second, consider the concept of "coworking spaces." Here it is even clearer that the organizational and management problem that prompted its emergence was created by the downsizing and outsourcing associated with business process initiatives, which resulted in many knowledge workers becoming independent contractors and freelancers. Early knowledge management concepts addressed dysfunctions related to the business process model by establishing communities of practice *inside* and *across* companies, but this left many independent knowledge workers and freelancers *outside* companies without adequate communities to support their practice. The innovative solution developed by the independent IT specialist Brad Neuberg in San Francisco was to offer the spatial and social infrastructure for a community of practice relevant to people like himself—to freelancers, entrepreneurs, and other individual knowledge

workers (Hunt, 2009; Neuberg, 2014).⁸ The theorization phase of coworking evolved rather differently from the theorization of prior concepts. Neuberg (2014), a member of the open-source movement, suggested to his colleagues and friends to “take this idea, steal it, and make it your own.” Two of his colleagues, social media consultants Chris Messina and Tara Hunt, were instrumental in conceptualizing the coworking idea by developing a coworking wiki and a Google groups list. The coworking concept diffused first within the San Francisco area, later within the U.S., and then worldwide (Hunt, 2009; Neuberg, 2014). The means of diffusion were the coworking wiki, the online magazine *Deskmag.com*, national and continental “Global Coworking Unconference Conferences” (GCUC), and texts and books on coworking (Foertsch and Cagnol, 2013). We might see coworking, like open innovation, as a concept contributing to the creation of new types of communities of practice and falling under the knowledge management model and the network paradigm.

A Longer-term Trend?

In contrast to the image of a pendulum swinging, we understand the evolution of management models as part of a series of technological and organizational paradigm revolutions. Readers might ask if our image of successive revolutions affords any greater insight into the longer-term direction of change across these revolutions.

Reviewing the evolution of primary and secondary cycles across these waves suggests that they have both evolved toward an ever-broader “object” of the process of organization design and change. The first of the primary cycles yielded a model that rationalized the role of the professional manager. The primary cycles of subsequent waves progressively widened the scope from the manager to workstations and factories, to corporations, and finally to processes that span interfirm boundaries. Likewise, the object of secondary cycles broadened over the successive paradigms from individual managers and workers, to teams, and then to communities of practice. This widening scope implies not only quantitative expansion but also qualitatively greater complexity—more heterogeneous activities, interlinked in a greater variety of ways, spanning entities under different ownership and control. In this sense, optimizing heterogeneous work processes synchronized in the factory represented a task of greater complexity than professionalizing management in the railroads. Reorganizing the multi-divisional corporation aimed at mastering a more-complex task than optimizing the unitary factory. And redesigning supply chains across firms is more complex than reorganizing an individual corporation.

Reviewing our account of the actors involved in the various phases associated with successive waves and cycles, we also note a related, long-term trend. Though management history has focused to date on consultancies as the key actors disseminating new management models (e.g., Clark and Fincham, 2002; Kipping and Engwall, 2002; Kipping and Clark, 2012), our historical sketch suggests that the community of actors involved has evolved toward a more-complex and interdependent division of labor that now includes

⁸ A similar development took place within the “Hub” in London (Foertsch and Cagnol, 2013), where the initial focus was on social entrepreneurs.

industrial innovators, guru–theorists, government agencies, and industry peer networks. These actors’ interdependence with respect to model development and diffusion has grown over time, and the boundaries between them have blurred.

This combination of growing complexity of the division of labor, growing interdependence among actors, and increasing scope of the corresponding integration and control efforts might plausibly be read as an indicator of what Adler (2012) called the “socialization of production.” Socialization, in this context, has both an objective and subjective dimension—it operates at both societal and individual levels. Objectively and societally, it consists of giving any one enterprise access to a wider range of capabilities through a wider array of denser ties to other enterprises and other sources of expertise, as we have described. The subjective and individual component corresponds to the more-familiar use of the word: the process of a focal actor acquiring this wider range of capabilities. If a manager working in the early 1800s time-traveled to the present and was asked to manage a contemporary company, he or she would first need to master many of the lessons accumulated by the successive paradigms and models of the last century and a half. Developmental psychologists such as Vygotsky (1978) have explained the mechanism that connects societal and individual development: the child masters the skills (speaking, writing, calculating, etc.) and cultural resources that society has accumulated over the course of its history. The socialization of the individual involves appropriating the collective, accumulated assets of a historically formed culture, and some individuals later develop innovations contributing new assets to that evolving culture. We see a related process in management. Each model that has left its mark on the evolution of management offers a lesson for the individual who wants to master management as an activity.

We can summarize the lessons succinctly. Line-and-staff: do not attempt to do everything alone—learn how to use professional assistance. Industrial betterment: focus some of this professional assistance on the social aspects of the operation. Scientific management: define everyone’s tasks clearly and optimize how they are executed. Human relations: attend to the motivation of the employees executing these tasks. Strategy-and-structure: ensure that your company’s structure reflects the diversity of your customers and markets. Quality management: organizational structure is not worth much if employees don’t have the tools with which to ensure the quality of their products and services. Business process: stay attuned to the processes that span internal and external boundaries and the profitable opportunities provided by new technology to change those boundaries and the links across them. Knowledge management: cultivate the communities of practice needed to sustain innovation in these dispersed value-chain activities.

We see these lessons as reflecting a (disruptable, reversible, open-ended) long-term trend of accumulating management-related cultural assets across waves, cycles, and phases. This trend is almost imperceptible in everyday life because lessons originating in prior revolutions are viewed as common sense, while the challenges of the present technological revolution are far more salient in current experience and discussions. Figure A1 in the Online Appendix visualizes this longer-term perspective.

CONCLUSION

Our theory highlights the interplay of repetitive patterns and progressive patterns, an open-ended dialectical evolution, sparked periodically by technological revolutions. The complexity of this interplay perhaps helps explain why the question “Where do new organizational forms come from?” (Suddaby and Greenwood, 2005: 35) is so difficult to answer.

The evolution of management models represents the emergent result of bottom-up and top-down innovation and selection. It is driven by the tension between the possibilities opened up by technological revolution and the constraints created by established organizational paradigms and practices. Our theory thus combines structural and agency perspectives on change. Actors involved in creating, theorizing, and diffusing organizational innovations play an important role in shaping management models and concepts and thereby in shaping organizational paradigms. Yet once a management model or an organizational paradigm achieves dominance, it is seen as common sense and shapes human decision making.

We have built on the neo-Schumpeterian work of Perez and others on technological revolutions, and we extended this work with a focus on the organization and management dimension of these revolutions. This line of argument suggests several issues and opportunities for future research. First, although we focused on key management models highlighted by prior research, future research might usefully deploy our frameworks to explore the larger population of innovative management concepts (Birkinshaw, Hamel, and Mol, 2008; Mol and Birkinshaw, 2014; Volberda, Bosch, and Mihalache, 2014) to better understand why some garner more “market share” than others. The logic of our argument implies that a given management model is likely to inspire the creation of incremental innovation in the form of management concepts that are more tailored to specific applications; it would therefore be useful to draw more-detailed genealogical charts. Our effort to group management concepts into higher-order models and to link the models to specific paradigms should be tested by more-rigorous statistical analysis on a richer corpus of text.

A second set of issues flows from the limited attention we have paid to changes in institutional context. Some changes—most notably, wars—have had major effects on the evolution we address. The American Civil War (e.g., Clark, 2001), World War I (e.g., Bruce, 1995), and World War II (e.g., Baron, Dobbin, and Jennings, 1986) all influenced the evolution of both technology and management models. Such historical contingencies are difficult to integrate into any general and simple historical theory such as we have tried to develop here. Other institutional changes, however, are less purely exogenous, and future research might attempt to integrate our insights with the literature on socio-economic regulation (e.g., Boyer, 1990) and social structures of accumulation (e.g., Gordon, Edwards, and Reich, 1982). Those two strands of scholarship bring into the foreground macro-contextual institutional changes that we referenced only in passing.

A third set of issues concerns how the activities of actors such as engineers, consultants, gurus, and scholars influence the evolution of technology, paradigms, and models. While our account acknowledges the key roles played by this creative agency, our theory also explains the way this activity is shaped by the opportunities and constraints created by technological revolutions. Future

research might usefully aim to refine our theoretical understanding of this mutual constitution and explore it empirically.

Fourth, interesting issues can be explored at the firm level. Our paper followed Barley and Kunda (1992) in focusing on the emergence of new concepts, models, and paradigms. But these persist over time, albeit under labels that might change, so at any given time managers confront a range of ideas of different vintages, and all of them have some bearing on the practice of management. Our account implies that managers will pay more attention to those that fit their technological opportunities and constraints, but these vary across industries and across firms within a given industry. How managers make sense of all this is an important question for future research. Jacobides, MacDuffie, and Tae (2016) offered an exemplary case study along these lines.

A further limitation of our theory is that it is predominantly informed by the evolution of management models in just one country, the U.S. Future research should assess how our theory needs to be expanded or modified if the focus broadens to include other countries. Such research can build on Guillén's (1994) work to explore differences in the development and adoption of management models in a broader international context. Whereas Guillén focused on the UK, Germany, or Spain, today it is urgent to broaden our field of vision to other countries such as China, Brazil, India, Japan, and Russia.

Finally, our study suggests we need a stronger integration of management and organization studies with technology studies. Our field often treats technology at a level of abstraction that makes it difficult to grasp the specific ways in which workers' and organizations' tasks are transformed by new technologies. Without a concrete understanding of tasks and technologies, it is difficult to understand some of the more-powerful forces that shape organizations and drive change in management models.

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ONLINE APPENDIX

Historical Evolution of Management Models: Key Sources

A considerable literature focuses on individual management models as they emerged in the U.S. railroads, and their line-and-staff management model was discussed by Chandler (1965, 1977) and industrial betterment by Brandes (1976), Jacoby (1985), and Nelson (1975). Taylor's (1911) scientific management, the dominant model during the first half of the twentieth century, has been the object of many studies (e.g., Aitken, 1960; Nelson, 1980, 1992; Kreis, 1992; Kanigel, 2005; Wren, 2005; Nyland, Bruce, and Burns, 2014). Several studies (e.g., Gillespie, 1991; Wren, 2005; Bruce and Nyland, 2011; Hassard, 2012) analyzed the relationship between the human relations model (Roethlisberger and Dickson, 1939) and scientific management. General Motors and its multidivisional form inspired the preeminent model of U.S. companies in the second half of the twentieth century, strategy-and-structure, which has been analyzed by several famous texts (Drucker, 1946; Chandler, 1962; Sloan, 1964). Guillén (1994: ch. 2) traced the evolution from scientific management to human relations and strategy-and-structure. Several studies have analyzed the relationship between this last model and the subsequent emergence of quality and culture concepts in U.S. industry (e.g., Dertouzos, Lester, and Solow, 1989; Womack, Jones, and Roos, 1990; Cole, 1999). Several authors have argued that we now live in an age in which internal and external networks are interconnected by information technology–supported work and information flows (e.g., Nohria and Eccles, 1992; Castells, 1996): business process reengineering inaugurated what we call the business process model that captured some of the potential of these new technologies (Hammer, 1990; Hammer and Champy, 1993). More recently, the focus has shifted to knowledge management as a possible alternative model (Nonaka, 1994; Nonaka and Takeuchi, 1995; Prusak, 1997; Davenport and Prusak, 1998;

Scarbrough and Swan, 2001; Davenport, Prusak, and Wilson, 2003).

Labor process theory grounds an important strand of scholarship on the history of these management models, although it offers only modest insights into the evolution of their specific content. The underlying assumption in this work is that insofar as the employment contract is incomplete, workers' and executives' interests are starkly opposed in determining the delivery of labor services; the conflict over work intensity is therefore the main determinant of work organization (Braverman, 1976). Under competitive and profitability pressure, managers develop and adopt new technologies; they respond to workers' struggles over work intensity by developing ever-more-refined systems of labor control, which diffuse where workers lack the capacity to resist. Whereas Braverman (1976) posited a simple contrast between the direct entrepreneurial control that predominated in the nineteenth century and the family of scientific management techniques that proliferated in the twentieth, later work in this stream of scholarship suggested greater complexity. Edwards (1979) saw a shift from direct control to a variable combination of technical control via the assembly line and bureaucratic control based on internal labor markets (the latter emerging in conjunction with the human relations model). Barker (1993) interpreted the quality-management model as a new, concertive control system. Burawoy (1985) saw the main sequence going from market despotism (Edwards' direct control) to hegemonic control (Edwards' bureaucratic control) and most recently to a neo-liberal system of "hegemonic despotism."

As Barley and Kunda (1992) noted, for the main part this labor process tradition sees the evolution of management models as following a sequence that can be described in terms of Etzioni's (1961) typology of control, going from coercive to utilitarian to normative forms of control. Others have added nuance to this view. Littler (1982) highlighted the importance in the

nineteenth century of internal contracting as an alternative to direct control. Friedman (1977) argued that a strategy of “responsible autonomy” was an enduring alternative to direct managerial control and scientific management. Jacoby (1985) made a similar argument with respect to the “welfarist” tradition of non-union employment relations. From this literature, we take the idea that the struggle over work intensity influences forms of work organization and models of management, but studies on labor control offer little further insight into the evolution of the content of the successive models.

A Neo-Schumpeterian Foundation: Perez’s Influence

Perez (2010: 190) wrote this about the shift in focus that brings technological revolutions to center stage in developing a theory of causal connections among management models:

It should be noted that this concept of great surges represents a break with both Kondratiev’s and Schumpeter’s notion of long waves (Kondratiev, 1935; Schumpeter, 1939). For them, the focus is on the upswings and downswings in economic growth. Although Schumpeter clearly ascribes such waves to technological revolutions while Kondratiev does not commit himself to any particular causal factor, they are both trying to explain long-term variations in gross domestic product (GDP) and other economic aggregates. What this author proposed (Perez, 2002: 60–67, 2007: 783–786) was to focus instead on explaining the process of diffusion of each technological revolution and on its transformative effects on all aspects of the economy and society, including among them the impact on rhythms of economic growth. This re-orientation has resulted in a different dating of the surges (as opposed to those of the traditional long waves) and in identifying a different set of regularities in the patterns of diffusion. . . .

Fagerberg (2003) provided an overview of evolutionary economics that situates Perez alongside Schumpeter and other long-wave theorists, work on systems of innovation, Nelson and Winter (1982), and other strands. Tylecote (1992) offered a parallel periodization of long waves along with critical commentary on Perez’s theory. Silverberg (2007) added a skeptical review of efforts to interpret these waves as cycles with any necessary periodicity. Perez’s (2002, 2010) account has the merit of not requiring any strong theory about the linkage between techno-economic paradigms and macro-economic waves, nor any strong theory about the timing of

revolutions themselves.

Perez's work (2002, 2007, 2010) offered a detailed account of the periods of a technological revolution. She argued that during the installation period of a technological revolution, while the rest of the economy cannot absorb the new techno-economic paradigm, enthusiasm prevails in the new core industries. As a result, she argues, investors crowd into the leading industries to fund the exciting new opportunities, and any existing regulatory constraints are deliberately weakened to encourage more investments. The result is typically a financial bubble—whence the “canal mania” of the 1790s, the “railroad mania” of the 1840s and early 1850s, the “roaring 1920s,” and the “Internet bubble” of the 1990s and 2000s. The installation period thus typically culminates in a major financial and socio-economic crisis, which also represents an inflexion point in the wave of paradigm change. After the crisis is resolved, we see a return to economic stability and macro-economic growth, the re-regulation and re-stabilization of the financial markets, and the paradigm moves into the deployment phase, reaching across the broader industrial landscape.

Beyond Cultural Antinomies

Instead of a pendulum swinging between cultural antinomies of rational and normative models, our historical account suggests an asymmetrical, dialectical process. The first, rational type of model is generated in response to the emergence of a technological revolution and therefore is marked by the specific features of that revolution. The second, normative type emerges in reaction to the dysfunctions of this initial response and is marked by both the underlying technological features of that revolution and the organization misfits generated by the initial response. We offer some further textual evidence of this interpretation of the secondary cycles in table A1.

The cumulative effect of this dialectical process is portrayed in figure A1, which shows the interconnect between technological revolutions, waves of change in organizational paradigms, primary and second cycles of model development, and phases within those cycles, as well as the hypothesized longer-term socialization trend that was outlined in the Discussion. The figure offers only a simplified representation, of course: as described in the main text, each wave had its own characteristics; cycles were overlapping and increasingly integrated over time; phases were interrelated, overlapping and non-linear; and the overall trend is disruptable, reversible, and open-ended.

Figure A1. Revolutions, paradigms, and models over time.

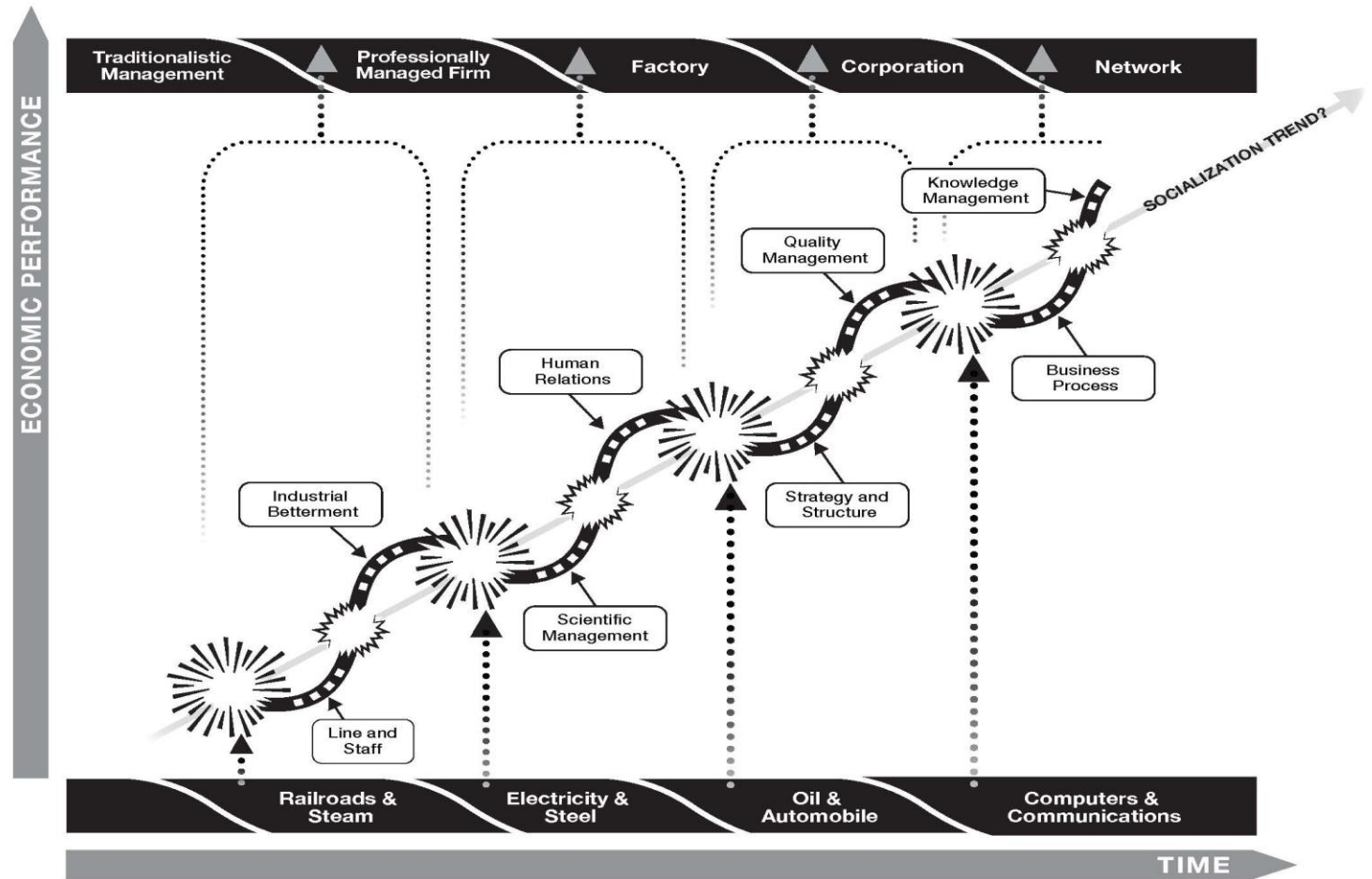


Table A1. Secondary Cycles and Their Motivating Problems

Primary, paradigm-revolutionizing model	Key dysfunctions of primary model	Secondary, paradigm-balancing model's solution to the dysfunctions	Supporting text
Line-and-staff	Growing gap between the management and the worker, arduous living and working conditions, strikes	Industrial betterment: Establish welfare secretary (or social secretary) to address grievances of workers and prevent strikes	“In the old times master and man lived and worked together; there was a daily point of contact, a continuous personal touch. Today all is changed . . . the personal touch, the point of contact has been lost. . . . However, our American industrialists are beginning to realize that an intelligent regard and a tactful care for the labor part of the business is not only right, but a large factor in industrial peace and contentment. . . . The problem which confronts the social secretary is how to improve the conditions of life and labor for the individual, not only in the factory and workshop where he spends the greater part of his working day but in his home and all other relations in which he meets his fellowmen.” (Tolman, 1909: 48–50)
Scientific management	High turnover and low morale of workers due to management control over how and how fast tasks were performed	Human relations: Influence individual workers' attitudes to (re-)create greater harmony and sense of community within the company	“. . . pessimistic reveries, which culminate in disorder and unrest (absenteeism, high labor turnover, strikes) are relatively easily controlled provided that the management has a means of discovering the nature of its cause. . . . The investigation of individual situations is more satisfactory than the inquiry into general or departmental situation. . . . In by far the greater number of cases there is some unsatisfactory circumstance, usually of personal history or private life, which is a habitual topic of dispersed thinking or revery. Any monotony of occupation or unpleasantness in work tends to extend and emphasize this thinking . . . whenever pessimistic reflection emerges, the effect on productive efficiency is striking and immediate. . . . In a sense, this work involves an extension of that begun by the pioneer, whose name is honored by this society. Taylor confined his attention, upon the whole, to the irrelevant synthesis or mistaken coordination in our muscular apparatus. There is an urgent need to extend this inquiry to discover what irrelevant syntheses of emotions and ideas are imposed upon workers.” (Mayo, 1924: 255–259)

Primary, paradigm-revolutionizing model	Key dysfunctions of primary model	Secondary, paradigm-balancing model's solution to the dysfunctions	Supporting text
Strategy-and-structure	Poor quality and service, low worker involvement, lack of cooperation and political gamesmanship	Quality management: Train and involve teams to assure higher quality	“The evidence is overwhelming that in the case of the color TV set, the Japanese do a more complete scrub down than do their competitors in the West. . . . In the West, the scrub down is less complete and the manufacturers are usually aware that the quality problems have not been fully solved. However, the decision is nearly always to go to market anyway because of the pressures of the schedule. . . . Manufacture is done by a few large companies. Marketing is done mainly by numerous independent distributors and retailers. Repair service is done mainly by numerous independent repair shops. In Japan, as in the West, manufacture is also done by a few large companies. However, marketing is done mainly by captive markets controlled by these same manufacturers. In addition, service shop networks are owned by the large manufacturers.” (Juran, 1978: 11–13)
Business process	Risks to the fabric of collective tacit knowledge among experienced employees and to the innovation-generating capacity of the firm	Knowledge management: Strengthen and deploy the knowledge-producing capacity of communities of practice	“Of course, the real creators of reengineering weren't consultants or academics. They were real people with real problems to fix . . . experimenting with new uses of information technology to link processes that cut across functional boundaries. . . . The rock that reengineering has foundered on is simple: people. Reengineering treated the people inside companies as if they were just so many bits and bytes, interchangeable parts to be reengineered. But no one wants to ‘be reengineered.’ No one wants to hear dictums like, ‘Carry the wounded but shoot the stragglers’—language that makes workers feel like prisoners of war . . . putting the company's veterans through their paces like they're just another group of idiots who ‘can't think out of the box.’” (Davenport, 1995: 70–71)

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