Organization Science

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http://pubsonline.informs.org

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To cite this article:
Zlatko Bodrožić, Paul S. Adler (2022) Alternative Futures for the Digital Transformation: A Macro-Level Schumpeterian Perspective. Organization Science 33(1):105-125. https://doi.org/10.1287/orsc.2021.1558

Published in Organization Science on December 30, 2021 as DOI: 10.1287/orsc.2021.1558.
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http://pubsonline.informs.org/journal/orsc

ORGANIZATION SCIENCE
Vol. 33, No. 1, January–February 2022, pp. 105–125
ISSN 1047-7039 (print), ISSN 1526-5455 (online)

Alternative Futures for the Digital Transformation: A Macro-Level Schumpeterian Perspective

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Received: January 13, 2020
Revised: December 29, 2020; June 20, 2021; September 11, 2021
Accepted: October 2, 2021
Published Online in Articles in Advance: December 30, 2021

https://doi.org/10.1287/orsc.2021.1558

Abstract. This paper develops and deploys a theoretical framework for assessing the prospects of a cluster of technologies driving what is often called the digital transformation. There is considerable uncertainty regarding this transformation's future trajectory, and to understand and bound that uncertainty, we build on Schumpeter's macro-level theory of economy-wide, technological revolutions and on the work of several scholars who have extended that theory. In this perspective, such revolutions' trajectories are shaped primarily by the interaction of changes within and between three spheres—technology, organization, and public policy. We enrich this account by identifying the critical problems and the collective choices among competing solutions to those problems that together shape the trajectory of each revolution. We argue that the digital transformation represents a new phase in the wider arc of the information and communication technology revolution—a phase promising much wider deployment—and that the trajectory of this deployment depends on collective choices to be made in the organization and public policy spheres. Combining in a 2×2 matrix the two main alternative solutions on offer in each of these two spheres, we identify four scenarios for the future trajectory of the digital transformation: digital authoritarianism, digital oligarchy, digital localism, and digital democracy. We discuss how these scenarios can help us trace and understand the future trajectory of the digital transformation.

History: This paper has been accepted for the Special Issue on Emerging Technologies and Organizing.

Keywords: digital transformation • technological revolution • ICT • Schumpeter • management models • public policy • scenarios • digital authoritarianism • digital oligarchy • digital localism • digital democracy

Introduction

Digital technologies such as artificial intelligence (AI), the Internet of Things, big data analytics, robotics, digital platforms, social media, blockchain, and three-dimensional (3D) printing have the potential to transform vast swaths of human activity. The term "digital transformation" is often used to capture the commonalities and interdependencies within this cluster of emerging technologies and the scope and magnitude of the revolutionary changes they portend in industry and society (Nambisan et al. 2019, Vial 2019, Lanzolla et al. 2020, Hanelt et al. 2021). However, uncertainty about its future trajectory abounds. Both practitioner literature and scholarly literature offer extrapolations from the current situation, forecasts that are sometimes pessimistic (e.g., "surveillance capitalism" as delineated by Zuboff (2019)) and sometimes optimistic (e.g., commons-based peer production as delineated by Benkler (2006)). This paper aims to bound the uncertainty about the direction that the digital transformation will take, and to identify the collective choices we face in shaping that direction. To do this, we advance a conceptual framework that locates the factors that will shape this trajectory, and we use this framework to identify several plausible alternative scenarios for it.

The digital transformation is not simply a basket of individual innovations: it is an interdependent cluster of revolutionary technologies, where developments in each technology affect many others. Moreover, the trajectory of such an epochal transformation is shaped by organizational and societal contexts, and those contexts evolve in interaction with each other and with technological changes. To understand such a

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phenomenon, we need to shift attention from the "micro" level of individual innovators and innovations (Scott and Bruce 1994) and from the "meso" level of individual technologies and industries (Anderson and Tushman 1990) to the "macro" level of technological revolutions as epochal, societal-scale phenomena.

A natural starting point for such a discussion is Schumpeter's classic works (Schumpeter 1934, 1939, 1942). Although Schumpeter's ideas are often deployed in management and organization studies to explain the behavior of individual firms and industries (Nelson and Winter 1982, Ahuja et al. 2008), his macro-level theory of economy-wide technological revolutions is only rarely invoked in our field, perhaps reflecting something of a "theoretical vacuum" in organization studies at that macro level (Stern and Barley 1996) (exceptions include Chandler and Hikino 1990, Barley and Kunda 1992, Nelson 1995, Lewin et al. 1999, Dosi and Marengo 2007, Vaaler and McNamara 2010). Since Schumpeter's initial statements, scholarship has advanced, and we offer here an account based on the work of a school of neo-Schumpeterians who have plumbed the history of such revolutions (most notably Freeman and Louça 2001; Perez 2003, 2010; Mazzucato 2015).

This macro-oriented strand of Schumpeter-inspired scholarship (we will call it "macro-Schumpeterian" for short) has identified five economy-wide technological revolutions over the last two centuries: the original "industrial revolution" based on machinery and water power, followed by the steam-power-and-railway revolution, then by the steel-and-electricity, automobile-and-oil, and most recently the computers-and-data revolution, aka the information and communication technology (ICT) revolution. Viewed in this context, the digital transformation appears as the latest phase of the wider arc of the ICT revolution. Relying on "reasoned history"—historical accounts that are based on qualitative historical-comparative methods rather than on formal quantitative, cliometric models (Freeman and Louça 2001, part 1; Schumpeter 1927, p. 288, 298)—these macro-Schumpeterians have discovered some striking regularities in the phases and dynamics of those technological revolutions. We build on these findings to argue that the future trajectory of the digital transformation will reflect changes in three main spheres—technology, organization, and public policy—and in their interaction. Whereas management scholarship has devoted considerable attention to the interaction of technology and organization, the study of such revolutions demands that we pay equal attention to the public policy sphere.

If, on the one hand, these retrospective regularities provide precious clues, on the other hand, such regularities should not obscure the contingency of history—the choices that might have led to other outcomes. Indeed, if our scholarship is to inform practice, it is critical that we understand the scope of the collective choices we face today in shaping the future of the digital transformation. Our framework therefore aims to deepen macro-Schumpeterian theory by incorporating that indeterminacy. To do this, we look back across prior revolutions to identify the types of problems in each sphere that held back the further development of the technological revolution—we call them "critical problems"—and the main competing solutions on offer.

Turning to the future of the digital transformation, we use this macro-Schumpeterian framework to guide us to three propositions. First, in the technology sphere, the critical problems appear to have been largely overcome. Many of the technologies associated with the digital transformation hold the promise of allowing, at last, the deployment of the ICT revolution to a much wider range of applications across industry and everyday life. This deployment will be shaped by the choices that will be made about how to respond to the critical problems in the organization and public policy spheres. Second, in the organization sphere, the critical problem today lies in the limitations of the currently dominant management model, which we call "Business Process." Deployment will be influenced by whether the choice is made to refine further that model to offer even more control and exploitation benefits or to supersede it with a model—we call it "Community-and-Collaboration"—that better supports the empowerment of communities and bottom-up collaboration across intra- and interfirm networks. Third, the choice of management models will itself depend in considerable measure on choices about public policy. The critical problem here lies in the limitations of the current "laissez-faire" public policy regime—aka "neoliberalism" (Saad-Filho and Johnston 2005, Harvey 2007a)—which has been dominant in the United States for the past four decades; deployment will be shaped by whether the collective choice is to move further in the direction of laissez-faire or to adopt a regime based on a more proactive, system-building role for government in the economy.

Putting together the main options for solving the critical problems in the organization and public policy spheres points to four alternative futures for the digital transformation. If a laissez-faire policy regime is combined with an exploitive Business Process model, we foresee a scenario evolving toward a corporate-dominated *digital oligarchy*. If a system-building public policy regime is combined with that Business Process model, we foresee a scenario toward a government-elite-dominated *digital authoritarianism.* If a laissez-faire policy regime is combined in some local jurisdictions with a Community-and-Collaboration model and in other jurisdictions with a reinforced Business Process

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model, we foresee a patchwork pattern of *digital localism*. If a system-building policy regime is combined with wide diffusion of this new Community-and-Collaboration model, we foresee a scenario of *digital democracy*. Given the United States' leading role in the ICT revolution so far, our primary focus is on the prospects for the digital transformation in the United States, but we will also call out key factors that might shape differences across countries, orienting them to different scenarios.

With this argument, our paper makes three main contributions. First, aiming to theorize technological revolutions at the societal level, we mobilize macro-Schumpeterian theory and expand the two-way interaction of technology and organization to a three-way interaction of technology, organization, and public policy: we identify the dominant models in each of the three spheres, and we show how their interplay shapes the trajectories of macro-level technological revolutions. Second, we augment macro-Schumpeterian theory by developing a framework that accommodates the contingency of history: by identifying the critical problems and the competing alternative solutions, we can clarify the collective choices ahead of us in the digital transformation. Third, we offer a theoretically and historically informed framework that enables us to go beyond the discussion of either optimistic or pessimistic digital futures and outline a richer, more realistic set of alternative futures for the digital transformation.

In the following sections, we first introduce the proposed macro-Schumpeterian framework and the three-way interaction of technology, organization, and public policy and explain the role of critical problems and alternative solutions. We then discuss the development of the digital transformation in each of the three spheres, their respective critical problems, and competing solutions. This leads to our discussion of the four scenarios. We conclude by identifying some directions for future research.

Macro-Schumpeterian Framework

Schumpeter (1934, 1939, 1942) saw technological revolutions as critical to understanding capitalism's characteristically uneven pattern of "creative destruction." He argued that capitalist development is shaped by technological competition between firms, encompassing innovation in products, processes, raw materials, and ways to organize business. A successful innovator will attract a swarm of imitators. Moreover, there may be knock-on effects as some innovations induce other, complementary innovations. Such systemic interdependencies among technologies explain why innovations often occur in clusters. The largest of these clusters form technological revolutions that affect not only individual industries but the entire structure of industry and fabric of society.

The macro-Schumpeterians identify five technological revolutions in the history of capitalism—rather than lumping the first four into one big "Industrial Revolution," as do, for example, Brynjolfsson and McAfee (2014). Their reasoned history of these various revolutions (primarily: Freeman and Louça 2001; Perez 2003, 2010) has yielded some striking generalizations—"stylized facts," as discussed by Helfat (2007)—about the way they unfold.[1]

First, revolutions take shape initially in one or two "leading countries"—Britain in the Industrial Revolution and the steam-power-and-railways revolution, the United States and Germany in the steel-and-electricity revolution, and the United States in the automobile-and-oil and ICT revolutions. The revolutions then diffuse to other countries, mutating along the way as they encounter diverse organizational and societal contexts.

Second, comparing the four prior revolutions in their leading countries, we find a common phase pattern: we summarize it here and discuss the underlying dynamics. The technologies that eventually cohere as the core of a technological revolution emerge during an *incubation* period, whose duration seems to have been rather variable across revolutions. At some point, the most successful of these new technologies draw the attention of investors and the *installation* period begins with the rapid expansion of new "leading industries," and with the development of complementary product, process, and infrastructure innovations. However, beyond those new industries, the rest of the economy benefits much less from the new technologies, because the organizational forms and public policies inherited from the prior revolution are ill suited to the new technologies. Moreover, the tensions associated with the frenzy of investment in the new industries and the limited deployment across the rest of the economy generate a period of financial, economic, and social *crisis*. The urgency of the crisis and the widely shared eagerness to ensure wide *deployment* of the new technologies across the economy together stimulate further innovations in organization forms and public policies. Finally, the revolution enters a period of *exhaustion*: here the developmental potential of the new technologies is largely fulfilled, and this exhaustion encourages a shift in the direction of technological innovation efforts.

Third, the cumulative effect of technological, organizational, and public policy innovations in each revolution yields a new paradigm in each of the three spheres—paradigms that are in turn made obsolete by the subsequent revolution. By analogy with the concept of scientific paradigm (Kuhn 1970), we use the term to refer to a constellation of interrelated concepts that are institutionalized in practices and that together set an agenda for future refinement. In the

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technology sphere, paradigms emerge in the form of a new "technological system" (Perez 2010). Technological revolutions also stimulate paradigm changes in the organization and public policy spheres, and the pattern of change is distinctive within each sphere.

From a macro-Schumpeterian perspective, the dynamics that shape each technological revolution are a function of the evolution within the technology, organization, and public policy spheres and interactions between them. Each sphere in each technological revolution is characterized by a revolution-specific paradigm, which emerges as the cumulative result of successive problem-solving cycles. In the following paragraphs, we identify the main problem-solving cycles and the main solutions—different types of dominant models—yielded by these cycles in each of the three spheres. We focus on the patterns found in earlier revolutions and leave to the subsequent section our discussion of how this history helps us make sense of the ICT revolution and the digital transformation.

Technology Sphere

In the macro-Schumpeterian account, technological innovations often cluster into waves—"revolutions"—that yield new technological paradigms. Innovations lead to revolutions if "bandwagons" of several different innovations "roll" together (Freeman 1982, p. 67). This is particularly likely in the presence of a general-purpose technology (GPT) (Bresnahan and Trajtenberg 1995) and the resulting complementarities and synergies among associated technologies (Rosenberg 1979).

Generalizing across prior revolutions, the pattern here appears to be that each new technological paradigm emerges through two types of problem-solving cycles. A first type is aimed at consolidating the new GPT itself—yielding a set of foundational innovations and establishing enough evidence of the GPT's potential to attract innovators aiming to exploit it. A second type is aimed at expanding and cheapening a set of applications and complementary products.

Freeman and Louça (2001) summarize the foundation of these generalizations in their analysis of prior technological revolutions. The original "industrial revolution" (approximately 1750s–1840s) started in Britain. It was based on water power as a GPT, on cotton, iron, and water as core inputs, and on weaving and water-power machinery. The emerging water-power-and-cotton paradigm was augmented by new supporting infrastructure (canals and roads), by new complementary technologies (e.g., iron components of water wheels and weaving machinery), by new production processes (water-powered industrial production of cotton products), and eventually by new unanticipated applications (e.g., iron cutlery and cooking tools).

The second technological revolution (approximately 1790s–1890s) also began in Britain, but the United States was not far behind. It was based on steam power as a GPT, on coal and iron as core inputs, and on the railway. The emerging steam-power-and-railways paradigm was augmented by new supporting infrastructure (railway and telegraph networks), by new complementary technologies (e.g., the telegraph), by new production processes (e.g., steam-powered industrial production of machine tools that were independent of waterways), and eventually by new unanticipated applications (e.g., steamships).

The third revolution (approximately 1850s–1940s) saw the United States take the role of leading country. This revolution was based on electricity as a GPT, on iron as a core input, and on steel applications. The emerging steel-and-electricity paradigm was augmented by new supporting infrastructure (intercontinental trade enabled by robust steel ships), by new complementary technologies (e.g., heavy engineering), by new production processes (more flexible production processes that were independent of bulky steam engines and based on deploying the electric motor), and eventually by new unanticipated applications (e.g., the telephone).

The fourth revolution (approximately 1880s–1980s) was based on the internal combustion engine as a GPT, on oil as a core input, and on the automobile. The emerging automobile-and-oil paradigm was augmented by new supporting infrastructure (e.g., highways and airports), new complementary technologies (e.g., plastics), new production processes (assembly-line-based mass production), and eventually by new unanticipated applications (e.g., myriad new household applications).

These partly overlapping technological revolutions also yielded new leading industries and exemplary firms. Giant oligopolistic firms emerged in the installation period of each successive revolutions: Erie Railroad and Pennsylvania Railroad; Bethlehem and United States Steel; the "big three" auto companies, General Motors, Ford, and Chrysler (Bodrožić and Adler 2018). The dominance of these firms was not only based on their technological prowess but also on changes in the organization and public policy spheres.

Organization Sphere

Inventions are consequential when they are taken up by enterprises as innovations—when enterprises invest in them, refine them, and bring the associated products to market and new processes to scale. That distinction between invention and innovation was one of Schumpeter's core insights. Macro-Schumpeterian

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research on prior revolutions shows that this innovation process necessitates organizational changes. The radically new technologies fit uneasily within the inherited organizational paradigm, and each technological revolution has thus led to a new organizational paradigm. The historical record suggests that each new paradigm emerged in two problem-solving cycles, with each cycle yielding a new dominant "management model"—a new body of ideas that offer management guidance on how to deal with their technical and social tasks (Bodrožić and Adler 2018).

In a primary cycle, a "paradigm-revolutionizing" model emerges in response to the perceived inadequacy of the then-prevailing organizational paradigm in the face of the new technologies' potential. This primary cycle yields a new management model that obsoletes the inherited paradigm and restores "external fit" between key organizational elements and the new technologies' potential. It solves some of the misfit between the technology and organization spheres but simultaneously generates dysfunctional misfit among organizational elements. Its limitations spark a secondary problem-solving cycle, which yields a new, "paradigm-balancing" management model, which aims to reestablish "internal fit" among organizational elements (Miller 1992) to harness the bottom-up innovation capacity of people and organizations. This new balancing model helps to stabilize the revolution's organizational paradigm.

Viewed through the lenses of Schumpeter's (1942) theory of creative destruction—and the critical role of the destructive moment—it is not hard to see why the primary cycles typically led to unbalanced models that left in their wake considerable labor strife, and that thus triggered secondary, balancing cycles. The dialectical tension between paradigm-revolutionizing and paradigm-balancing models was captured in organization theory in the contrast between rational, technical models and normative, commitment-oriented ones drawn by Barley and Kunda (1992). Market and Hierarchy were the dominant organizing principles in the former, and Community was more salient in the latter (Adler 2001).

We can illustrate by pointing to the two cycles in some of the prior revolutions (as reviewed by Bodrožić and Adler 2018). In the steel-and-electricity revolution, the radical technological innovations associated with steel production and electric power afforded higher throughput speed and greater efficiency in factory layout. This challenged managers and engineers to rethink workstation design and workflow plans. The prevailing organizational paradigm inherited from the steam-power-and-railways revolution did not offer answers: Frederick Taylor's organizational innovations, developed and implemented in leading steel firms such as Bethlehem Steel, emerged in response. Scientific Management integrated these organizational innovations into a coherent, new management model characterized by time-and-motion studies, new principles in plant layout, and more rational and equitable incentive payments.

However, in the form in which it was most frequently implemented, Scientific Management also generated dysfunctions, such as highly regimented work and weakly motivated factory workers. These dysfunctions in turn triggered a secondary cycle of organizational innovations focused on restoring greater internal fit. This cycle coalesced around the Human Relations model, which aimed to create greater harmony in workplaces by encouraging individualized personal consideration in supervisor-employee relations. It was the synthesis of the Scientific Management and Human Relations models that defined the dominant organization paradigm (which we call the "Factory" paradigm) in the early decades of the 20th century.

The next revolution, the automobile-and-oil revolution, brought a proliferation of cheap, mass-produced consumer goods, challenging firms to respond to the different "purse and purpose" of different consumers. The Factory paradigm did not offer answers to this problem, and in response, organizational innovators in the automobile industry (most notably Alfred Sloan in General Motors) created the "Strategy-and-Structure" model, which was subsequently diffused across the corporate landscape: semiautonomous business units were assigned the responsibility for offering mass-produced goods and services to differentiated market segments. The dysfunctions of that Strategy-and-Structure model, such as poor quality and low worker involvement, were subsequently addressed by the emergence of a paradigm-balancing model—"Quality Management." The synthesis of the Strategy-and-Structure and Quality Management models defined the organizational paradigm (which we call the "Corporation" paradigm) of the second half of the 20th century.

We should note that causality runs both ways between the technology and organization spheres. Technological innovation (e.g., widely available electrical power) triggered organizational innovation (e.g., factory reorganization based on Scientific Management), which in turn triggered technological innovation (e.g., the development of new variants of electric motors and electric-powered machinery that offered more flexibility in factory layout). The interplay of technology and organization spheres alone, however, does not explain why leading steel and automobile firms turned into powerful oligopolies.

Public Policy Sphere

Macro-Schumpeterian research on the history of prior revolutions suggests that the two-way interaction of

technology and organization has both shaped and been shaped by their interaction with a third sphere—public policy. In this sphere too, each revolution saw two successive problem-solving cycles, which each generated a distinct model of public policy—a public policy "regime." (We adopt the definition of policy regimes offered by May and Jochim (2013, p. 428) as "the governing arrangements for addressing policy problems.")

In the installation period of each of the prior technological revolutions, growing concern with the misfit between the new technologies and the inherited public policy regime typically led to a shift in public policies toward laissez-faire, taking a somewhat different coloration in each revolution. In practice, this has meant not so much a retreat of the state as breaking down restrictions on the business sector that were inherited from the prior public policy regime (such as labor laws, banking regulations, etc.) and that might stand in the way of the enthusiastic flow of investment into the new core industries. The primary goal was to unleash the energy associated with the potential for private-value creation. A laissez-faire policy regime lifted roadblocks to investments in the new cluster of technologies, but it also allowed the emergence of giant oligopolies in key industries (in successive revolutions: railways; steel and electricity; automobile and oil), growing inequality, and the erosion of market-stabilizing regulations. The latter fueled an investment *frenzy* (successively: the canal mania, the railway mania, the Gilded Age, the Roaring Twenties), and these frenzies have all culminated in society-wide financial, economic, and institutional crises (successively: the Panic of 1847 in Britain and the 1870s depression in United States, followed in the United States by the 1890s depression, and then by the 1930s Great Depression).

In the course of each of the prior revolutions, these crises led to a reorientation of public policy toward a system-building role for government—both to absorb the crisis and to assure the wider deployment of the new technologies beyond the leading industries. Indeed, the macro-Schumpeterians have shown that, whereas the installation period was often assisted by public policies aimed at increasing the *rate* of private-sector innovation, the deployment period has typically been associated with public policies that also aimed to shape the overall *direction* of innovation (Mazzucato 2015). The authoritative power of government created a shared sense of the likely course of economic development, which in turn strengthened investor confidence. The system-building regimes—again, with a somewhat different coloration in each revolution—established critical material and social infrastructure and shared more equally the fruits of the technological revolution.

Adopting again the creative-destruction lenses of Schumpeter (1942, p. 70), we can see why a laissez-faire public policy regime typically dominates initially, but why it also leads to a crisis, triggering a system-building regime in its wake. The dialectical tension between these two policy regimes was articulated by political scientists such as Hirschman (2002) as a contrast between private versus public interests and by political economists such as Polanyi (1968) as a contrast between a disembedded economy versus one that is re-embedded.

To illustrate the contrast, consider the steel-and-electricity revolution, whose installation period started in the 1870s. It gave rise to a massive wave of investment in machine-based manufacturing and agriculture, to the huge increase in inequality known as the Gilded Age, to the emergence of giant steel firms (whose owners were denounced as "robber barons"), and eventually to the Panic of 1893 and the deep depression of 1893–1897. The subsequent shift from installation to deployment during the Progressive era was marked not only by government support for the creation of the country's comprehensive "network of power" (Hughes 1993) but also by a broad campaign to eliminate government corruption, by the first serious enforcement of the Sherman Antitrust Act of 1890 (which was strongly opposed by advocates of laissez-faire policies but supported by social movements), by the introduction of women's suffrage, by the creation of the Federal Reserve, and by a range of system-building rural reforms (Freeman and Louça 2001).

Consider the automobile-and-oil revolution, whose installation period ran from approximately 1910 to 1930 (Freeman and Louça 2001). The opportunities represented by the new technology prompted a wave of investment and accelerated productivity growth and thereby contributed to the dynamism of the Roaring Twenties. Public policy moved in a laissez-faire direction. As President Coolidge famously stated in 1923: "the business of America is business" (Wilson 2016, p. 24). Weak regulation encouraged a frenzy of speculative stock market investment and a rapid expansion of consumer credit for the new commodities (cars, appliances, etc.). Levels of concentration grew in core industries (most notably, in the growing share of the Big Three in the auto industry). Inequality soared. Agricultural employment collapsed as productivity growth accelerated, leading to social crisis in rural areas. Public policy did little to boost consumer purchasing power, and investment and production rapidly outstripped demand. The combination of these factors (among others) led to the Wall Street Crash of 1929 and the Great Depression.

In response to this crisis, a new public policy model emerged in the New Deal. New regulations were

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introduced to stabilize the banks and financial markets. Government encouraged the expansion of investment in the real economy and supported home mortgage loans. Legislation formalized the role of unions, and these unions negotiated wage increases in line with productivity increases, thereby ensuring growing demand for the output of a technological dynamic manufacturing sector. This system-building regime also responded to the opportunities created by the automobile-and-oil revolution with massive public investment in highways, creating the transport infrastructure on which we still rely (Gordon 2000).

Robustness of This Framework

The present paper aims to build on and expand this macro-Schumpeterian foundation to understand the digital transformation. However, before proceeding, we should address some potential limitations and explain why they should not deter us.

First, some doubt that innovations cluster so strongly (Puffert 2003). Many historians of technology recoil at the idea that we can reduce the historical record of the manifold technologies to a series of neatly discrete technological revolutions. Historians of management and public policy might have a similar reaction. We see this as a matter of the difference in taste between lumpers and splitters.

Second, there is debate about the connection between these technological revolutions and the "Kondratieff" cycles of gross domestic product growth and contraction of about 50–60 years in duration (Kondratieff 1979). Whereas Schumpeter argued that technological revolutions explained these long waves (Mager 1987), some macro-Schumpeterians see only a looser connection (Perez 2003, 2010). This is an interesting question, but it does not have much impact on the questions addressed in the present paper.

Third, our focus on these three spheres means leaving aside a range of other contextual factors that surely play a role. Culture, for instance, has had a significant impact on the trajectory of technological revolutions (see the discussion of Perez and Leach (2018) on the importance of lifestyle changes). We make this simplification to avoid escalating theoretical complexity; however, the framework can be expanded in the future.

Fourth, we abstract from major, relatively unpredictable events like wars, volcanic eruptions, and pandemics, which can affect a technological revolution's trajectory (as noted by Schot and Kanger 2018 and Kaldor 2021). Both of the 20th century's world wars, for example, had important effects (Jaworski and Fishback 2018). In contrast, a focus on public policy has the advantage of bringing into focus the means by which we might collectively influence the trajectory of the revolution currently underway.

Finally, whereas macro-level macro-Schumpeterian historical research has revealed a strong pattern across prior revolutions, it has been less helpful in identifying the uncertainties and options facing actors as they made the various choices that gave rise to that pattern. Here is where we propose to augment the macro-Schumpeterian framework, as we explain in the following subsection.

From Ex Post Regularities to Ex Ante Choices

Our review of prior revolutions revealed some important regularities across them. In reality, however, each of the prior technological revolutions encountered "forks in the road" where different choices could have led to different outcomes. A rigorous account of technological revolutions—especially one that aims to inform the collective choices ahead of us with the digital transformation—must therefore dive deeper and characterize these forks in the road.

We saw that in each of the prior revolutions there were two main types of problem-solving cycles in each of the three spheres. In each cycle, a critical problem came into focus as the impediment to the progress of the revolution—visible in significant system-level performance limitations and disappointing rates of system-level performance improvement (David 1990, David and Wright 1999).[2] There was considerable uncertainty about how to overcome such critical problems. Innovators entered uncharted territory here and different actors advocated competing, alternative options. Our account brought to the fore the repeated sequence (across revolutions) in the types of solutions retained: however, we need to unpack this observed ex post pattern to reveal the underlying ex ante choices and the options not retained. We review the three spheres in turn to offer some illustrations.

In the technology sphere, in the narrative offered previously, each revolution encountered critical problems that cluster in two broad types: one related to consolidating the core GPT, and another, more heterogeneous cluster related to the dearth of creative applications that would drive wider deployment beyond the core industries. We can illustrate the critical problems and alternative solutions for both types with examples from the fourth technological revolution (the automobile-and-oil revolution). For the first type: before the internal combustion engine became recognized as the GPT, some vehicles were powered by steam or electric engines. The internal combustion engine only became dominant after a series of technological innovations led to its higher efficiency relative to those alternatives (Freeman and Louça 2001). Consider the second type: many accessories and components for automobiles were initially made of natural materials such as metal, wood, rubber, and leather. With the advent of oil-based plastics, cheaper and

lighter alternatives emerged, becoming increasingly dominant in the course of the 20th century, even if some product lines continued to rely on the natural materials to signal their luxury status (Freeman and Louça 2001). (The 21st century might witness a reversal of the 20th century's choices: the re-emergence of the electric motor and of materials that are not synthetic and are easier to recycle).

Turning to the organization sphere, the historical pattern of retained solutions that we described previously was the following: in each revolution, a first problem-solving cycle led to the emergence of a paradigm-revolutionizing model, which was dominant in the earlier phases of the revolution, and a second cycle led to a paradigm-balancing model, which was dominant in the later phases. This pattern should not obscure the variety of possible resolutions of the critical problems in each of the cycles, and the vigorous debates among proponents of alternative models. Consider the third technological revolution (steel-and-electricity). A coercive form of Scientific Management became the dominant model in the installation period of this revolution; however, from its early years, that option was in competition with a more participative one proposed by Frank and Lillian Gilbreth and other like-minded organizational innovators (Nyland 1998).

Consider the Human Relations model, which emerged in the deployment period of that revolution to rebalance the coercive Scientific Management model and restore greater internal fit. Human Relations was just one of the options competing for hegemony in the 1920s and 1930s. In comparison with the more vigorous paradigm-balancing options on offer—such as ones based on a vision of "industrial democracy" (Jacoby 1985)—it proposed a relatively modest rebalancing, aiming to inject more individualized personal consideration into supervisor-employee relations.

In the public policy sphere, installation periods' problem-solving cycles led to laissez-faire regimes and deployment periods' cycles led to system-building regimes. However, here too, this regularity should not obscure the variety of possible resolutions of critical problems in each of the cycles and the vigorous debates between proponents of competing regimes. These options were already visible in the very early history of the United States, as a conflict between Alexander Hamilton, who urged a system-building regime, and Thomas Jefferson who advocated a laissez-faire approach (Parenti 2020).

Consider for example the fourth technological revolution (automobile-and-oil). The public policy regime during the installation period of this revolution (culminating in the Roaring Twenties) was strongly laissez-faire oriented, promoting deregulation and privatization. However, even during this period, system-building alternatives (e.g., public ownership of infrastructure) had their promoters, and in some local jurisdictions (e.g., New York), those solutions were implemented with some success (Wilson 2016). Conversely, during the crisis and early deployment phases (1930s and 1940s), a strong system-building regime emerged in the form of the New Deal. However, even during World War II, there were strong voices advocating a return to laissez-faire (Wilson 2016).

Indeed, in prior technological revolutions, critical problems in each of the three spheres could have been resolved in alternative ways. In the organization sphere, these alternatives represent different resolutions of the dialectical tension between paradigm-revolutionizing and paradigm-balancing goals, whereas in the public policy sphere, the alternatives represent different resolutions of the tension between laissez-faire's push for private-value creation and system-building's push for public-value creation. Let us now turn to the digital transformation and use this framework to understand its critical problems and alternative solutions.

Digital Transformation in Macro-Schumpeterian Perspective

Writing in 2021, we appear to be in an extended period of crisis that began with the dot.com crash, continued with the 2008 financial crisis, and continues as yet unresolved. Although the COVID-19 pandemic is an externally induced shock, its fatal consequences for vulnerable groups of the society are an indicator of burning issues in public policy. This crisis condition is one of many indicators suggesting that we are at the inflection point—the crisis period—that typically separates installation and deployment in a technological revolution (Perez 2010). The following subsections test that idea by assessing the state of each of the three spheres and putting that state in historical perspective.

Technology Sphere: Ready for Deployment

We argue that the digital transformation is the latest phase in the wider arc of the ICT revolution. This ICT revolution is essentially a computers-and-data revolution that conjoins, as did preceding revolutions, a new general-purpose technology (here, the computer) and new core inputs (here, digital data) to create the germs of a new technological paradigm. This emerging ICT paradigm was augmented by new supporting infrastructure (notably, the Internet; subsequently, social media), new complementary technologies (e.g., those pertaining to telecommunications), and new computer-controlled production processes. New applications such as the smart phone (complemented by myriad "apps"), and a family of application-oriented digital technologies (e.g., AI, the Internet of Things, big

Published in Organization Science on December 30, 2021 as DOI: 10.1287/orsc.2021.1558.
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data analytics, robotics, social media, blockchain, and 3D printing) have further expanded the ICT paradigm.

A broad consensus has emerged that this family of digital technologies offers exciting prospects for very wide deployment. Grounds for this optimism are visible when we examine the longer arc of the key ICT technologies (Table 1). The earlier, installation period of the ICT revolution faced critical problems related to the utilization of the computer as a GPT. One of these problems was the transmission of data between computers: the lack of an adequate infrastructure for the core input of the ICT revolution impeded the development of the whole cluster of technologies. This critical problem was solved (if not optimally: see Bellovin et al. 2006) with the development of the Internet as an open, semipublic platform: this innovation profoundly affected the trajectory of the whole ICT cluster, and gradually the entire economy. With the emergence of the Internet, the diffusion of further innovations accelerated, and network effects began transforming entire industries (Kushida and Zysman 2009).

The second type of critical problem then emerged in the technology sphere—the need for cost-effective, user-friendly applications that could appeal to a wider set of industries and activities. The more recent innovations associated with the digital transformation promise to solve that critical problem, and thereby take the revolution far beyond the core "tech" industries that incubated this revolution (World Economic Forum 2020). We note, for example, the development of high-powered AI and its use in fields such as biology and chemistry (Benaich and Hogarth 2021); the enormous potential of the Internet of Things in both industry and households (Ranger 2020); the emergence of blockchain, which opens new possibilities for smart contracting and collaboration (Murray et al. 2022); and the range of commercial and scientific applications for low-cost, high-powered visualization tools (*The Economist* 2020).

If, on the one hand, the technologies of the digital transformation seem poised for wide deployment, on the other hand, it is much less clear what form this deployment will take. In contrast to the development of the Internet, the development of these emerging technologies is increasingly dominated by large private companies such as Google and Facebook (Benaich and Hogarth 2021). Whereas the new technologies facilitate globalized commercial, financial, and social interaction and new forms of collaboration, participation, and democracy, they also enable control, manipulation, and surveillance. Network effects and permissive public policies have enabled high levels of concentration in

Table 1. Timeline of the ICT Revolution

Critical problems in the evolution of the digital paradigm	Period	Major shift	Founding of exemplary organizations
Development of core ICT foundations	1960s	Incubation of computer components	1968: Intel
	1970s	Rapid rise of mainframe computers	1975: Microsoft
			1976: Apple
			1977: Oracle
	1980s	Rapid rise of personal computers	1982: Adobe
			1984: Dell
			1985: Cisco
			1987: McAfee, Huawei
	1990s	Emergence of networked computers and Internet	1993: Nvidia
			1994: Amazon, Yahoo
			1996: eBay
			1998: Google, PayPal, Tencent
			1999: Napster, Alibaba
Development of digital technologies that facilitate a wider variety of applications	2000s	Emergence of mobile, social, platform, and cloud technologies	2001: Wikipedia
			2003: MySpace
			2004: Facebook
			2005: YouTube
			2006: Twitter, Spotify
			2008: Airbnb
			2009: Uber, WhatsApp, Pinterest, Bitcoin
	2010s	Emergence of AI, big data, Internet of Things, blockchain	2010: Instagram, DeepMind
			2011: Banjo, Snapchat
			2012: ThoughtSpot
			2013: Databricks
			2014: SenseTime, Zoox
			2015: Ethereum
			2015: CloudMinds, OpenAI
			2016: Argo AI, Clarivate Analytics

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industry, and the resulting behemoths have gathered a vast amount of data about customers—as have governments about their citizens—even as the mechanisms of data gathering and use have been kept remarkably opaque (Faraj et al. 2018, Zuboff 2019). Battles for control over data and the underlying technologies have led to international tensions between the United States and China (e.g., in 2020 regarding the role of Huawei in communications infrastructure).

This discussion of the current state of the technology sphere leads to the first of our three summary propositions:

Summary Proposition 1. *The emergence of the family of application-oriented digital technologies represents a maturation of the new ICT technological paradigm. It signals that the ICT revolution is ready to move from the installation period to the deployment period. Our current uncertainty as to the future trajectory of this revolution is caused not only by our ignorance but also by the underdetermined nature of this deployment period. Deployment will be shaped by choices yet to be made in the organization and public policy spheres.*

Organization Sphere: Between Business Process and Community-and-Collaboration

The ICT revolution is stimulating the emergence of a new organizational paradigm—the Network paradigm (Benkler 2006, Castells 2011). Viewed from the vantage point of our macro-Schumpeterian model, this Network paradigm appears to have been initially triggered by a paradigm-revolutionizing Business Process management model. This Business Process model was a response to the first critical problem in the organization sphere of the ICT revolution—the mismatch of ICT technologies and the siloed character of the inherited organizational paradigm. The tall walls between units within the firm and between the firm and its upstream and downstream exchange partners were seen as impediments to exploiting the new technologies' potential. This critical problem was frequently identified as the main reason for the ICT revolution's "productivity paradox"—the surprisingly slow productivity gains during this period in industry taken as a whole (Solow 1987, David and Greenstein 1990, Macdonald et al. 2000).

This situation prompted a problem-solving cycle that yielded the concept of "business process reengineering" (Hammer 1990): here, new technologies were used to break the siloes that characterized the inherited organizational paradigm. Firms were urged to use the new technologies to rationalize their business processes across the value chain, to outsource "noncore" activities and employees, and to bridge internal and external boundaries (Davenport and Short 1990, Hammer 1990, Ashkenas et al. 2015). Although business process reengineering was widely criticized and rapidly dropped as a label, the more general idea of a "process orientation" within and between organizations (Majchrzak and Wang 1996) persisted, representing the core of the Business Process model. It enabled the coordination of global supply chains (Sturgeon and Lester 2002, Garcia-Dastugue and Lambert 2003), contributing to the rise of "supply chain management" as an important new management concept (Cooper et al. 1997).

These organizational innovations prompted and then in turn shaped technological innovation, particularly in the form of standardized interfaces and linkages that facilitated the flow of information across boundaries both within and between firms. Processes were of course important loci of innovation in prior revolutions: here what was novel was the use of ICT to expand vastly the reach and increase the granularity of management control and value capture, both within and between firms, by deploying a combination of hierarchical authority and market power.

The Business Process model was accompanied by dysfunctions (paralleling the emergence of dysfunctions caused by the primary cycle of prior revolutions). Most critically, process reengineering and outsourcing often disrupted the fabric of collective tacit knowledge shared by experienced employees both within and across firm boundaries, which in turn limited innovativeness and flexibility (Davenport et al. 2003). In the macro-Schumpeterian perspective, the need to address these dysfunctions appears as a second critical problem in the organization sphere, one that might potentially trigger the emergence of a paradigm-balancing model.

Whereas we have considerable evidence for the importance of the Business Process model as a paradigm-revolutionizing model, the corresponding paradigm-balancing model is still in gestation. Nevertheless, the pattern in prior revolutions and the recent trends in management publications are sufficiently clear to point us to our second summary proposition:

Summary Proposition 2. *The trajectory of the digital transformation will depend on the response to the current critical organizational problem of the ICT revolution. More specifically, it will depend on whether the Business Process model is refined further to generate greater management control and value-capture benefits, or a new model emerges that better supports community-building and collaboration in networks. We call this alternative the Community-and-Collaboration model.* (The contrast between the two models is presented in Table 2.)

The current popularity of a number of management concepts points to the emergence of a balancing model based on community and collaboration. The literature on

"open innovation" embraces the potential of collaboration among firms to generate innovation (Chesbrough 2006, Gassmann 2006). Research on crowdsourcing (Majchrzak and Malhotra 2020) shows how "collaborative crowdsourcing" enriches Business Process–oriented types of "idea searching." The emphasis on (re)creating the fabric of collaboration is central in some (but not all) online communities (Faraj et al. 2011), coworking spaces (Garrett et al. 2017, Spinuzzi et al. 2019), ecosystems (Dattée et al. 2018), and crowdfunding platforms (Belleflamme et al. 2014, Leung and Sharkey 2014). The goal of cultivating collaboration among community members underlies management concepts like scrum, agile, and DevOps in software development (Schwaber and Beedle 2002, Conboy 2009).[3] Within firms, Community-and-Collaboration approaches appear in a range of forms, from producer cooperatives to advanced forms of participative management in conventional capitalist firms. Between firms, it can take the form of "managed ecologies" (Altman et al. 2021) and the "collaborative communities" discussed by Snow et al. (2009).

The contours of this Community-and-Collaboration model are still somewhat undefined, but they appear to fit the general characteristics of paradigm-balancing models in aiming to harness bottom-up innovation capacity. As with previous revolutions, it does so by renewing the salience of the Community principle in the organization of various activities, while at the same time introducing a new type of community. Earlier revolutions' balancing models relied on forms of community that were based on tradition or affectual ties. This revolution, by contrast, with its process orientation, seems to rely on and stimulate the emergence of a new type of community—one that is capable of supporting key processes by bringing together large networks of very heterogeneous groups of people around a sense of "shared purpose" (Adler and Heckscher 2018). The "purpose" of such communities can be more localized and mundane—for example, to develop a software utility—or it can be more elevated, like responding to a "grand challenge" such as the climate emergency. In either form, its day-to-day management relies on collaborative goal setting, contribution-based rewards offering low-powered financial incentives combined with prominent social incentives, formal systems that enable rather than coerce,

Table 2. Two Management Models for the Digital Transformation

	Primary, paradigm-revolutionizing management model	Secondary, paradigm-balancing management model
Current alternative models	Business Process model: Rationalizing internal and external processes, enabling exploitation and value capture	Community-and-Collaboration model: Recreating social fabric, enabling collaboration toward shared purpose
Model's role in technological revolutions	Obsoleting the inherited organizational paradigm and establishing the new organizational paradigm Harnessing the new possibilities generated by the new technology cluster Re-establishing external fit by overcoming the limitations of the inherited model in this new technological context	Rebalancing the new organizational paradigm Harnessing the bottom-up innovation capacity of people and organizations Re-establishing internal fit by overcoming the limitations of the primary model
Historical examples of models	Line-and-Staff in steam-power-and-railways revolution Scientific Management in steel-and-electricity revolution Strategy-and-Structure in automobile-and-oil revolution	Industrial betterment in steam-power-and-railways revolution Human Relations in steel-and-electricity revolution Quality Management in automobile-and-oil revolution
Theorizations of the contrast between models	Rational/technical (Barley and Kunda 1992) Environmental fit (Miller 1992) Market and Hierarchy as dominant organizing principles (Adler 2001)	Normative/human (Barley and Kunda 1992) Internal fit (Miller 1992) Community as dominant organizing principle (Adler 2001)
Key features of the current alternatives	Use technology to eliminate labor Outsource to arm's-length suppliers Build asymmetrical power relations Pursue market goals: exploitation and value capture	Use technology to augment labor capabilities Build collaborative interfirm networks Build shared power Pursue shared purpose: exploration and collaboration
Examples of contrasting concepts supporting the current alternatives	Strategic alliances (Barney and Hansen 1994) Idea searching (Majchrzak and Malhotra 2020)	Ecosystem (Jacobides et al. 2018) Collaborative crowdsourcing (Majchrzak and Malhotra 2020)

Published in Organization Science on December 30, 2021 as DOI: 10.1287/orsc.2021.1558.
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and distributed leadership (Adler and Heckscher 2018).

Looking forward to the prospects of the digital transformation, we see two main types of responses to the current critical problem in the organization sphere; each type points to a different scenario and different type of network. In the first type, the Business Process model remains dominant and integrates the Community-and-Collaboration model only partially, perhaps only at a symbolic and rhetorical level. In the second type, the Community-and-Collaboration model becomes dominant and incorporates the advances of the paradigm-revolutionizing model while transcending its limitations.

This fork in the road is particularly visible in the case of platform companies. In many of the dominant platforms, we see the first type of scenario: the Business Process model remains dominant, even as its dysfunctions have become increasingly visible, and there is little evidence that the Community-and-Collaboration model is diffusing. The massive network effects of digital technologies generate "winner-takes-all" competitive dynamics that subordinate Community to Market priorities. Consider Facebook. Yes, Facebook created opportunities for users to communicate, and this social media technology could support the flourishing of community; but that potential was not fulfilled: Facebook's deployment of this technology is dominated by a Business Process logic (exchanging clicks for advertising dollars), and the company jealously guards its ability to repurpose the resulting data regardless of users' interests or preferences (notoriously in the case of Cambridge Analytica). Governance of this network is controlled by and for the platform owner (Srinivasan 2019, 2020). Or consider Amazon Marketplace. Here too, the actors on both sides of the platform are weak relative to the platform owner. Digital technologies are used to control and eliminate labor. Amazon uses data on their suppliers' sales to design and under-price competing products. The Business Process model helps exploit "platform dependency"—the asymmetrical power relation between platform users and platform owners (Kenney et al. 2020, Schor 2020)—and in the process, undermines community.

The second type of scenario could be easily imagined: In the case of platforms such as Facebook, the network would not be controlled by the platform owner but would be operated by and for the community of users. In the case of Amazon, data would not be used to enable Amazon's owners to capture more private value but would help build a community among suppliers that would enable them collectively and collaboratively to improve their offerings. The power relations between platform users and owners could be much more symmetrical.

The choices made at this fork in the road will also have a major impact on the future path of the technology sphere. In the first type of scenario, new technologies such as AI, robots, and autonomous vehicles might be the basis for a future governed by a small number of companies—like Facebook, Google, and Amazon—who rely on the Business Process model to intensify their control and surveillance, or by authoritarian governments for the same benefit. Alternatively, if the Community-and-Collaboration model were to prevail, these technologies could be used to enhance organizational transparency and accountability (Albu and Flyverbom 2019) and AI could create and enrich jobs rather than destroy and impoverish them (Acemoglu and Restrepo 2020). Worker-owned platform cooperatives, where members collectively set fares, compensation, and investment, could displace extractive platforms (Scholz and Schneider 2017).

Which path will the digital transformation take? History suggests that this depends in part on choices made in the public policy sphere.

Public Policy Sphere: Between Neoliberal Laissez-Faire and Proactive System-Building

As was the case in previous revolutions, the dominant public policy regime in the installation period of the ICT revolution was a laissez-faire type. The enthusiasm for the potential of the new technologies conflicted with the inherited public policy regime, and the latter gave way to the current instantiation of laissez-faire—"neoliberalism" as it is frequently referred to (Saad-Filho and Johnston 2005, Harvey 2007a, Cahill et al. 2018).[4] Each new laissez-faire regime differs from the preceding ones, jast as each new system-building regime does. In particular, neoliberalism is relatively novel *inter alia* in its focus on privatizing the delivery of public services. Bernstein (2006) describes this neoliberal form as a YOYO regime: "you're on your own." Enthusiasm among investors for the new technologies' potential led to a stock-market frenzy, which government encouraged by scaling back financial regulations: the Clinton administration abrogated the long-standing Glass-Steagall Act and refused to regulate the expanding market for derivatives. The network effects so common among the new core technologies might have led to antitrust action, but in the enthusiasm of the installation period, antitrust enforcement was scaled back rather than intensified—yielding platform oligopolies such as Amazon, Apple, Facebook, Google, and Microsoft. Similarly, the outsourcing encouraged by the Business Process model prompted the proliferation of independent contractors and, in the face of this development, labor regulations were ignored when they would have barred the misclassification of so many employees. Online retailers like Amazon were allowed to

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sell into states without collecting the corresponding sales tax. Many of the leading platform companies relied on business models in which users were offered free access while data about them were captured and sold to advertisers
—yet privacy regulations were remarkably absent. (Europe imposed somewhat stricter privacy rules with the General Data Protection Regulation.)

The neoliberal laissez-faire regime thus encouraged installation; however, as we move toward deployment, a new critical problem has emerged in the misfit between the technology and public policy spheres. Moves toward neoliberalism have led to extreme income inequality, stagnant real wages for most, and exacerbated employment insecurity, which all limit the mass market for new digitally enhanced consumer goods. The emergence of giant oligopolies has raised urgent questions about market power and political influence. Moreover, the exciting possibilities of digital technologies—helping us address critical issues in sustainability, education, healthcare, and advance opportunities like autonomous automobiles—are held back by doubts among firms and investors as to which direction deployment will take and how fast it will unfold. Deployment is further handicapped by lack of investment in the requisite social and material infrastructure. In prior revolutions, massive system-building investments in canals, railways, electric grids, and highway systems were key enablers of deployment. Whereas in some countries government has played a bigger role than in the United States in telecommunications infrastructure (resulting, for example, in wider use of broadband at lower cost), neither in Europe nor the United States has government adopted a policy regime that promises to address the material and social infrastructure required to unleash the full potential of the digital transformation.

Faced with this critical problem in the public policy sphere, we are today at a fork in the road. One option is to go yet further in a laissez-faire direction: the system-building efforts necessary for deployment could be led by private firms. If a laissez-faire regime went further in dismantling antitrust regulation and in further weakening labor laws protecting employees and unions, perhaps platform oligopolies such as Amazon, Apple, Facebook, Google, and Microsoft could create the necessary systems, not as tax-funded public goods and services but as investor-financed private ones (Rikap and Lundvall 2020). Proponents of the neoliberal laissez-faire view highlight the advantages of retaining initiative in the hands of private firms and point to the dangers of "government failure" (Winston 2006). It is not clear, however, how this option, which seems destined to further aggravate income inequality and economic precariousness, would sustain effective demand for these new digital goods and services. And the political costs of leaving so many people "behind" are high: it prompts the emergence of nationalist populist movements, which in turn creates political havoc.

The alternative to a neoliberal laissez-faire regime in the current technology revolution is still taking shape but some powerful concepts are emerging (Schot and Steinmueller 2018). Mazzucato (2021) synthesizes several of these concepts in her description of a new form of system-building regime (which we call "proactive"), where government proactively creates public value by taking the lead in system-building "missions"—integrated programs that create knowledge and infrastructure in the public interest, and that guide private industry and investment in a more sustainable direction. (On public value, also see O'Flynn 2007.) Mazzucato argues that reliance on private-value creation by industry, as expressed in the neoliberal laissez-faire regime, might lead to some important technological innovations such as autonomous vehicles, wearable devices, or cheaper solar panels, but will not enable us to deploy the ICT revolution across the wider spectrum of applications in education, healthcare, mobility, or energy systems. The creation of a comprehensive smart-energy system, for example, requires coordinated changes in electricity, heating, buildings, and transportation systems (Lund et al. 2017), and it is difficult to see how we can achieve this coordination and mobilize the required investment if the effort is led by the currently dominant oligopolies. This brings us to our third summary proposition:

Summary Proposition 3. *In the face of the current critical public policy problem, the choice is whether to strengthen further neoliberal laissez-faire or to move toward a proactive system-building regime. The choice between these two options will enable and constrain choices in the organization sphere, and in combination, these two choices will condition the future trajectory of the digital transformation.* (The contrast between these options is presented in Table 3.)

Laissez-faire and system-building regimes are characterized by a dialectical tension similar to the one we observed in the organization sphere. Arguments in favor of a proactive system-building regime are triggered by the dysfunctions of neoliberalism in the face of the potentialities of the ICT revolution. The extended period of crisis that separates installation and deployment, which began with the dot.com crash and continues unresolved, has "unfrozen" debate over which path is more promising. The installation period under neoliberal auspices has brought considerable destruction in its wake—the destructive part of Schumpeter's "creative destruction"—and a proactive system-building regime looks increasingly attractive as a way to get to the creative part. The counterargument is that system-building efforts could better be led by the private sector.

Table 3. Two Public Policy Regimes for the Digital Transformation

	Laissez-faire policy regime	System-building policy regime
Current alternative regimes	Neoliberalism: Government supports primacy of private-value creation by self-organizing markets	Proactive public policy: Government leads public-value creation through system-building missions
Regime's role in the technological revolution	Buttress the autonomy of firms in the economic playing field Enable private-value creation through deregulation and privatization Keep political influence out of economic activity	Tilt the economic playing field in the direction of the desired change Lead public-value creation to address "grand challenges" and "grand opportunities" Exert political influence to prevent negative externalities; subsidize positive externalities; expand public enterprise
Historical examples of consequences of regime	Railway mania Steel mania Roaring Twenties	Comprehensive US railway system Comprehensive US electricity system Comprehensive automobile-based transportation system
Theorization of the contrast between regimes	Private interest (Hirschman 2002) Disembedded economy (Polanyi 1968)	Public interest (Hirschman 2002) Re-embedded economy (Polanyi 1968)
Key features of the current alternatives	Private innovation systems that advance the deployment of AI and other technologies Technology sovereignty in the hands of private firms Government and courts strengthen property rights of technology firms with respect to data and knowledge	Public innovation systems that advance the deployment of AI and other technologies Technology sovereignty in the hands of public institutions Government and courts strengthen public and citizen property rights with respect to data and knowledge
Examples of contrasting concepts supporting the current alternatives	Minimal state (Nozick 1974) Free-market economy (Friedman 1970) New public management (Barzelay 2001)	Entrepreneurial state (Mazzucato 2015) Smart, green growth (Perez 2019) Mission economy (Mazzucato 2021)

The collective choice we make in the public policy sphere also has an impact on the organization sphere. To illustrate this impact, consider ride hailing. On the one hand, Uber is a prototypical "extractive" platform based on the Business Process model. Uber's growth in the United States, facilitated by laissez-faire, has led to some benefits for passengers (cost, convenience) and drivers (access to part-time employment) but also to considerable negative externalities (lower pay levels, reduced support for public transportation, city congestion). Uber stands as emblematic of the installation period frenzy, driven not by a sustainable business case, but by the zeal of investors convinced there is a pot of gold at the end of the rainbow (Horan 2019).

On the other hand, cooperatives such as the Green Taxi Cooperative in Denver (Colorado) and the ATX taxi cooperative in Austin (Texas) (Schneider 2016, Scholz 2017, Borowiak and Ji 2019) offer an alternative closer to the Community-and-Collaboration model. However, it is hard to see how such a management model can generalize across the economy without a turn away from neoliberal laissez-faire, through renewed antitrust enforcement and stronger regulations ensuring workers are not inappropriately treated as independent contractors. As long as Uber can treat drivers as independent contractors, as long as laws limit the collective action options available to such independent contractors, and as long as Uber can use predatory pricing to drive out competitors, Uber will be able to pay drivers much less than any cooperative and keep their dominant market position. Is there a scenario in which public policy could support the development of a superior community-oriented alternative, such as a public transportation system that embodies the flexibility and convenience of Uber? We turn to such options in the next section.

Scenario Analysis

It follows from the preceding sections that different societies, characterized by different responses to the critical problems that have emerged in the organization and public policy spheres, will deploy differently the emerging technologies of the digital transformation. Our analysis in the previous sections suggests the basic choices available in each of the two spheres:

(1) In the organization sphere, deployment can be guided by a Market- and Hierarchy-based Business Process model, or alternatively by a Community-based paradigm-balancing model (Community-and-Collaboration)—either dominating networks to capture value or empowering community to create value.

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(2) In the public policy sphere, deployment can be guided by a neoliberal laissez-faire regime based on faith in self-organizing markets and the primacy of private-value creation, or alternatively by a proactive system-building regime where government advances missions aimed at creating public value.

Combining the two key choices, we can identify four scenarios for the future trajectory of the ICT revolution and the digital transformation: development can proceed toward digital oligarchy, digital authoritarianism, digital localism, or digital democracy. (On the value of scenarios in management and organization research, see Hoffman and Jennings (2021) and Farjoun (2008).) These four scenarios represent "corner solutions" (Figure 1), and most real-world cases will be situated between these extremes. We outline the four scenarios, and then discuss their heuristic value.

Digital Oligarchy

Oligarchy means rule by the few, but we follow Aristotle and use it to refer to rule by the wealthy few (Miller 2017). Digital oligarchy is a scenario that combines a neoliberal laissez-faire regime with a Business Process management model. Government plays little active role in stimulating technology development or deployment, leaving it to market forces—and to digital oligopolies as they emerge through market competition—to set the direction of the digital transformation.

The United States has moved in this direction since the 1970s. Over this same period, and partly encouraged by this shift in regime, the Business Process model diffused across U.S. industry. This diffusion was fastest in the new core industries of the ICT revolution. These new conditions, characterized by a winner-takes-all logic encouraged by the strong network effects of the ICT revolution, were fertile ground for the rise of oligopolists such as Amazon, Apple, Facebook, Google, and Microsoft. These firms' market and political power enabled them to buy innovative technology startups (e.g., Amazon acquired Zoox; Apple, Siri; Facebook, Instagram; Google, DeepMind; and Microsoft, Skype) and to integrate them into their ever more powerful platform empires (Umeh 2016, Radziwill 2018). As a consequence, emerging technologies are increasingly shaped by these corporate giants. In this scenario, these giants' property rights preempt national data- and technology-sovereignty. Surveillance—extracting and selling data culled from users in ways kept secret from those users—is a key source of profit (Zuboff 2019). Even free-speech rights become a matter of private corporate policy rather than public policy, as platforms like Facebook, Twitter, and YouTube decide who and what to censor.

Digital Authoritarianism

The digital authoritarianism scenario combines a proactive system-building regime with a Business Process management model. Here government plays an active role in investing in technology development and deployment, and thus creating public value—albeit public value as understood by an unaccountable governing elite (Polyakova and Meserole 2019, Khalil 2020). Hierarchy functions as the key organizing principle within government and between government on the one hand and private enterprises and citizens on the other. Community is suppressed—social networks are restricted—because it might threaten government control. Deployment of digital technologies is steered in a way that keeps technology sovereignty in the hands of a powerful state elite and equips that elite with effective systems for surveillance and control. Surveillance is legitimized by a low rate of criminality, by nationalist appeals, and/or by aggregate economic growth. Authoritarian rule has performed rather well in accelerating economic growth in "developing" economies—witness China (Yang 2006) and Singapore (Verweij and Pelizzo 2009).

Digital Localism

Digital localism combines a laissez-faire public policy regime at the national level with a variety of management models at the local level, yielding a patchwork pattern where the Community-and-Collaboration model prevails in some jurisdictions and Business Process in others. With a laissez-faire public policy, central government plays little role in shaping the direction of deployment.

We might expect this to lead generally to digital oligarchy; however, in some local contexts, alliances of actors might push successfully for the resolution of urgent local problems, shaping the decisions of local jurisdictions. Local jurisdictions might opt for policies more supportive of the Community-and-Collaboration alternative, and they might be powerful enough to block the entry of giant corporations and to mobilize citizens and local businesses toward community wealth building. (Hess and Gottlieb 2009, Dubb 2016). Deployment of digital technologies can be organized here to ensure a certain level of technology sovereignty for the local community, as in Barcelona for example (Eizaguirre et al. 2017). Whereas change at the local level may be easier, the digital localism scenario foregoes the potential benefits of scale and interconnectivity at the national level.

Digital Democracy

A digital democracy scenario combines a proactive system-building regime with a Community-and-Collaboration management model. In contrast to digital oligarchy, government here not only encourages private-sector initiative and responds energetically to the resulting negative social and environment externalities but also shapes the direction of technology development and deployment in a purposeful way. In contrast to digital localism, deployment activates all

levels of government and society, harnessing network effects and other positive externalities on a national level. In contrast to digital authoritarianism, here deployment is steered in a way that strengthens collaboration and enriches and activates community by widening and deepening democratic participation. The formal systems of government in this scenario play an enabling rather than coercive role, fostering rather than suppressing community initiative. Whereas an authoritarian regime is fearful of the political risks of community, a democratic one would activate community in neighborhoods and organizations and in relations between the public and government. Technology sovereignty would be in the hands of citizens.

Notwithstanding the fact that no major country has thus far embraced a digital democracy scenario, macro-Schumpeterians like Perez (2009) and Mazzucato (2018) argue that this is the most likely path to deployment success, given the historical record of previous revolutions, where deployment was stimulated by the combination of a system-building policy regime and a paradigm-balancing management model. The other three scenarios seem less likely to tap the digital transformation's full potential.

Heuristic Value of the Scenarios

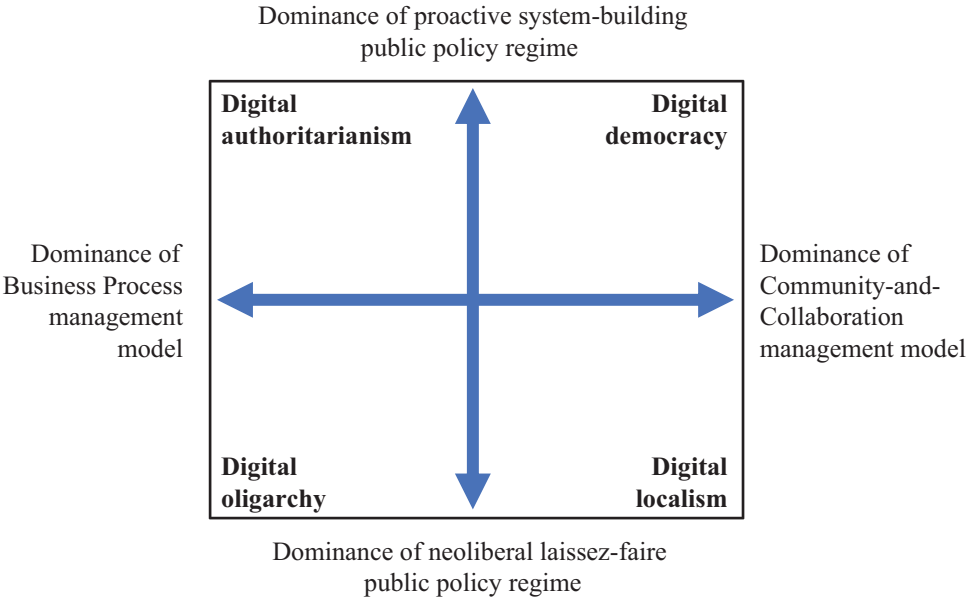
Most real-world cases will be situated between the extremes represented by these four scenarios (as presented in Figure 1). Therefore let us now show the heuristic value of this scenario matrix as a map for analyzing concrete cases.

First, Figure 1 could be used to locate different countries or supranational unions and trace their zig-zag trajectories. A comprehensive analysis of any specific country would require a paper of it its own, but some observations might be useful.[5] The United States has been the global leader in the installation period of the ICT revolution: the combination of a dominant Business Process model and a neoliberal laissez-faire regime has strengthened the position of the giant U.S.-based platform firms. It is not clear, however, that this digital oligarchy scenario will allow the United States to retain leadership as we move into deployment, given the retreat of both the federal government and the private sector from R&D investment and the escalating inequalities in income and wealth (Soskice 2020). We should note that the United States is not a pure case of laissez-faire: the defense and security domains, for example, seem to operate under a more system-building public policy regime and are largely exempt from budget cuts.

China too has relied mainly on the Business Process model but has married that with a system-building policy regime. Government control over the economy has become considerably more selective since the reforms of the late 1980s and early 1990s, offering a more laissez-faire regime in important sectors of the economy; this has yielded giant digital oligopolies of its own (e.g., Tencent and Alibaba) operating under the umbrella of digital authoritarianism (Lundvall and Rikap 2022). It remains to be seen whether that mix is stable or whether the growing power of private enterprise will threaten the control of the Communist Party (Csanadi 2016).

The European Union seems to be aiming for middle-way solutions somewhere between digital oligarchy and localism. However, such a middle way

Figure 1. (Color online) Four Scenarios for the Digital Transformation



Published in Organization Science on December 30, 2021 as DOI: 10.1287/orsc.2021.1558.
This article has not been copyedited or formatted. The final version may differ from this version.

has encountered roadblocks, generating neither globally competitive tech firms nor dominant public platform alternatives. In the interim, smaller innovative tech firms in Europe are assimilated into the U.S. tech platform empires, such as in the case of Google's acquisition of British DeepMind (Rikap and Lundvall 2020). Efforts to find a middle way might risk getting "stuck in the middle."

Zooming in from the country level to smaller units of analysis, we can also use this map to explore empirically the effects of alternative management models and public policy regimes on specific sectors and regions that may operate under different models and regimes, as noted previously for the U.S. civilian versus defense sectors or as noted by Kattel and Mergel (2019) for Estonia's ICT sector versus other sectors.

We could also use the four scenarios as a heuristic to inform meso-level research (reviewed by Ahuja et al. 2008), to understand, for example, the political strategies of organizations. The tech giants have actively lobbied for a laissez-faire regime in the United States and in Europe (Brannon 2019, Corporate Europe Observatory 2020). Given that China is the only country where major competitors to these giants have emerged, it would seem that their strategies have been largely successful. What then are the prospects for platform cooperatives? Taxi cooperatives have encountered enormous difficulties when trying to "share the road" with Uber (Schneider 2016, Scholz 2017, Borowiak and Ji 2019). As noted earlier, under the prevailing neoliberal laissez-faire regime, Uber undermines the cooperatives' competitive viability by offering customers unbeatable prices. Our scenario matrix suggests that where interests diverge so fundamentally, the most effective strategic choice for taxi cooperatives might be to seek out arrangements with local governments to pursue a digital localism scenario, with rules of the game that favor small cooperatives.

Conclusion

This paper aimed to develop a conceptual framework for understanding and bounding the uncertainty regarding the future trajectory of the digital transformation. To that end, we expanded Schumpeter's theory of technological revolutions and the macro-Schumpeterian account of prior revolutions, and we explored how the trajectory of those revolutions was shaped by the emergence of critical problems and competing solutions in the triple system of technology, organization, and public policy. Given the advanced state of technology today, the future of the digital transformation hinges on choices to be made between the competing solutions in the organization and public policy spheres: in the former, the choice appears to be between the currently dominant Business Process model or an emerging Community-and-Collaboration model, and in the latter, between the currently dominant neoliberal laissez-faire regime or an emerging proactive system-building alternative. The conjunction of these two choices suggested four scenarios for the future trajectory of the digital transformation: digital oligarchy, digital authoritarianism, digital localism, and digital democracy. Given the uncertain evolution of management models and public policy regimes, it is easy to understand the current deep uncertainty about the future trajectory of the digital transformation. In the United States, Zuboff (2019) argues that we are headed toward "surveillance capitalism" and a digital oligarchy scenario. However, debate—and political struggle—continue in both public policy and organization spheres: the die is not cast.

We hope that the framework we have advanced here and the conclusion to which it leads us will encourage future research on the forces shaping the choices we face. This paper focuses on the nature of these choices, but we need to understand who is doing the choosing and how. Future research should aim to identify the specific actors involved in the digital transformation and how their power and interactions both shape and are shaped by choices in management models and public policy. We should explore the competition and cooperation between the various groups and individuals involved—competing firms and sectors, innovative practitioners, academic theorists, gurus popular in the media, consultancy firms, institutional entrepreneurs in government agencies, unions, and social movements. They all played roles in previous revolutions (Bodrožić 2008) and will surely play important roles in this one. What networks do these actors form and how do these networks shape the course of this technological revolution? Which actors promote and which resist the broadening of government's role and the transformation of management models? How do these struggles unfold over time? What are the mechanisms underlying the persistence of inherited management models and policy regimes? Political-economy theory, social movement theory, and neo-institutionalist theory might provide powerful conceptual tools for this kind of analysis.

Whether the digital transformation serves the needs of the people and the planet, or, alternatively, serves to reinforce structures of inequality and domination will depend on the choices and actions of citizens, innovators, movement activists, and policy makers. We can choose to create and implement digital tools, management practices, and public policies to support surveillance of activists, to enable corporate censorship, or to empower local communities, or even to reinvigorate democracy. Management and organization scholars have a role to play in informing these choices.

Acknowledgments

The authors thank the Special Issue senior editors, especially Diane Bailey and Samer Faraj, and the three anonymous reviewers for insightful and constructive feedback throughout the review process. The paper has also benefited from comments by Stan Karanasios, Ann Majchrzak, Carlota Perez, Florenta Teodoridis, Charles Umney, Eero Vaara, the seminar participants of the 2019 Special Issue Paper Development Workshop at the University of California, Santa Barbara, of the Organizations & Strategy working group at the University of Southern California, and of the European Group for Organizational Studies 2019 Subtheme "Historical-Evolutionary Organization Studies: Understanding the Past to Shape the Future." The authors also thank Stan Karanasios for help in compiling the timeline in Table 1.

Endnotes

[1] On the nature and importance of stylized facts in scholarship, see Helfat (2007, p. 187), who characterizes them as "observations that have been made in so many contexts that they are widely understood to be empirical truths, to which theories must fit."

[2] Theoretically, we can connect the notion of a critical problem to the concept of reverse salient: "A salient is a protrusion in a geometric figure, a line of battle, or an expanding weather front. As technological systems expand, reverse salients develop. Reverse salients are components in the system that have fallen behind or are out of phase with the others" (Hughes 1987, p. 66–67). We build on Hughes's observation that reverse salients have often emerged outside the technology sphere—in the constraints of prevailing organizational forms or limited access to finance, for example.

[3] The Community-and-Collaboration model transcends the more common concept of "community of practice": the latter typically refers to communities that share a common discipline and socialization informing their occupational practice. Such a bounded form of community would be less adequate to bridge the diverse occupations and perspectives that need to be recombined in the Network paradigm.

[4] "Neoliberalism is a theory of political economic practices proposing that human well-being can best be advanced by the maximization of entrepreneurial freedoms within an institutional framework characterized by private property rights, individual liberty, unencumbered markets, and free trade" (Harvey 2007b, p. 22).

[5] During technological revolutions, the trajectories of "leading countries" and countries that are "catching up" differ. For a comparative analysis of the evolution of management models in some countries that were catching up during the prior two technological revolutions, see Guillen (1994). For a discussion of contemporary catching-up strategies, see Whittaker et al. (2020).

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