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Beyond design and use: How scholars should study intelligent technologies

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ABSTRACT

This paper proposes a unified approach to studying intelligent technologies such as artificial intelligence (AI) that extends current studies of design and use. Current discussion of the implication of AI and the future of work gloss four important issues: variation, power, ideology, and institutions. By a unified approach we mean a research agenda that coordinates studies of variation in use with research on power, ideology, design, and institutional change, all focused on a specific technology or set of technologies. The approach rests on the image of a technology timeline that begins with the issues of power and ideology that underwrite the promotion of intelligent technologies by firms and other stakeholders that have an interest in building and diffusing such technologies. Moving to the right the timeline encompasses studies of design, implementation, and use that pay attention to variation in how intelligent technologies occasion changes in work and employment. Finally, the unified approach extends beyond current workplace studies to consider the institutional changes that may arise as the result of how intelligent technologies are used and employs such considerations to shape the agenda of promoters and designers so that they will create technologies that better benefit society.

1. Introduction

In a recent surge of publications, artificial intelligence (AI) researchers, economists, and public intellectuals have argued that AI is radically different from prior technologies in its potential to transform the landscape of work and employment (Brynjolfsson & McAfee, 2011; Ford, 2015; McChesney & Nichols, 2016). In fact, several commentators see AI as the harbinger of a new era of industrial transformation in which many people will have no jobs (Kaplan, 2015; Lanier, 2014; Schwab, 2016). The future they portray reflects Zuboff's (2013) first law: "Everything that can be automated will be automated." Even scholars who allow that some jobs will be eliminated, others will be created, and some will be transformed worry that AI could spawn a radical transformation of work and society (Autor, 2015; Brynjolfsson & McAfee, 2014; Mindell, 2015).

These authors deserve considerable credit for opening the conversation on intelligent technologies—by which we mean AI and the suite of associated technologies that complement or contribute to it, such as machine learning, big data, robotics, smart sensors, the Internet of things, and analytics—as well as their potential effects on society. Indeed, the work of these authors has led several governments and think tanks to consider policies for alleviating potential negative consequences of widespread technological unemployment (Furman, Holdren, Munoz, & Smith, 2016; National Academies of Sciences, Engineering, and Medicine, 2017; National Science and Technology Council, 2016a, 2016b; World Economic Forum, 2016). In so doing these authors and organizations have exhibited concern for how workers may suffer in this transformed landscape and how we need to rethink social programs, policies, and institutions as we develop new understandings of the role work plays in society.

Despite these considerable contributions, current formulations of the problem of intelligent technologies gloss four issues that are crucial for fully understanding how an expanding use of these technologies could occasion changes in work, employment, and

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society: variation, power, ideology, and institutions. These four issues have implications for understanding whether intelligent technologies will partially or completely automate jobs and transform the nature of work. Bringing these issues to the forefront is necessary for informing future research as well as the kinds of programs, policies, and institutions needed to guide us toward a more equitable future.

Scholars of technology, work, and organization are well versed in addressing the first issue, variation. Indeed, our field emerged from the premise that the implications of a technology vary significantly by its context of use. However, like those who write about intelligent technologies at the level of the economy, we have also paid limited attention to issues of power, ideology, and institutions, especially as they extend beyond a single organization. Nevertheless, we argue that scholars of technology, work, and organization should push for and organize efforts to extend research on intelligent technologies into these domains.

The intellectual implication of what we are proposing is that those of us who consider ourselves students of technology, work, and organization must face up to the limitations of how our research agenda and ontology have evolved over the last three decades. Specifically, we need to admit that the implications of a new technology are not always the product of ongoing action and interpretation at the point where people are using technologies. Rather, those who design and promulgate technologies have visions of what work is and what it should be like (Orlikowski, 1992; Pollock & Williams, 2010; Williams & Pollock, 2012). Such visions shape the outcomes of technological change. Thus, we cannot continue to view the implications of new technologies as solely situated, contextual, and emergent. As Hughes (1994) noted, infrastructural technologies bring about institutional developments that are difficult to trace to what occurs in any specific setting of use. In other words, there are macrosocial and economic trends that emerge over time as unanticipated consequences despite variation at the local level.

Bearing in mind these limitations of how our field evolved and the ontology that many of us have adopted, we first delineate the four issues that have been glossed by current formulations of intelligent technology and work. To address these issues, we next discuss the kinds of studies and findings that current schools of research on technology produce. We then outline and advocate a unified approach for studying workplace technology in the age of intelligent technologies that seeks to unearth less situated regularities while continuing to appreciate the value and importance of the detailed, contextual studies that have characterized our field since the 1980s.

By a unified approach we mean a research agenda that coordinates studies of variation in use with research on power, ideology, design, and institutional change, all focused on a specific technology or set of technologies. We are not simply calling for a series of disconnected and independent studies by scholars with expertise in distinct approaches to technological change. Rather, we call for teams composed of a variety of scholars across multiple disciplines who collaborate with each other by jointly designing a set of coordinated and parallel studies. Our notion is that these studies would build off each other to cover the range of relevant actors, events, practices, and dynamics involved in a technological change over time.

2. Four issues glossed in current formulations of intelligent technologies and work

The first issue concerns the obscuring of variation. Because economists and policy makers gravitate to assessing the scale and scope of intelligent technologies' implications for work at the level of a society or economy, they tend to operate at a relatively high level of abstraction that obscures variation in both implementation and use in favor of identifying general trends in labor markets. For example, to identify the probable impact of automation on occupations researchers have relied on databases developed from standardized descriptions of types of jobs. The most commonly used database for this purpose has been the U.S. Department of Labor's O*Net, which builds descriptions of jobs based on job incumbents' answers to standardized survey questions. The data from multiple incumbents are then aggregated to create a modal profile for each occupation. This process obscures potential variation in the skills, tasks, and work practices of jobholders across organizations and locations. What this means is that an analysis that suggests that intelligent technologies can automate a particular job may be true for jobholders in some organizations and locations, but not others. Moreover, such analyses are highly sensitive to the methods that researchers use to predict the potential for automation as well as to the unit of analysis to which the methods are applied. For example, researchers have predicted radically different degrees of automation depending on whether they focus on skills, tasks, or occupations (e.g., Frey & Osborne, 2013; Manyika et al., 2017; OECD, 2016; Select Committee on Artificial Intelligence, 2018). In short, when data are cast as a single, universal job description that covers all members of an occupation, they cloak variation in how work is done and, consequently, are subject to misleading predictions.

Moreover, such databases cannot possibly include the details of how and why specific organizations implement a technology. As students of technology have repeatedly shown, organizations implement technologies for a variety of reasons and people integrate technologies into work practices in different ways (e.g., Barley, 1986; Edmondson, Bohmer, & Pisano, 2001; Orlikowski, 2000). Both types of variation strongly shape the way work and organizing change in the face of new technologies. For this reason, new technologies have a host of consequences that are rarely predicted because they arise out of the interaction of technologies and the settings in which they are deployed (Sproull & Kiesler, 1991).

Overlooking the importance of power is the second issue. Behind the design and adoption of technologies lie interests and agendas. Thomas (1994) made this point well in his study of the adoption of flexible machining systems, robotic assembly cells, and shop-programmable machine tools, among other manufacturing technologies. He found that if engineers or middle managers wished to adopt a new technology, they first had to sell the idea to top management. Regardless of the real reasons that the groups wanted to purchase a new technology, they could only justify their case by appealing to greater efficiency and lower labor costs. In other words, the design and spread of technologies, as well as the technologies' expected outcomes, were shaped by the interests, goals, and perspectives of those who had the authority to authorize the purchase. Thomas, therefore, emphasized the idea that technological change is driven by politics, an idea that other scholars have also articulated (Markus, 1983; Noble, 1984; Winner, 1980). To the degree that this is true, and to the degree that the exercise of power in industry and on Wall Street gravitates toward automating work, then current writers are mistaken in attributing loss of jobs solely to the technology itself. Moreover, if we recognize that power plays a crucial role in shaping the social outcomes of intelligent technologies, then it leaves open the possibility that a different zeitgeist might lead decision-makers to design and implement intelligent technologies in ways that augment work rather than replace workers (Markoff, 2016; Zuboff, 1988).

The third and related issue lies in ignoring ideology. As Forsythe (2001) pointed out more than two decades ago, the AI community approaches design with its own culture and its own ideology of design. As a full-time observer over several years in a series of AI laboratories, Forsythe turned her anthropologist's eye to how the designers of expert systems viewed their own work and the work of experts whose knowledge they sought to codify. Although the AI community has replaced the building of expert systems with machine learning approaches, the conclusions that Forsythe reached remain relevant. Based on her observations and interviews, Forsythe argued that AI designers, with backgrounds in computer science, information science, and intelligent systems technology, operated from a cultural perspective that privileged the technical over the social. Similarly, Markoff (2016) emphasized in his history of intelligent technologies two radically different paradigms for conceptualizing their use. The dominant paradigm, which Markoff called "artificial intelligence," and which was championed by early computer scientists such as John McCarthy, focuses on taking humans out of the loop and replacing them with intelligent technologies. The second paradigm, which Markoff called "augmented intelligence," emphasizes designing intelligent technologies that will complement and assist workers in their tasks. This paradigm was originally championed by Douglas Englebart, best known as the creator of the mouse. There is reason to believe that the first paradigm is more common among technologists than the second because it meshes nicely with the economic logic of efficiency, which pursues the lowering of labor costs. By ignoring design ideologies–in particular, the possibility of the "augmented intelligence" paradigm–current writers' predictions may be too dire. This seems especially likely since some recent research on intelligent technologies suggests that replacing labor may be more difficult than first anticipated (Shestakofsky, 2017).

The fourth issue concerns the breadth of institutions that may be affected by widespread unemployment resulting from the adoption of intelligent technologies. Economists and policy makers have paid attention to educational institutions as well as legal institutions that underwrite the social safety net. For example, they place heavy emphasis on revising the educational system to better prepare people for higher-skilled jobs and changing careers. They also offer ideas for policies that would ameliorate the hardships of unemployment and underemployment, the most common being establishing a universal basic income that would provide every citizen with an annual lump sum payment to complement any earned wages. But the institutional effects of widespread unemployment are likely to extend beyond education and the social safety net.

Consider the institutions of family life and marriage. Our ideal image of family and home life is that of a refuge where we can escape the burdens of our job for more fulfilling activities and relationships. However, research suggests that home life, marriage, and parenting may not always be the refuge our culture suggests they are. For example, when Hochschild (1997) studied a firm in the Midwest she became puzzled by the fact that not only managers and technical workers but employees on the factory floor *willingly* worked exceedingly long hours, sometimes happily volunteering for overtime. To her surprise, the primary reason for working such long hours was not simply to make additional money, but to escape family life, which the workers, including women, found less rewarding and less pleasant than the workplace. Both men and women noted that at work they were praised and rewarded for what they did. But at home, routine and endless tasks such as doing the laundry and washing the dishes elicited little gratitude or acknowledgement, much less a raise. Hochschild's research suggests that widespread unemployment may significantly impact the institutions of family and marriage.

The transportation infrastructure is an example of another institution that might face critical challenges from widespread technological unemployment. Our highways, railways, subways, bus routes, ferries, and local streets are laid out to accommodate traffic moving to and from workplaces, many of which are centered in towns and cities (U.S. Department of Transportation, 2017). With throngs of people no longer commuting to work and possibly traveling in different directions for recreation, our systems for moving people will need to be redesigned and rebuilt. With work commutes no longer a significant consideration, we may wish to commit to a transportation infrastructure attuned to ideas of social justice and the fair distribution of resources and access, yet to date we have little design guidance in this realm (Martens, Golub, & Robinson, 2012). In addition, the hollowed-out cores of towns and cities could be put to new uses, which would similarly require considerable urban planning and redevelopment.

Current research on technology in the workplace traces the trajectory of a technology on a timeline that begins with the design of the technology and moves to use (see Fig. 1). In general, students of technology, work, and organization have positioned themselves

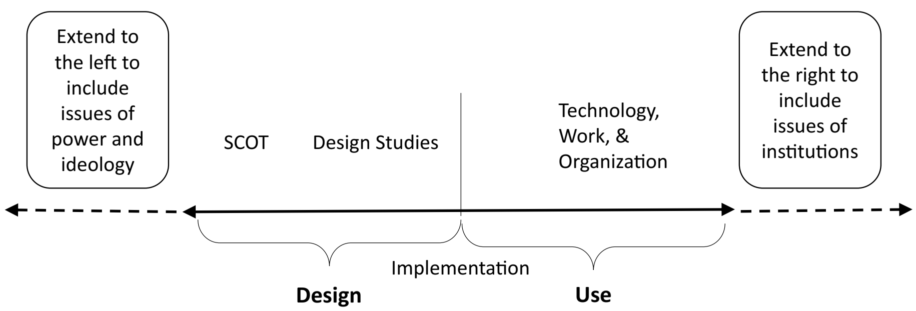

Fig. 1. Current and extended timeline of a technology's trajectory.

on this timeline by focusing on a technology's use, variation in such use, and the ramifications for work, workers, and organizations. If they were to address all four issues that we have discussed, and not just variation, they would need to broaden their own purview by attending to what happens in design as well as extending the entire timeline on both ends.

3. Extending the timeline of a technology's trajectory to the left and the right

To begin, addressing issues of power and ideology would require scholars to extend the timeline of a technology's trajectory to the left by examining the interests, goals, and perspectives of those who make or influence decisions about design and adoption. Addressing the issue of institutions would require scholars to extend the timeline to the right to capture the broad array of societal changes that may arise from the adoption and use of intelligent technologies. Because no single scholar can reasonably take on a project of such scope, scholars of technology, work, and organization will need to build diverse interdisciplinary research teams. For example, students of the social construction of technology (SCOT) might help with expansion to the left while macro-sociologists, urban planners, social workers, and institutional economists would assist in the expansion to the right. We advocate a unified approach that would extend the timeline in both directions. Our belief is that by taking a unified approach, scholars of technology, work, and organization can significantly inform the current debate over intelligent technologies, as well as position themselves to champion their own expertise, participate in policy discourse, and join forces with economists and others who have already begun to take on the socio-economic challenges posed by intelligent technologies.

Extending the timeline to the left and the right will have significant academic value because it will allow students of technology, work, and organization to build better theories and gain richer understandings of the shaping of a technology and the consequences of its use. Perhaps just as important, conducting research in this broader and more integrated approach opens the possibility for action research: using research findings to shape the design of new intelligent technologies prior to their adoption and implementation in the workplace. This kind of action research may be useful in ensuring that dire forecasts of technological unemployment are avoided. In sum, extending to the left positions scholars of technology, work, and organization to become involved in the shaping of new technology while extending to the right informs that shaping by allowing us to begin to speak to what intelligent technologies ought and ought not to do to society.

Extending the timeline will involve two departures from how research is currently done. The first is to join existing schools of thought that speak to the design and use of technologies with new groups of scholars who can help investigate power, ideology, and institutions. Fig. 1 situates current schools of thought and research on technological change on the technology timeline. As the figure shows, existing bodies of work cluster on either side of the point at which technologies are implemented, with the social construction of technology (SCOT) and design studies to the left (both of which study design) and technology, work, and organization to the right (which studies use). Further extension to the left would involve investigating those who fund, commission, and authorize broad design parameters while moving further to the right would entail studying a variety of institutions (such as marriage, the family, and the transportation infrastructure) that are likely to be affected by intelligent technologies at work. These expansions on either side would necessitate including new groups of scholars with whom scholars of technology, work, and organization have not historically worked.

The second departure would be to create pathways, procedures, and systems for effectively running projects of such broad scope as well as assembling and coordinating teams composed of a diversity of scholars. We will need to work out the pragmatics of how to design large-scale studies that attend to the epistemological and methodological differences that exist across scholarly communities.

To prepare scholars for this work, we summarize research in the realms of SCOT and design studies, which we jointly call "studies of design," followed by a summary of research in technology, work, and organization, which we call "studies of use." In our summaries we include examples of scholars who have attempted to bridge design and use. We then discuss the kinds of scholarship needed to expand research even further on both ends of the timeline. Finally, we provide ideas for the kinds of research methods and systems of coordination that would facilitate such a large intellectual agenda.

4. The state of current research on the design and use of technologies

4.1. Studies of design

Scholars who work in the SCOT tradition typically approach the study of design historically (Bijker & Law, 1992; MacKenzie, 2001). That is, they use archival evidence and sometimes interviews to reconstruct the social and political dynamics that occurred during the period in which a new technology was emerging. For example, Pinch and Bijker's (1987) famous study of the evolution of the bicycle pointed to a variety of stakeholders who saw the bicycle from different perspectives. Some were racers. Some advocated for women cyclists. Some were "young men of means and nerve. They might be professional men, clerks, schoolmasters, or dons. For this social group the function of the bicycle was primarily for sport" (p. 34). Others were touring cyclists. Still others saw the bicycle as a mode of transportation rather than recreation. There were even groups that opposed all bicycles on moral and social grounds. What a bicycle looked like and what purpose it should serve varied across these groups: each group had a problem it was trying to solve and a solution it promoted. After nineteen years of competing designs, the "safety bicycle," the bicycle we know today (a low-wheeled bicycle with rear chain drive, a diamond frame, and air tires), became the dominant design. The example of the bicycle highlights the lengthy period that may occur before a technology takes it most familiar form and function (what SCOT scholars call "closure").

Few researchers have studied the design process from which AI technologies spring; in this respect, the work of Forsythe (1993a, 1993b, 2001) more than two decades ago stands out as an exception. As noted above, she pointed out that AI designers operated from a cultural perspective that privileged the technical over the social. The designers' perspective made it difficult for them to see the value in user studies or subjective assessments of their designs that might draw upon social science methods and perspectives. It also hindered their ability to recognize that a gap might exist between their idea of reality and users' experience of reality (Suchman, 2002) or to consider that the knowledge of a single expert might not be universally applicable to all experts in that field. Forsythe's arguments that AI designers operated from their own cultural perspective, and her call to extend user research beyond elicitation of knowledge from a single expert to extensive and detailed study of users' workplaces, practices, and interactions, were echoed by others (e.g., Gould & Lewis, 1985; Norman & Draper, 1986; Suchman, 1987; Swanson, 1988).

Such critiques prompted a move toward user-centered and value-sensitive design approaches. These approaches recognized that designers' mental models of work and users were insufficient and often inaccurate: to build better mental models, designers would need information about the context of use, the desires and needs of users, and the social dynamics of work surrounding a technology's use. Hundreds of design studies heeded this advice as the field extended its reach across the point of implementation to incorporate an understanding of use and users. Many studies abided by the three principles that Gould and Lewis (1985) laid out for user-centered design: (1) focus on users and tasks early in the design process, (2) use empirical measurements to evaluate a design's effect, and (3) design iteratively to take into account new user information and empirical measurements. The methods that researchers used in following these principles for good design included contextual inquiry, task analysis, observation, focus groups, user interviews, user personas, surveys, and user testing in situ (Friedman, Kahn Jr., & Borning, 2006; Gulliksen et al., 2003; Vredenburg, Mao, Smith, & Carey, 2002).

Today, user-centered and value-sensitive design approaches remain popular, prompting continued instruction and discussion of their basic principles (e.g., Brhel, Meth, Maedche, & Werder, 2015; Ritter, Baxter, & Churchill, 2014). Friedman (1997), Bynum (2008), and others have argued that these approaches enable designers to better consider basic human values when designing, thereby avoiding problems with user acceptance as well as ethical problems that technologies may pose. At their extreme, these approaches bring users completely into the fold of design as co-creators with designers to avoid designers' (potentially incorrect) interpretation of users' needs, prompting the term “participatory design” (Greenbaum, 1993). However, the extent and degree of user participation required for good design, as well as the motivations for user participation, remain an issue of debate in design studies (see, for example, Bratteteig & Wagner, 2016). Moreover, designers' recognition of the importance of users' work contexts has not extended to their own organizational context; in the rare instances when designers have considered their own context, the discussion has tended to focus not on how the interests, goals, and perspectives of designers and managers may shape design, but on how a desired user-centered design may require too much time (due to iterations), money (materials and designers are expensive), or labor (extra designers are needed to solicit user input) (e.g., Kim, 2007; Wilson, Bekker, Johnson, & Johnson, 1997).

4.2. Studies of use

In the late 1970s and early 1980s, scholars of technology, work, and organization began to investigate how the situated use of new technologies occasioned social processes that altered work practices with significant implications for workers. For example, in a year-long ethnographic study, Barley (1990) showed how the implementation of computerized imaging modalities such as ultrasound and CT scanning changed the roles and role relationships of radiologists and radiological technologists in two radiology departments. He found that technologists who ran the computerized modalities worked more closely with radiologists and could better interpret images than those technologists who worked in X-ray and fluoroscopy, thus gaining more autonomy over their work. These changes in roles and role relationships, in turn, altered the social networks of the two departments ultimately leading to the bifurcation of each department into two groups: one that worked with older imaging modalities under a bureaucratic structure and one that worked with the new modalities in a collaborative structure. Over the next thirty years a number of researchers using close and careful field methods found similar results for work roles and network structures, as well as knowledge, skills, dependencies, organizational and group dynamics, and status (e.g., Bailey, Leonardi, & Barley, 2012; Barley, 2015; Beane, 2018; Boczkowski, 2004; Boudreau & Robey, 2005; Levina & Vaast, 2005; Yates, Orlikowski, & Okamura, 1999).

Research on technology, work, and organization has also documented that the use of similar technologies often produces different outcomes for different organizations. Zuboff (1988) provided early evidence for such variation in her comparison of computerized control systems in three pulp paper mills. The degree to which the new systems enabled operators to use data from the control algorithms to make autonomous decisions hinged significantly on whether a mill's middle managers were willing to alter their own roles in ways that ceded responsibility to operators. Similarly, Edmondson et al. (2001) examined the introduction of minimally invasive cardiac surgery in sixteen hospitals and documented how different practices and attitudes among surgeons distinguished successful from unsuccessful implementations. Surgeons who acted as a member of the team, who convinced nurses and technicians that successful implementation would depend on collective effort, and who attended training with members of their surgical teams were more likely to lead successful implementations. In another study of variation, Bailey and Leonardi (2015) showed that occupational factors such as product liability, the ability to test for product failure, and the rate of knowledge change shaped the extent to which members of three engineering occupations embraced new technologies for design and analysis. Such studies reveal that the outcomes occasioned by a new technology are heavily influenced by how people interpret and use the technology, by previously existing power relationships, and by other context-specific factors. Instead of viewing technologies as materially deterministic, this school of thought argues that technologies pose constraints and affordances that users can sometimes circumvent and alter if they so desire. Hence, the same technology can lead to very different and often unanticipated outcomes in different workplaces.

To date only a handful of scholars have applied this perspective to study the implementation and use of AI technologies in the workplace. For example, Shestakofsky (2017) investigated an online platform that employed machine learning techniques to match buyers and sellers of a variety of local services. The company's programs were not capable of handling the large volume of requests that it received. Consequently, the company hired hundreds of programmers in the Philippines to do manually what the software was supposed to do. The firm also hired contractors in Las Vegas whom the firm discovered were better skilled than its programs at doing the emotional labor needed to placate angry buyers and sellers. Maiers (2017) investigated an intelligent algorithm that detected infections among babies in a neonatal intensive care unit. Although the algorithm was designed to determine when doctors and nurses should intervene, Maires found that medical personnel treated the algorithm's output with skepticism and, hence, came to use it as just another tool for arriving at their own diagnosis. In short, the medical staff used the intelligent technology to augment rather than replace their own judgement. Zhang, Lindger, Lyytinen, and Yoo (2017) studied designers in a semiconductor firm that used a genetic algorithm to place components on integrated circuit chips. The algorithm altered the designers' experience and practice significantly. Prior to the new technology, designers were intimately involved in finding a design solution, guiding the entire process, and determining what changes to make as the design evolved. With the new algorithm, designers simply input all the design parameters at the start of the process, and the software mysteriously and opaquely created a complete solution. The use of the new technology meant that designers no longer fully understood the chip's layout and how it was determined, consistent with the opacity of algorithms discussed by Faraj, Pachidi, and Sayegh (2018). The foregoing studies illustrate the kinds of contributions that scholars of technology, work, and organization can make by turning their attention to intelligent technologies. Given the increasing importance of intelligent technologies and the debate surrounding their use, many more such studies are needed before we can arrive at an adequate understanding of the panoply of changes that these technologies might trigger in the workplace and the conditions that underwrite the variation.

Like most studies of technology use, the emerging work on intelligent technologies stops at the boundary of the organization. Researchers neither attend to the design of the technology prior to its implementation nor consider the ramifications for institutions beyond those of the organization. We can, however, point to exceptions that have tried to address the left and right censoring typical of studies of the use of previous technologies.

Poole and DeSanctis (1990, 1992) studied how various groups made use of decision support systems (DSS). Although they did not study the designers of these systems, they knew that the systems had been explicitly designed to promote democratic and participative decision making. Groups that used the technology in a participatory way were said to have “faithfully appropriated” the democratic spirit of the technology. However, the authors discovered that not all groups appropriated the technology faithfully. Some employed the technology in ways contradictory to the designers' intentions, which Poole and DeSanctis called “ironic appropriation.” Among scholars of technology, work, and organization, Poole and DeSanctis realized that technologies are designed and deployed to foster certain objectives and demonstrated that these objectives are sometimes realized and are sometimes not realized by the way users employ them in their work. In short, Poole and DeSanctis pushed studies of use to the left by acknowledging that designers and those who adopt technologies have agendas for the technologies' use. Other scholars have also shown that the values and assumptions of designers may not translate meaningfully to users' contexts, prompting the potential for users to modify designs (e.g. Orlikowski, 1992; Venters, Oborn, & Barrett, 2014; Walsham & Sahay, 1999).

Leonardi (2012) returned to Poole and DeSanctis' insight that designers' agendas might or might not influence how people use technologies. He realized that during implementation designers and managers attempt to persuade users to adopt and use technologies in specific ways. Because attempts at persuasion take time, Leonardi envisioned implementation as a phase, not a single point in time. During this phase designers and managers communicate their ideas of how and why the technology should be used. For example, in a study of an automotive engineering analysis suite, Leonardi found that some designers argued the suite would be more efficient (less tedious, faster, or competitively advantageous). Other designers argued that its use would be inevitable (required by new work practices or driven by technological competition). More often than not users rejected these claims based on their encounters with the analysis tools. The only rhetoric that users believed was the argument that the software would facilitate standardization of analytic processes across the engineering group. Importantly, standardization was a goal that the automotive engineers also valued.[1]

Whereas Poole and DeSantis and Leonardi pushed studies of use toward design, Brayne (2017) took institutional change resulting from use into account. She studied the Los Angeles Police Department's use of Palantir's algorithms for predicting the location and timing of crimes. The algorithm enabled the police to move from reactive to proactive policing. By drawing on multiple databases the algorithm not only targeted high crime areas of the city, it also predicted specific locations and even specific suspects. As a result, the police altered their patrol activities to hone in on places where crimes were likely to occur and on individuals who were likely to commit them. The software drew information on criminals from law enforcement, social service, and private databases to construct networks that connected suspected criminals to other persons (e.g., employers, roommates, family members, and friends), events, places, and possessions such as phones and vehicles. Placing individuals in these networks deepened the surveillance to which they were subjected. This deeper surveillance appeared on the surface to be highly objective given its mathematical basis, but it cloaked witting and unwitting biases. Brayne suggested that such data made it less likely for targeted individuals to use such institutions as hospitals, employment agencies, and other social services for fear of increasing their visibility to the police. Brayne's work illustrates how we could connect studies of use to studies of institutional change. It also does so in the context of AI, thereby underscoring the importance of studying the unintended institutional ramifications of intelligent technologies.

[1] Although Fig. 1 makes a clear distinction between design and use, and this distinction also characterizes most of the literature, it is worth considering the possibility that the line between design and use may become increasingly blurred with the spread of intelligent technologies, especially those that rely on machine learning. Such technologies are in principle capable of evolving during use as additional information is captured and processed. In such cases the initial algorithm for the technology may remain fixed but, with additional data, predictions and outcomes may change. Two implications are that design may not be fixed and that a technology implemented at one site may become distinct from the same technology implemented in another setting, thereby contributing to the variation to which scholars of technology, work, and organization have long attended.

5. Toward a unified approach for studying intelligent technologies

Although the foregoing studies moved beyond use to issues of design and adoption, on the one hand, and implications for institutions beyond the workplace, on the other, there remains considerable territory for exploring the far left and right of Fig. 1. We have in mind studies that would speak to power and ideologies, thereby helping us explain why designers pursue some visions of technology and not others. We also call for studies that at least consider the broader institutional implications of technologies' use. To get a sense for how such studies of intelligent technologies might be approached, consider prominent studies of technology that focus on issues of power, ideology, and institutions at the extremes of our timeline. Although such studies are scarce and rarely focus specifically on either design or use, they do provide templates for how we might proceed toward a unified view of the genesis, adoption, and aftermath of intelligent technologies.

Perhaps the most comprehensive account of the power dynamics and ideologies that propelled the development and use of a class of technologies is Noble's (1984) historical treatise on numerically controlled machine tools. Noble documented how a convergence of powerful interests and ideologies paved the way for numerical control while selecting against alternative approaches to automating machining that would have done more to preserve machinists' expertise and jobs. Although firms in the metal working industry were certainly interested in deskilling their workforce and controlling labor, their agenda alone was insufficient for explaining the rise of numerical control. To account for the entire story Noble found he had to also attend to the plans and agenda of the military (especially the Air Force) for weapon systems that required fine tolerances in the machining of parts so that, for example, fighter planes could fly at high speeds without falling apart. The story also included MIT's servomechanism lab and Project Whirlwind (MIT's attempt to build a digital computer). In taking over the military's contract for automated machining from an industrial firm, MIT had a broader scientific agenda than simply fulfilling the industrial objectives of the contract. In particular, researchers at MIT hoped to create a system that would do continuous cutting, to develop and promote their own automatic programming language, and to solve difficult mathematical problems for research purposes. In short, the rise of numerically controlled machine tools had nothing to do with their technological superiority relative to competing solutions but had everything to do with the agendas and interests of powerful actors such as MIT and the Air Force. Importantly, whether numerical control deskilled or eliminated machinists' jobs was irrelevant to the agendas of these backers.

It is to Noble's wide-ranging analysis of politics and ideology that we point scholars who seek to study intelligent technologies. Although IS scholars have examined issues of power, their focus typically has remained within the boundaries of an organization. For example, King (1983) alerted scholars to how the centralization or decentralization of computing resources spoke to intra-organizational power struggles. Similarly, Markus (1983) documented how IT can underscore political battles among an organization's departments and divisions. In a study of the persistence of IT shadow systems in a savings bank, Furstenau, Rothe, and Sandner (2017) employed a power perspective to describe and analyze the shifting relations between IT groups and organizational departments. Likewise, Barrett, Oborn, Orlikowski, and Yates (2012) pointed to how the introduction of a pharmacy robot altered boundary relations and occupational power dynamics among pharmacists, technicians, and assistants. In a unified approach, we call for such detailed workplace studies to be joined with those that consider power dynamics beyond the organization as well as those that shape the processes of design, adoption and implementation.

Studies of ideology, while few in number, have more often featured such a broader perspective. For example, studies that have drawn upon Swanson and Ramiller's (1997) concept of an organizing vision for IT or that otherwise investigate the rhetoric and dialogue around emerging technologies move analysis beyond single organizations. Davidson, Østerlund, and Flaherty's (2015) study of the many actors (e.g., health insurers, IT vendors, healthcare foundations, and government agencies, among others) involved in the discourse over personal health records provides such an example, as does Barrett, Heracleous, and Walsham's (2013) argument for a rhetorical approach to integrate ideas of ideology and framing when theorizing IT diffusion as seen in free and open source software. Similarly, Pollock and Williams' (2009, 2010) studies of industry analysts revealed how influential actors made claims that did not simply describe marketplaces but became performative by shaping technologies and people's expectations of them. These studies provide models of the work to be done to the far left of our timeline.

On the other end of our timeline, technologies employed at work have the potential to transform institutions far beyond the workplace. For example, historians and sociologists of technology have documented how the assembly line, electrification, and other technologies of the Second Industrial Revolution spawned urbanization, the breakdown of the extended family, and the spread of bureaucracy (Chandler, 1977; Hays, 1995). During the late 19th and early 20th centuries, owners built American factories in cities that were transportation hubs. As a result, rural people and immigrants moved to cities such as Detroit and Chicago in search of better paying jobs, leaving behind their extended families. With this influx of population, cities grew and flourished. As factories became more mechanized and work became more rationalized, firms became increasingly bureaucratic. With increasing population, city governments also became more bureaucratic as they adopted civil service reform (Tolbert & Zucker, 1983).

We also see institutional changes resulting from the use of more recent technologies. Consider the commercialization of the Internet. As an increasing number of retailers hired software developers and web designers to advertise and sell their goods online, the buying patterns of consumers changed. For example, while Black Friday remains a popular shopping day, it is now joined and threatened by Cyber Monday (Cheng, 2018). As Internet-based sales have grown, large numbers of local and national businesses have seen their revenue decline and many establishments have gone out of business, decimating downtown areas, shopping strips, and malls in many towns and cities (Bhattarai, 2019; Zentner, 2008).

Electronic communication technologies provide a final example. As increasing numbers of people use cell phones, email, and videoconferencing to communicate with co-workers, the number of hours many professionals work has been on the rise. Many people now wake up early in the morning and stay up late to handle work-related communications, thereby extending their work day, cutting into family time, and exacerbating work-family conflict (Barley, Meyerson, & Grodal, 2011; Nippert-Eng, 2008). The upshot has been to transform family and leisure time into (unpaid) work time.

In sum, we argue that the field needs more studies of the use of intelligent technologies, more studies that link the design of intelligent technologies to their use and, perhaps most importantly, studies of intelligent technologies that span the entire timeline of a technology's trajectory. Others before us have called for expanded studies of technology in ways that resonate with our idea of a unified approach. Orlikowski (1992) called for a structurational model that included technology designers, technology users, institutional properties, and the technology itself to better explain human choice, technology development, use, and organization design. More recently, in a call to move beyond the confines of a single organization, Williams and Pollock (2012) asked scholars to study the "biography" of a technology across space and time. Like us, they lamented the dearth of IS studies of design. Their view of institutions, though, like Orlikowski's, was focused on industry and organizational institutions that shape design and use on the left of the timeline, not social and other institutions affected by use on the right of the timeline. In addition, other scholars before us have argued for teams of researchers to handle the increasing complexity and range of design and use in emerging technologies (e.g., Crowston & Myers, 2004; Williams & Pollock, 2012). The approach we advocate builds on and extends these suggestions and uniquely aims to influence technology design and social policy.

Such a unified approach will be difficult but not impossible. The key will be to assemble research teams that span the current division of labor in most universities because the types of projects that we envision will require teams of scholars from across a wide range of disciplines. Beyond the traditional fields of SCOT, design studies, and research on technologies' use, these teams may include historians of technology, scholars of managerial ideology, labor economists, institutional sociologists, applied anthropologists, institutional economists, macro-sociologists, urban planners, social workers, and scholars from other related disciplines. To inform such investigations, researchers may also need to draw on experts who rarely participate in social science research such as industry representatives, policy makers, futurists, community activists, labor leaders, engineers, computer scientists, and others.

Such teams will require funding to enable their collaboration. Fortunately, there are many funding agencies calling for the development of interdisciplinary teams to tackle the larger social implications of intelligent technologies, including initiatives at the National Science Foundation to tackle what it calls "big ideas." One such idea, "The Future of Work at the Human-Technology Frontier," speaks directly to the kinds of issues that we have been discussing.[2]

What remains is to conceive of how such teams might design and carry out research programs of this type. To do so we draw and extend upon own experience in conducting large-scale team ethnographies of technology, work, and organization. We first describe the components of a unified approach and then illustrate it by drawing on studies of self-driving commercial trucks, a topic that has attracted considerable attention in the discourse about intelligent technologies and the future of work.

6. Components of a unified approach to studying intelligent technologies

Without a doubt, a unified approach to studies of intelligent technologies would include the long tradition of detailed field studies of use. Such field studies are crucial for gaining a wider understanding of how intelligent technologies will be integrated into the work that people do. As past studies have done so well, such field work will surface variation that will enable us to better grasp under what conditions intelligent technologies will either automate or augment work practices, tasks, and jobs. Ideally such studies will go beyond traditional research on technology, work, and organization by documenting work practices and divisions of labor prior to the introduction of the technology. The purpose of capturing "before" data would be to uncover what aspects of the work employees and teams find meaningful, interesting, valuable, and rewarding and what tasks and jobs better serve the organization when they are performed by people.

These data will, in turn, inform studies of the design of intelligent technologies. Design studies should examine how designers think, how they are motivated, what incentives and objectives they face, and, most importantly, how they understand the work of those who will use the technologies they design. In the tradition of user-centered, participatory, and value-based design, studies of the design of intelligent technologies should draw on the type of field data previously discussed to provide designers with accurate information on the work that users do.

To inform both studies of use and design, the project team might engage in scenario building, critical systems thinking (Jackson, 2001; Jones, 2014), and related exercises with a broad swath of stakeholders to imagine ideal institutions and to try trace how those institutions might be achieved through the design and use of the technology. The idea would be to envision the kind of future we want and then feed these visions back into the design of the technology to increase the odds that intelligent technologies will yield desirable outcomes (Maessen, Lauche, & van der Lugt, 2019). Of course, one can never really predict the second order consequences of a technology (Barley, forthcoming; Sproull & Kiesler, 1991), but having a target for a desirable society is better than having no target at all.

To this end, project members should seek to influence policy. Although this is something that many scholars have no experience doing, there are a number of tactics that researchers can adopt to increase the odds of having a voice in policy making. For example, they might begin by attending and presenting at conferences, symposia, and workshops dedicated to intelligent technologies. Unlike gatherings of members of our fields, these events attract policy makers and journalists. In addition, researchers might write translational articles, op-ed pieces, and articles in policy journals. Taking this approach would move research further to the right of our timeline.

To move further to the left, project teams would closely examine stakeholders who have agendas, incentives, and interests in developing intelligent technologies. Rather than taking the historical approach of past research (e.g., MacKenzie, 2001; Noble, 1984), the project team would seek to identify in real time the relevant stakeholders and then analyze the rhetoric they employ using, for

[2] See: https://www.nsf.gov/news/special_reports/big_ideas/human_tech.jsp accessed on May 31, 2019.

example, discourse and computational textual analysis. Research of this type should surface the political and ideological underpinnings that push the design of intelligent technologies in certain directions rather than others. By making politics and ideologies explicit we increase the odds of countering forces that benefit select groups over the greater good. Although power dynamics will undoubtedly arise at every point along the timeline, the operation of power is especially crucial in defining what intelligent technologies will be used to do and this use of power is typically hidden from researchers. To illustrate how a unified approach might proceed we turn to the case of self-driving commercial trucks.

7. An example: self-driving commercial trucks

Original discussions about self-driving commercial trucks spoke of making highways safer by using unmanned vehicles that would do a better job than truck drivers of sensing highway conditions, with some estimates suggesting that automated trucking would save 1.25 million lives per year worldwide (for a review, see Bailey & Erickson, 2019). One projected cost of doing so would be eliminating the occupation of the truck driver. Nevertheless, programing vehicles to make the kinds of nuanced, situated decisions that drivers must often make to avoid accidents is proving quite difficult (Vinkhuyzen & Cefkin, 2016). As a result, companies such as Uber, a leader in self-driving vehicle technology, have suggested that autonomous trucks should only operate on open interstate highways while drivers would take command of the truck in populated and difficult to navigate terrains such as towns and cities (Wakabayashi, 2018). Discussions of decision making and navigation have framed the issue of self-driving vehicles only in terms of the capabilities of intelligent guidance systems.

In the unified approach that we advocate, the project team would use a broader lens and coordinate across individual studies being conducted at specific points along the timeline. Specifically, studies of use would document the work that truckers actually do and consider the benefits that truckers derive from their work as well as the stresses and strains of the job. Studies of design would investigate vehicle manufacturers that are designing self-driving trucks. These researchers would examine the incentives and constraints that face the firms' technology designers and managers. Studies of politics and ideology would focus on the industry's stakeholders including manufacturers and consultants who are promoting visions of what the industry will become (Heineke, Kampshoff, Mkrtchyan, & Shao, 2017; PwC, 2018; Rand Corporation, 2017) as well as regulators and legislators who are contemplating how to provide necessary legal safeguards for the public. Studies of institutions would seek to inform all other aspects of the project by suggesting possible and preferred outcomes of employing self-driving commercial trucks in the transportation system.

Because the literature contains ample research on the design and use of technologies, scholars should have little trouble imagining how to investigate the design and use of self-driving trucks. More difficult to imagine may be investigating power, ideologies, and institutions on the left and right of our timeline. Fortunately, several authors have recently published studies of commercial trucking that illustrate how one might approach investigations in these realms.

In a study reflecting issues of power and ideology, Levy and Franklin (2014) analyzed comments submitted to the Federal Motor Carriers Safety Administration (FMCSA), which had proposed a series of regulations regarding the use of electronic on-board recorders (EOBRs) in the cabs of long-haul truckers. As part of fleet management systems, these devices permit trucking companies to monitor truckers when on the road. In addition, EOBRs have the potential to improve the enforcement of laws that limit the number of hours that truckers can drive. Devices similar to EOBRs are likely to be a component of self-driving trucks, especially in convoy configurations where the lead truck is driven by a human. Like all federal regulatory agencies, the FMCSA is mandated by Congress to hold open-comment periods on all proposed regulation under the presumption that the comments will promote democracy by serving as feedback for revising regulations before they are enacted into law. Commenters on the EOBR regulations included truck drivers, concerned citizens, trucking companies, and technology venders. Levy and Franklin used a web scraper to download all comments made on EOBRs during three separate comment periods. They analyzed the comments using topic modeling to identify themes and then associated the themes with different stakeholder groups. The authors found that individuals (truckers and concerned citizens) voiced broad, value-based concerns around privacy, home, family (truckers thought that EOBRs would keep them away from home longer), safety, and delays related to loading and unloading. In contrast, organizations (trucking firms and technology vendors) more commonly wrote about technological specifications and emphasized quantitative data. In other words, organizations appeared to narrow the conversation to avoid issues concerning work practices and family life. As the authors noted: “comment processes may be ‘captured’ by resource- and expertise-rich corporations and special interests rather than by everyday individuals (p184).” Levy and Franklin show that it is possible to study power and ideology at the same time that intelligent technologies are being developed.

To study the possible institutional and infrastructural arrangements that might shape the long-term implications of deploying self-driving commercial trucks, Viscelli (2018) interviewed a variety of stakeholders including computer scientists, engineers, Silicon Valley technology companies, venture capitalists, trucking manufacturers, trucking firms, truck drivers, unions, academic experts, and others. Drawing on these interviews as well as industry documents, Viscelli developed six possible scenarios for the division of labor, the distribution of wages, and the infrastructures that might arise if self-driving trucks became common. The scenarios featured different combinations of human drivers, self-driving trucks, and drones for the delivery of goods. Viscelli identified the scenario that would be most likely if regulatory interventions were absent. In that scenario, self-driving trucks without any human drivers would ply the open highways while humans would navigate the trucks through cities and towns. Viscelli also identified the scenario that would yield better social outcomes as the result of enlightened public policy. In this scenario a human driver would drive the lead truck in a convoy of drone trucks on open highways and again humans would take over all trucks through cities and towns. Viscelli claimed that this scenario would entail “fewer technological challenges” and “better jobs for long-distance drivers (p. iii).”

In another study of EOBRs, Levy (2015) discovered that trucking companies had begun to use the data they collected to enlist truckers' wives in “motivating” their husbands to follow the monitoring guidelines:

> Firms' efforts to resocialize electronically derived data do not end within the company. Firms also invoke social pressures in drivers' own non-trucking communities as well, particularly among their families. Incentives like awards ceremonies and banquets, to which drivers' families are invited, are common strategies. But involvement can be even more directed, as well: For instance, one firm sends small bonus checks for the highest performing drivers (as determined by driver scorecard data) to the drivers' wives, in the wives' names. The idea behind the program, as it was described to me, is that wives come to expect the checks periodically (as "a profit-sharing arrangement," in recognition of a wife's familial support of her trucker husband); wives are expected to create pressure for their husbands to continue meeting the company's organizational performance benchmarks. (p. 171).

Viscelli's and Levy's research shows that it is possible not only to develop reasonable scenarios for desirable futures involving intelligent technologies but to glean empirical information on how technologies can affect other institutions, such as marriage.

8. Conclusion

Although a unified approach would help us better understand any workplace technology, it is especially urgent in the case of intelligent technologies because by the time these technologies have been adopted and implemented, we will have lost opportunities to influence their design and intent. If our goal is to decrease the possibility that intelligent technologies will lead to mass unemployment and other large-scale social problems, we cannot afford to take the normal route of waiting until a technology is implemented before we study its genesis, use, and social implications. The urgency arises from the fact that once an intelligent technology is good enough to be put into place in the workplace, the agendas of its makers will have been too cemented into its features that the degrees of freedom we have to alter the technology and or shape the changes it triggers will become more limited. Although no technology is determinant, SCOT scholars have shown that after closure on a design and an agenda, opportunities for affecting design narrow. The primary option with which one is then left is enacting how the technology is used in specific settings. Given the disruptive potential of intelligent technologies, intervening in their design by beginning to study such technologies long before they enter the workplace is imperative. We simply have too much at stake to proceed as usual.

One might question whether powerful stakeholders who control what technologies are built and who dictate the purposes of their design would be willing to engage with scholars to build technologies that promise more socially more desirable outcomes. Fortunately, recent events suggest that major players such as the large technology companies may be open to this kind of engagement. Evidence for such openness can be found in the emergence of consortia that are raising both social and ethical questions about how intelligent technologies should be designed and deployed. We have in mind such organizations as Data and Society,[3] the United Nations' AI for Good,[4] The Future of Life Institute,[5] and Data Science for Social Good programs at universities.[6] Many of these organizations have significant funding and involvement from technology firms and their leaders. The success of these endeavors points to the fact that there are now funding opportunities that go beyond government and foundation sources.

Furthermore, as we have seen, employee protests and public outrage have stimulated action by such firms as Facebook, Uber, and Google after they were criticized for transgressing boundaries of privacy, promoting fake news, or engaging in military contracts involving intelligent technologies. These firms feared losing users and tarnishing their reputations which contributed to their rise to power. Technology firms also generally fear regulation. One can interpret the recent creation of "ethics panels" by technology firms as a desire to act before governments do (see, for example, Hern, 2017). For these reasons, technology firms may now be more willing to join as partners with students of technology, work, and organization who use social science methods than they were when Forsythe (2001) conducted her research. Our call is for scholars to look beyond simply documenting how the use of technologies shapes work and work practices. Ironically, intelligent technologies come at a time when we no longer have institutions that could help us resist unilateral change dictated by those who create, purchase, and use intelligent technologies. We can no longer count on the power of strong unions, traditional employment contracts that provide security for loyalty, the social safety nets that rescue workers when they "fall from grace" (Newman, 1989), or the idea that businesses will put the good of their workers before the demands of the financial industry (Fligstein, 1993; Mizruchi, 2013). Thus, what we are calling for is for scholars to step forward to lead teams in a unified approach to research on intelligent technologies so that they can actively engage in debates over design, policy, and social outcomes.

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[3] https://datasociety.net/.

[4] https://ai4good.org/.

[5] https://futureoflife.org/.

[6] For the first such program, see https://dssg.uchicago.edu/.

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