The Emergence of Materiality within Formal Organizations

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Abstract: In their demonstrations that technologies and organizations are sociomaterial, or how they become sociomaterial, scholars have not reflected in any measurable depth on the concept of materiality by itself. This chapter explores how materiality emerges from an organization’s interaction with its environment. The verb “emerge” is used purposefully. To say that materiality is entirely strategically crafted would be to place an undue onus on the agency of technology’s designer or developer, an onus which the author suggests may be misplaced. Thus to say that materiality emerges is to recognize that the physical and/or digital materials that are arranged into particular forms are arranged by someone. But the selection of those materials or the ways in which that person decides to arrange them may not be entirely under their control because they do so within the constraints of an organization’s formal structure. By considering the insights of organizational theories that depict organizations as actively responding to environmental stimuli and other theories which propose that organizations are largely ineffective at responding to environmental pressures and are directly acted upon by their environments, the chapter demonstrates how the micro-level interpretative flexibility of artifacts, the evolution and composition of the set of relevant social groups that contribute to the artifact’s construction, the processes by which an artifact reaches a point of stabilization and closure, and the structure of the technological frames shared by designers are influenced by macro-level organizational responses to and pressures from their environments.
7.1 Introduction

Among theorists interested in the relationship between technological and organizational change it is becoming popular to employ the concept of materiality (e.g., Dale, 2005; Orlikowski, 2007; Leonardi and Barley, 2008; Osterlund, 2008; Suchman, 2000). Students of technology and organizing appear to use this term somewhat interchangeably with the more popular word, “technology” or as something that belongs to a technology (e.g., “technology’s materiality”). It seems that one reason the term is used in this way is because decades of research aimed at countering technologically deterministic claims proffered by early contingency theorists (e.g., Hickson et al., 1969; Hunt, 1970) have led organizational researchers to treat technologies like computers, software programs, and even desks and chairs as artifacts that are embedded in a web of social practice. That is to say, without people either developing or using them, the technological artifacts with which those people work daily would have no meaning nor could they bring particular affects to the organization of work.

This over-socialized view of technology has been tempered, in recent years, by a new stream of research arguing for a “sociomaterial approach” to the study of organizing. One of the goals of this approach is to bring the substance of technological artifacts back into theories of organizing. But it does so in a clever way. Rather than argue that technologies exist apart from the organizations in which they are developed and used, the sociomaterial approach argues that work occurring within organizations is not a social practice enabled or constrained by technology (Orlikowski, 2010), that technological artifacts are not simply collections of materials organized by social processes (Pinch, 2010), but rather that organizations and technologies are simultaneously social and material. That is, they are both “sociomaterial.” As Leonardi (2009: 300), suggests:

if technology is a sociomaterial process and organizing is a sociomaterial process, too, there exists no important distinction between technological and organizational change. That is, the appropriate unit of analysis for “technology” is the artifact and the people interacting with it and around it, and the appropriate unit of analysis for “organizing” is people interacting with each other and the artifacts that enable or constrain their interaction.

Given such a conceptualization, it is not surprising that many recent research papers have aimed to demonstrate, empirically, that a particular technological artifact is as much social as it is material (Svahn et al., 2009; Berente et al., 2010), that certain organizational practices are as much social
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as they are material (Wagner et al., 2010; Johri, 2011), or to theorize how
the social and the material become, in Orlikowski’s (2007: 1437) words,
“constitutively entangled” (Jonsson et al., 2009; Leonardi, 2011).

In their demonstrations that technologies and organizations are socioma-
terial, or to show how they become sociomaterial, scholars have not reflected
in any measurable depth on the concept of materiality by itself. Materiality is
deﬁned here as the arrangement of a technological artifact’s physical and/or
digital materials into particular forms that endure across differences in place
and time and are important to users. Of course, embedded in this deﬁnition is
a paradox of sorts. The notion of arrangement implies agency and discretion
on the part of a technology’s designer such that the process of arranging is
sociomaterial. Likewise, for physical or digital materials to become important
to users also requires people making interpretations and developing
perceptions—a process that is certainly sociomaterial as well. But leaving
this paradox—that a technology’s materiality only comes to be so through
sociomaterial processes occurring during activities of development and
use—aside for a moment, it seems to make good empirical sense to treat a
 technological artifact’s materiality as something that exists at least physically
(if not conceptually) apart from the people who create and use it.

Although we might agree that a technological artifact like a social media
tool or an enterprise resource planning tool or a computer-simulation tool is
sociomaterial in nature, it still has a certain materiality that transcends space,
time, and context. For although someone arranged the digital materials out
of which such tools are fashioned during development, those arrangements
endure after the technology leaves the developer’s desk. Similarly, when
everyone leaves the ofﬁce at the end of the day some part of those tools
still sit on someone’s hard drive on a computer on a desk. It is precisely
because technological artifacts have a materiality that exists apart from
people that they are useful for work. For example, because the materiality
of a certain type of simulation technology is the same whether an engineer
uses it at the ﬁrm’s ofﬁces in Detroit or Bangalore means that offshoring of
work at the task-level can occur (Leonardi and Bailey, 2008). In fact, if a
 technological artifact did not have a ﬁxed materiality, extreme constructivist
thorizing would not be possible. The prototypical constructivist study
shows that people in two different organizations use the same new technol-
yogy differently and, consequently, change (or do not change) their informal
organizing in distinct ways (e.g., Zack and Mckenney, 1995; Robey and
Sahay, 1996; Orlikowski, 2000). The only way that scholars have been able
to demonstrate these ﬁndings empirically is because the materiality of that
technology was the same in both organizations under study. Given these
arguments, it seems reasonable to use the term materiality to refer to those properties of the artifact that do not change from one moment to the next or across differences in location (Faulkner and Runde, 2011).

For these reasons, it would behoove organizational studies of sociomateriality to have a more theoretically informed understanding of how and why the materiality of a technological artifact emerges as it does. I use the verb “emerge” purposefully. To say that materiality is entirely strategically crafted would be to place an undue onus on the agency of technology’s designer or developer, an onus which I will suggest below may be misplaced. Thus to say that materiality emerges is to recognize that the physical and/or digital materials that are arranged into particular forms are arranged by someone. But the selection of those materials or the ways in which that person decides to arrange them may not be entirely under their control because they do so within the constraints of an organization’s formal structure. To discuss the emergence of materiality, then, I will focus my discussion on the development of new technologies as it is here that we see most clearly how an actor’s choices—and the way that those choices are enabled or constrained—results in an artifact with a particular type of materiality.

One obvious place to begin considering choice in the design and development of new technologies is with the insights from the social construction of technology. The pioneering work on the social construction of technology (SCOT) by Pinch and Bijker (1984), which they elaborated in subsequent works (Bijker, 1992, 1995a; Pinch, 1996; Pinch and Trocco, 2002; Pinch, 2008), introduced four mechanisms to understand the social foundations of technology design and development. The first is that relevant social groups play a key role in the development of a technological artifact. Such groups share a particular meaning of the artifact. This meaning then can be used to explain why artifacts develop along particular paths. Pinch and Bijker describe that there were at least two relevant social groups important to the development of the bicycle: “young men of nerve,” and “older men and women.” Each of these groups contributed to the development of the bicycle in different ways. Second, to understand how technology is socially constructed, one must keep in mind that all newly created artifacts are interpretatively flexible. Interpretative flexibility is the notion that the meaning of an artifact does not reside in the technology itself, but is determined by the meanings attributed to it by its relevant social groups (Pinch, 2003). Thus, there is an interpretative flexibility over the meaning to be given to an artifact. In the case of the bicycle, the high-wheeler simultaneously had the meaning of “macho machine” for young men and “unsafe machine” for older men and women. As a result, the one
artifact itself was interpretatively flexible among the various social groups and different meanings were embodied in new artifacts. The third mechanism is related to the second: All newly created artifacts reach a state of stabilization and closure. As Pinch and Bijker (1984: 426) describe, “closure in technology involves the stabilization of an artifact and the ‘disappearance’ of problems.” Over time, the artifact stabilizes and interpretative flexibility is diminished as one meaning becomes dominant. Pinch and Bijker suggest that artifacts can reach a state of closure through two avenues. The first is rhetorical closure, whereby designers talk about the technology in a way that emphasizes its finality. The second is closure by redefinition of the problem. In this mechanism, designers begin to tackle a new problem of development, thus leaving the solution to the old problem satisfactorily behind, essentially closing further exploration into it. Bijker (1995a) later proposed a fourth conceptual lever to help understand the process by which technologies are socially constructed: technological frames structure the interactions among the actors of a relevant social group. A technological frame is comprised of the elements that influence the interactions of a group of designers and lead to the attribution of meanings to technical artifacts. Bijker (1995a) cites the development of Bakelite as a process that occurred because of the technological frames shared between the developers of the technology. Goals of the production process, for example, focused problems with the chemical composition of the material that then led to solutions that seemed “necessary” and “inevitable.” As a result, artifacts come to have their meaning by the technological frames through which they are interpreted. In this frame, the technical and the social are intimately interrelated.

Although SCOT is often referenced by organizational theorists as a reminder that (though these are likely not the words they would use) the materiality of the particular technological artifact under study is the result of some prior sociomaterial process (e.g., Garud and Rappa, 1994; Rosenkopf and Tushman, 1994; Orlikowski, 2000; Pentland and Feldman, 2007), it remains today, as Klein and Kleinman (2002) argue, a decidedly “agency-centered” perspective. In other words, the agency of individual actors and, by association, their ability to profoundly and often autonomously affect the course of a technology’s development figures prominently in the SCOT perspective. Perhaps this is because studies that have systematically used the SCOT framework have tended to focus on entrepreneurial ventures, embarked upon by innovators who were, at least initially, largely free from the influences of formal organizational structures. Such studies have explored the social construction of plastics (Bijker, 1987), mountain bikes.
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(Rosen, 1993), electrical systems (Hargadon and Douglas, 2001), and electronic synthesizers (Pinch and Trocco, 2002), as just a few examples.

At a basic level, a pronounced focus on the agency of individual actors to shape the developmental path of a new technology’s materiality is to be expected from early SCOT studies. SCOT arose in response to popular and appealing deterministic notions of technological change (Bijker and Pinch, 2002). In leveling their critique against such a perspective, Pinch, Bijker, and other contributors often emphasized the interests, autonomy, and capability for action of human agents as antidotes for technologically deterministic thinking, which claimed that humans could exert little force on a technological trajectory in the face of an artifact’s intrinsic logic.

Recently, however, a number of scholars have begun to cite a lack of attention to the effects of organizational and occupational structures on the development of new technologies as a major shortcoming in the SCOT approach. Klein and Kleinman (2002), for example, argue that the SCOT perspective does attempt to take into account the wider “socio-cultural and political milieu” in which artifact development takes place, yet they criticize SCOT for failing to systematically consider how such influences constrain and enable the social construction process:

From this seminal work has flowed a body of research that is rich and diverse—but that has largely remained committed to an agency-centered approach. Despite some conceptual evolution in the direction of structural theory, most notably in Bijker’s (1995a) later and more comprehensive work, Of Bicycles, Bakelites, and Bulbs, the SCOT approach has made only limited contributions to illuminating how social structures can influence the development of technology. (Klein and Kleinman, 2002: 28)

Kranakis (2004) has also shown that SCOT’s over-emphasis on the agency of individual actors can pose problems for the analysis of technologies that are developed in large organizations. In examining the Quebec Bridge disaster of 1907, Kranakis showed how those responsible for “fixing the blame” for the bridge collapse did so without considering the ways in which the “working” of the bridge was constructed among the organizations involved in its development. Kranakis suggests that the SCOT perspective leads researchers of technology to a similar folly, ascribing the problems that emerged in the construction of the bridge to individual responsibility and error. Kranakis’ careful analysis shows that the day-to-day administration of the project, how technical expertise was deployed, how complex tasks were divided and responsibility assigned, how the design process was organized and linked with other production priorities, and the choices made about who had responsibility for
all these arrangements implicated organizational culture as a major contributor to the collapse of the bridge. Vaughan’s (1999) study of the *Challenger* launch decision also attempts to account for structural constraints upon the social construction of technology. She shows how certain reporting structures and procedures for decision-making at NASA led the development of space shuttle technology down predictable paths and obscured the potential danger of a launch by creating administrative procedures and “go/no-go” decision criteria that were not reflective of the safety issues proposed by engineers.

The collective point that these critiques raise is that although the SCOT perspective provides four useful mechanisms for explaining the social construction process resulting in the configuration of a technological artifact’s materiality, the perspective does not theorize how those mechanisms might be influenced in fundamental ways by the organizational structures in which they occur. Yet, if organizational theorists intend to continue discussing the intellectual purchase that a sociomaterial perspective can bring to studies of work in organizations, they must have in their theories a detailed understanding of how and why an artifact’s materiality looks and acts the way it does.

The rest of this chapter examines how SCOT might be amended to account for the influences of formal organizational structure upon the emergence of materiality. As organizational researchers have shown, technology development processes and outcomes are quite disparate depending upon whether they were conducted by an autonomous inventor or by individuals within a formal organization (Allen, 1977; Van de Ven, 1986; Thomas, 1994; Hargadon and Douglas, 2001). This is because the process of technology development within organizations is very much linked to the formal procedures and arrangements of organizing. More than a half-century of research has convincingly shown that organizations exist in uncertain and ambiguous environments. Sometimes they seek to actively manage their environment (Pfeffer and Salancik, 1978), and sometimes the environment exerts selection pressures directly on them (Hannan and Freeman, 1977). In all cases, organizations are constantly acting and being acted upon as they interact with their environments in ways that are not always directed toward the benefit of developing new technologies. Instead, organizations make structural changes in order to respond to environmental pressures and technology development efforts are often pulled along and shaped as organizations contend with external exigencies (Davis and Taylor, 1976; Tushman and Anderson, 1986; Brown and Eisenhardt, 1995).

For SCOT to be appropriated to usefully explain the emergence of materiality within formal organizations a more empirically accurate conception of organizational influences on the social construction process is needed. In
other words, researchers cannot expect to fruitfully employ the SCOT perspective, as it currently stands, to explain the emergence of materiality within formal organizations because explicit theorization of the mechanisms by which the social construction process unfolds is largely devoid of any consideration that interpretative flexibility, relevant social groups, technological frames, and stabilization/closure occur within the confines of formal organizing processes. To successfully explain the emergence of materiality within formal organizations, SCOT’s agency-centered perspective must be enhanced by considering the role that formal organizations play in enabling and constraining its four mechanisms. To create a framework of this kind, one needs a detailed theory of organizations. Fortunately, the organizational studies literature has several. In the remained of this chapter I consider how the insights provided by two dominant organizational theories—Resource Dependence and Population Ecology—might help to revise SCOT’s explanations of how technology development processes unfold in ways that make it better situated to describing the emergence of materiality in formal organizations.

7.2 The organizational construction of materiality

Although many formal organizations are created and perpetuated with the specific goal of developing new technologies, the actual practice of technology development comprises only one part of organizational action. Organizations strive to survive and in their pursuit of survival in an ambiguous and uncertain environment they participate in many activities that are not directly aimed at new technology development (Blau et al., 1976; Chandler, 1977; DeSanctis et al., 2002). Thus, it seems reasonable to expect that the various ways in which organizational theories suggest that organizations act in and are acted upon by their environment may have the latent effect of enabling and constraining the mechanisms by which new technology development is socially constructed.

Since the mid-1970s when organizational researchers first began to take seriously an open systems perspective (Scott, 2004), which treats organizations themselves as actors in an environment of other organizations, legal regulations, and market forces, a number of theories have emerged depicting the adaptation and change of formal organizational structures in response to environmental pressures. Among these, theories such as Resource Dependence, (Aldrich and Pfeffer, 1976; Pfeffer and Salancik, 1978), New Institutionalism (DiMaggio and Powell, 1983; Tolbert and Zucker, 1999), and Transaction Cost Economics (Williamson, 1981,
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1996) depict organizations as actively responding to environmental stimuli. Other theories such as Evolutionary Theory (Nelson and Winter, 1982; Dosi and Nelson, 1994) and Population Ecology (Hannan and Freeman, 1977, 1989) propose an alternative view that organizations are largely ineffective at responding to environmental pressures and are directly acted upon by their environments.

Because the goal of this chapter is to explore how formal organizational processes occurring as organizations interact with their environments may influence interpretative flexibility, relevant social groups, technological frames, and stabilization and closure—those same mechanisms through which SCOT shows that a technology’s materiality emerges—I have chosen to focus in depth on one theory (Resource Dependence) that describes organizations as active entities that are capable of responding to their environment. Conversely, I have chosen another theory (Population Ecology) suggesting that organizations are often acted on (selected in favor of or against) by their environments. Using these two competing theories to consider how a technology’s materiality is shaped by organization–environment relations, this analysis aims to explore how SCOT’s mechanisms are implicated in the formal processes of organizing.

7.3 Resource Dependence

Resource Dependence theory is rooted in the assumption that organizations are open systems that actively engage in interdependent relationships with their environments. Drawing on the work of contingency theorists such as Thompson (1967) and Perrow (1970), the theory holds that no organization is self-sufficient; rather all organizations draw resources from their environment to survive. Because particular resources are critical for successful functioning, and because an organization’s ability to obtain them is often uncertain, organizations find themselves in dependency relationships with other firms (Pfeffer and Salancik, 1978). To overcome dependencies, administrators seek to actively manage their environments as well as their organizations (Aldrich and Pfeffer, 1976). Depending on the level of uncertainty of a particular resource, managers regularly utilize two major mechanisms to resolve such dependencies: Buffering and Bridging strategies. The use of these strategies can have profound effects on the social construction of technology development within the organization.
7.3.1 Buffering

Thompson observed that when faced with environmental uncertainties that could potentially hinder its technical core—the processes that characterize its mode of production—organizations operating under norms of rationality “seek to buffer environmental influences by surrounding their technical cores with input and output components” (1967: 20). Put more plainly, organizations seek to minimize dependencies on other organizations by reducing the uncertainty of obtaining important resources. To do so, organizations buffer their technical cores through strategies such as coding: classifying inputs before inserting them into the technical core; stockpiling: collecting and holding raw materials; leveling: reducing fluctuations in its input or output environments; forecasting: anticipating changes in supply or demand conditions and attempting to adapt them; and adjusting scale: changing the scale of the technical core so as not to use so many resources (Scott, 1998: 197–8). As examples, stockpiling and adjusting scale are two processes that demonstrate how buffering strategies may affect the social construction of technology development.

When either the availability or the price of critical resources is uncertain, organizations often stockpile them; that is, they collect and hold those resources so they are assured they will be available when needed. In the process of technology development described by most SCOT research, designers begin their quest to create a new technology by addressing a particular problem and seeking a technological solution to it (Berg, 1998). In this sense, designers seek resources that will help them create a solution to a predefined problem. Once organizations stockpile certain resources such as raw materials, however, research shows that they are often compelled to find new uses for them to justify their investment (Kupperman and Smith, 1970). One popular use is to incorporate them in the design of new technologies, and there are many examples of technologies that are developed in this way (Basalla, 1988; Shane, 2000). If a designer begins with a stockpile of resources and searches for a new technology he or she can develop from them, the outcome is quite different from a process where the problem is the starting point. Sarasvathy (2001: 245) terms these “effectuation processes”—where a designer “begins with given ingredients and utensils and focuses on preparing one of many possible desirable meals with them.” Thus, when organizations stockpile resources, the development of a new technology often begins by considering what existing resources are available and then what can be developed within the boundaries provided by those resources (Eppinger and Chitkara, 2006).
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Designing a new technology based on an effectuation process rather than a problem–solution process dramatically affects the interpretative flexibility of the artifact. One of the key components of interpretative flexibility is that the actual functionality of the artifact is not determined by its material properties, but rather by the meanings attributed to it by relevant social groups. In Bijker’s (1995a: 75) words, “the ‘working’ and ‘nonworking’ of an artifact are socially constructed assessments, rather than intrinsic properties.” Thus, when a designer develops an artifact through a problem–solution process, the artifact “works” only if it is understood to “solve” the problem that spurred its development (MacKenzie, 1996). By contrast, when the designer develops the artifact through an effectuation process, starting not with a specific problem, but with a set of resources the organization has stockpiled, the “working” of the artifact is judged by much different criteria. Thus, when organizations stockpiles particular resources, designers may develop new technologies aimed at utilizing those resources. In so doing, the interpretative flexibility of the artifact—the meanings they attribute to it to determine its “working”—will lead to radically different designs than if the technology was developed to combat a particular and well-defined problem (Carlson, 1992).

Organizations also adjust the scale of production in order to buffer environmental uncertainty of both materials acquisition and product sales. Economies of scale are crucial to reducing resource dependencies. Larger organizations are typically able to set prices and influence the actions of related organizations better than smaller ones (Pfeffer and Salancik, 1978). As a consequence, the degree to which an organization can use its scale to establish deals with suppliers and vendors directly affects that organization’s willingness to engage in certain technological developments over others. As technology researchers have demonstrated (e.g., Christensen, 1997), more innovative designs are often only possible when developers can be assured that their investments will be returned through product sales. Pinch and Bijker (1984) argue that the stabilization and closure of an artifact is reached either rhetorically, or by redefinition of the problem. The agency-centered perspective makes the assumption that designers are free to seek additional resources if a certain technological problem has not yet been “solved.” The fact that organizations use scale adjustment as a buffering mechanism, however, demonstrates that they are often limited in their ability to gain crucial resources. Thus, if an organization believes that a new technological development will be profitable, it will be more likely to increase the scale-production of the technology, enabling access to more resources (Baum et al., 2000). If such returns are not anticipated, access to
crucial resources will be reduced, bringing the design of a new technology to closure before the problem is believed to be “solved.” In other words, if organizations anticipate modest returns from technology development, they will adjust the scale of production so that access to new resources is reduced prematurely, resulting in the stabilization of the artifact prior to rhetorical closure or closure by redefinition of the problem.

7.3.2 Bridging

In addition to buffering their technical cores, organizations also seek to reduce resource dependencies by building bridges to other organizations that might affect the certainty of those resources. Researchers within the Resource Dependence perspective draw on Emerson’s (1962) work on power to suggest that one of the key ways organizations can reduce their dependence on uncertain resources is to create interdependencies with organizations that control those resources. As a consequence, it is in each organization’s best interests to help the other obtain its necessary resources. Thus, organizations conduct bridging strategies to increase interdependence through actions such as cooptation, strategic alliances, mergers, and many more. Although each of these bridging strategies may potentially influence technology development, two are considered here: cooptation and strategic alliances.

Cooptation refers to the practice of incorporating representatives of external groups into the decision-making structure of an organization. Within the Resource Dependence perspective, numerous studies of cooptation have focused on interlocking boards of directors. Board interlocks may have two important implications for technology development. First, innovations diffuse among organizations in large part through interlocks. As Davis and Greve (1997) found, “poison pills” were adopted by organizations that learned of them from their interlocking boards. Thus, the ideas or the impetus to develop a new technology may come about precisely because they have proven effective or legitimate in other organizational contexts, and board members can share first-hand information on how to develop them effectively.

In the language of SCOT, interlocks bring new relevant social groups into the development of new technologies. Relevant social groups are important to the SCOT analysis because each group shares a particular meaning for a technology, but different groups often share different meanings for it (Bijker, 1987). As information is passed among relevant social groups pertaining to the development of a specific artifact, each group’s own meaning of the technology is altered slightly (Rosen, 1993). More importantly in the context of organizational technology development, the communication among
relevant social groups contributes new information about how and why to design new technologies, information that may have been well out of view of technology designers themselves. Cooptation strategies may bring new relevant social groups into the social construction of technology development that may not have otherwise entered the process. Moreover, information about particular resources or methods of development and production that is shared through cooptation strategies will influence the meanings attributed to the technology by relevant social groups.

Organizations also enter into strategic alliances with other firms to reduce uncertainty and to gain legitimacy in the market. As Scott (1998: 203) defines them, “alliances involve agreements between two or more organizations to pursue joint objectives through a coordination of activities or sharing of knowledge or resources.” Consequently, technology development may be shaped by the formation of organizational alliances. When firms collaborate to develop a technology, the resultant knowledge is available to all partners when they begin to develop future technologies on their own (Ahuja, 2000). Thus, alliances have the power to alter the social construction of technology development because organizations will have access to resources, tools, production methods, and patents that they did not have before.

Additionally, new entrepreneurial firms often attempt to reduce resource dependencies by developing alliances with more established market players. The results of such alliances often have the effect that the entrepreneurial firm is locked into certain modes of technology development pursuant to their agreement with another company (Santos and Eisenhardt, 2009). Thus, alliance agreements can often constrain the developmental paths along which organizations might wish to follow. This is tempered by the fact that alliances bring new resources, either in the form of material assets or information on new innovations in developmental or production procedures. From a SCOT perspective, alliances form the basis for the creation of new technological frames. A technological frame constitutes the shared structure of interpretation of an artifact among members of a relevant social group (Klein and Kleinman, 2002). Because alliances always provide a mixture of constraining and enabling forces upon organizations (Dyer and Singh, 1998), the social groups relevant to an artifact’s development must create technological frames that reflect the boundaries of such agreements. These technological frames become the basis for how designers interact as they develop a new artifact. Consequently, strategic alliances between organizations may result in the creation of new technological frames that are shared by technology designers. These frames provide the boundaries for new technology development as they help to specify in what ways new
designs will be constrained by agreements and in what ways they will be enabled by access to new resources.

When considering the emergence of technology's materiality through the lens of Resource Dependence theory it is clear that technology development is often influenced by the organizational arrangements made in response to environmental uncertainties. Resource Dependence theory instructs researchers adopting a SCOT perspective to consider an organization’s strategic decisions in regards to inter-organizational arrangements as levers that affect the agency of technical innovators. When considering the emergence of materiality, researchers would do well to recognize that technology developers face very practical and often palpable constraints on the materials with which they work, the vendors with whom they can contract, and the information about technical innovations or consumer demands upon which they base their designs. Although a developer or a team of designers may have the autonomy to decide how they will arrange an artifact’s physical or digital materials, Resource Dependence theory reminds us that they may be limited as to which materials they can use or with whom they can work to get them arranged. It is these social affordances and constraints that arise because of decisions that have little or nothing to do with the technologies under development that have profound consequences for the emergence of materiality.

7.4 Population Ecology

Population Ecology arose in response to models of individual organizations that were adaptive to their changing environments (i.e., Resource Dependence theory). Drawing on concepts of Population Ecology and natural selection in biology, ecology theory proposes that there are so many kinds of organizations because organizations are largely inert to environmental changes due in large part to the fact that initial founding conditions produce imprints on the organization’s structure. Thus, when the environment changes, organizations often cannot adapt and are out-competed (Hannan and Freeman, 1977). To understand why some organizations survive and others fail, ecology researchers look to population characteristics, resources, and founder-effects to understand success and failure rates over time. Such population-level processes may very well shape the development of new technologies within individual organizations. Ecology theory draws on a number of analytic conceptualizations to explain the process of environmental selection. Of the many, three of these insights are particularly useful.
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in explaining how organizational characteristics influence technology development: imprinting, structural inertia, and niche width.

7.4.1 Imprinting

In a famous essay, Stinchcombe (1965) observed that organizations are often founded with endowments that allow them to accumulate the resources they need to survive. He argued that organizations which are founded at a particular time must construct their social systems with the resources available and in line with the historically given labor market so they can recruit skills and motivate workers. Consequently, the types of organizations that emerge within a given time period are imprinted with the social structure of that founding period. Specifically, imprinting refers to a process “whereby specific environmental characteristics get mapped onto an organization’s structure and affect its development and life chances” (Carroll and Hannan, 2000: 205). The concept of imprinting helps to explain why organizations develop certain forms over others. As Aldrich and Fiol (1994) suggest, imprinting is not only about constraint, but opportunity as well because social contexts also set the conditions that create “windows of opportunity” for new organizations to carve out a piece of the market.

The circumstances in which an organization finds itself during founding play a key role in imprinting the initial form of the organization and influencing later organizational change. Thus, when organizations are set on a particular course at the time of founding, changing direction from this course may be difficult. Therefore, as research suggests (Boeker, 1988; Stuart and Sorenson, 2003), early patterns of organizing that are developed in response to the environment may limit the range of future decisions an organization will make, even if alternative options seem desirable. Research on product development processes shows that organizations often develop structures and procedures for technology development that reflect conditions at the time of their founding, including historic industry conditions (Katila and Ahuja, 2002), patent laws (Chou and Shy, 1993), inter-organizational alliances (Eisenhardt and Schoonhoven, 1996), and project team structures (Allen, 1977). All of these characteristics imprinted onto the organization at the time of founding affect the way technology development occurs not only in the short run, but over time as well.

The technological frames of varying relevant social groups are conditioned by the social contexts in which its designers are embedded (Pinch and Trocco, 2002). From an agency-centered perspective, these social contexts can change quite rapidly because there are few structural factors
holding them constant (Kline and Pinch, 1996). Within formal organizations, however, the organizational structures which carry the imprint of the time of founding serve to keep the context relatively stable. Thus, technological development within large organizations may differ substantially from more autonomous situations of development precisely because the elements that comprise a technological frame are conditioned by the organization’s founding imprint. Rather than changing fluidly over time, the imprinting hypothesis suggests that the technological frames that guide designers’ actions may be subject to homeostasis. One would therefore expect that the environmental characteristics that are imprinted on an organization will hold the technological frames of relevant social groups constant as the organization remains locked into practices and structures developed during its time of founding, despite the fact that new procedures may be available. Whereas evolutionary theories of technology development suggest that new processes of technological development will supplant the old (Nelson and Winter, 1982), the imprinting hypothesis demonstrates that an organization’s ability to adopt such innovations is often determined by environmental characteristics and less prone to designers’ choices than social-shaping theories suggest (e.g., Williams and Edge, 1996).

7.4.2 Structural inertia

In addition to imprinting forces, Stinchcombe (1965) observed that organizations were susceptible to certain “traditionalizing forces” subsequent to founding that preserved previously adopted organizational characteristics. He argued that in attempting to overcome their “liability of newness,” organizations built up a stock of resources and processes that locked them into certain patterns. Building upon this insight, ecology theory has focused on how certain organizational forms develop structural inertia—or limitations on the ability of organizations to adapt (Hannan and Freeman, 1977, 1984). Generally, three interrelated processes lead to inertia: intricacy, opacity, and asperity. Intricacy refers to the number of steps in a cascade of organizational changes (Carroll and Hannan, 2000). The more things that need to be changed, the more difficult change will be. Opacity concerns the nature of changes that one cannot see. Organizations can never fully know how the environment will change, and so they are largely unable to react to changes that have already occurred fast enough to capitalize on them. Asperity refers to the severity or rigor of the culture in which the organization is embedded. Within a given environment, certain organizational forms are legitimate and others are not. The degree to which
that environment is accepting of deviations from the norm affects an organization’s ability to change. Overall, if inertial forces within an organization are strong, the possibilities of adaptation in response to the changing environment are limited and attempts at reorganization might very well decrease chances of survival (Hannan and Carroll, 1995).

Ecology theory holds that organizations engage in many processes that create their own structural inertia. Some of these internal factors are sunk costs in plants, equipment, and personnel, the dynamics of political coalitions, and the tendency for precedents to become normative standards. Other factors are external to organizations, including legal regulations, exchange relations with other organizations, and loss of legitimacy during an attempted change (Hannan and Freeman, 1984: 149). Thus, organizations use their initial endowments to instantiate various mechanisms that make it difficult for them to change. This is not to say that organizations are stagnant and unproductive. In fact, inertia often confers many advantages for organizations in that firms with well-established processes and entrenched relations with other members in the environment are often able to survive in ways that fledgling organizations cannot (Hannan and Freeman, 1977; Baum, 1996). Sorenson and Stuart’s (2000) investigation of the ability of semiconductor and biotechnology companies to overcome structural inertia, for example, demonstrates that the competence to produce new innovations improves with age, but that such gains in organizational competence come at the price of an organization’s ability to adapt to evolving environmental demands. In other words, the more an organization works on perfecting a certain process or procedure, the more blind it becomes to impending environmental changes and is less able to absorb those changes.

One of the key assumptions from SCOT’s current agency-centered perspective is that technology designers have relative autonomy to change their designs. That is to say, if an independent designer discovers a new way to patch and channel different sounds into a synthesizer, he or she will be able to adopt a new set of processes or procedures to begin to develop the technology in a new direction (Pinch and Trocco, 2002). While this may be true for independent inventors, or technologists in small, adaptive companies, ecology theory highlights the fact that once established in large formal organizations, technological development processes may be locked in forward-motion because of inertial tendencies (Dobers and Strømme 2001). In SCOT terms, closure of a problem is often reached because the structural inertia of formal organizations precludes them from adopting new procedures and process that would lead technology development down new paths. In other words, due to the structural inertia inherent in
organizational forms, the design of a new technology may stabilize because of an organization’s inability to adopt new practices and procedures that would otherwise influence that technology’s design. While many organizational influences produce more changes in technology than a designer might anticipate, an organization’s structural inertia may very well inhibit a technology from changing as much as it would if its designers were free from organizational constraints.

7.4.3 Niche width

The concept of “niche” is central to Population Ecology. Borrowed from biology, a niche refers to “all those combinations of [environmental] resource levels at which the population can survive and reproduce itself” (Hannan and Freeman, 1977: 947). Hannan and Freeman (1989) further defined a niche as an “n-dimensional resource space,” which includes social, economic, and political dimensions, to name a few. Each population occupies a distinct niche in which individual organizations compete for scarce resources. The success of a given population can be explained by the extent to which organizations utilize the resources in a given niche. As Hannan and Freeman (1977) argued, organizations make use of the niche width differently depending on whether they are specialist or generalist organizations. Where the specialist maximizes the exploitation of the environment and accepts the risk of having the environment change, the generalist accepts lower levels of exploitation in order to enhance their security. Within the conceptualization of the niche, resource-partitioning theory (Carroll, 1985) has been useful in explaining the rise of generalist and specialist organizations. The theory predicts that generalist organizations seek to increase returns to scale by fighting over the densest resource areas of the niche, while specialists that do not have scale advantage tend to locate themselves in areas where resources are thin, and thus remain small. Resource-partitioning theory’s interpretative power comes from comparing the amount of resource space available for specialists when market concentration among generalists rises (Carroll and Hannan, 2000).

A well-explored area of niche width has focused on positioning and crowding of organizations in the resource space. Dobrev et al. (2002) found that larger automobile manufacturers who occupied dense resources areas at the center of a niche were more likely to survive than the many specialists in the early history of the industry who competed in thin resource spaces by attempting to produce more customized automobiles. In a related set of studies, identity figures prominently into the positions of generalists
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and specialists in a niche. In their study of American breweries, Carroll and Swaminathan (2000) found that generalists who identified as mass producers had difficulty gaining acceptance as they tried to enter the micro-brewery movement because their identities were firmly based upon their generalist image. The appeal of specialist organizations came precisely from their identity as non-corporate, craft-like producers using traditional brewing methods. Mass producers could not compete with this image. Such studies demonstrate that an organization’s location in a niche (resource space) matters in terms of the organization’s identity and chances of survival.

Clearly, an organization’s position within a given niche affects the types of resources that are available to it as well as the types of goods and services it produces. Large companies tend to produce fewer breakthrough products than smaller companies (O’Reilly and Tushman, 2008) precisely because they occupy a more general position in the environment and are less likely to take risks that jeopardize their ability to stay in the mainstream. Further, as identity becomes bound up in an organization’s location within a niche, as either a specialist or a generalist, such identity may very well impede an organization from developing new technologies that conflict with that identity. As Bijker (1995b) showed with the social construction of dikes in the Netherlands’ Deltaplan, and Vaughan (1996) showed with the social construction of engineering solutions to risk analysis at NASA, an organization’s identity has a major effect on the process of technology development by influencing an artifact’s interpretative flexibility. Developers identify a technology within a given artifact based on their perception of its functionality in relation to their specific needs. Interpretative flexibility is based on the notion that the meaning of an artifact is attributed to it by groups with particular backgrounds that influence their conceptualization of the artifact (Pinch, 1996). Given that the position of an organization in a niche dramatically affects its access to resources, and in turn its identity, we would propose that the meanings designers attribute to the artifacts they create, and thus the interpretative flexibility that artifact has, is a product of that organization’s location in the niche. Thus, the interpretative flexibility of an artifact will most likely be shaped by the degree to which an organization competes in the niche’s mainstream or on its periphery, and whether that organization’s identity is bound up with a specialist or generalist identity.

Overall, theories of Population Ecology instruct researchers of the social construction of technology to consider the fact that organizations cannot always actively adapt to environmental changes, but are instead often
selected in spite of them. Such population-level changes can place limits on the way that materiality emerges within formal organizations. Building on such recognition, one strategy that students of the sociomaterial approach might take would be to expand their analyses to include entire populations of organizations when considering how materiality emerges. Certainly, population ecologists would argue that the systemic dynamics of a particular population of organizations is the result of social processes. Although they may use evolutionary imagery to make their arguments, population ecologists no doubt envision that variation in a population and ultimately selection and retention happen as the result of decisions made by organizational leadership about how to position themselves with respect to each other. These population-level dynamics can quickly cascade down to teams of technology developers who find themselves pushed and pulled in particular directions due to strategic decisions about image, identity, and hopeful paths toward survival that are made in response to population-level dynamics, not necessarily to optimize the design of any new technology. In short, any account of how the social and the material become intertwined must recognize that organizations are jostled about on waves they cannot always directly control and that the materiality of new technologies can emerge in their wake.

7.5 Conclusions

This chapter began by suggesting that students adopting a sociomaterial approach to technology and organizing should not put the cart before the horse. Before showing how the social and the material become constitutively entangled, or before simply showing that they are, researchers should examine how and why a technological artifact’s materiality—the arrangement of a technological artifact’s physical and/or digital materials into particular forms that endure across differences in place and time and are important to users—comes to be the way it is. Focusing on the emergence of materiality is important because if we take seriously the notion that organizational practice is sociomaterial in nature, those features of a technology that pre-exist people’s interactions with it have the potential to afford or constrain work practices and the organization of work (Leonardi and Barley, 2010). In short, understanding the emergence of materiality in the first place may help to explain why certain sociomaterial practices of use arise, and why others do not.

To make explicit what has been implicit throughout most of this chapter, I argue that organizational theorists should not rush to adopt the
“sociomaterial” lens and begin to view everything seen through it as inherently sociomaterial. We can talk about sociomateriality on a conceptual plane only after we recognize that the social and the material have so thoroughly saturated each other on the empirical plane. In other words, what we see when we look through a lens of sociomateriality is that the materiality of an artifact emerged as it did, in large part, because of the social dynamics of the organizations in which it was developed and this very materiality which is so thoroughly social is the same that will become enmeshed with the social dynamics of the workplace into which it is introduced so as to render it conceptually “entangled” with local practice. Consequently, it is the process of sociomaterial entanglement, not the outcome of it, which deserves our research attention if our aim is to build interesting and useful theories of organizing.

This focus both shares in and departs from the current ontology of the sociomaterial approach. It shares in the belief that organizational theorists should consider the work practices of people within organizations as socio-material practices and that they should also consider organizing as a socio-material process. But it departs from contemporary views by suggesting that people working within organizations and who make organizing happen do not confront a world that they view as sociomaterial. Instead, they confront some phenomena that they understand to be social and they deal daily with the materiality of technological artifacts with which they work—most of which appear fixed, finite, and stabilized, not inherently social and utterly malleable. It is through the work that these actors conduct as they engage in their daily tasks that they turn the social and the material into the sociomaterial.

If one subscribes to this view, theorizing materiality itself before it comes in contact with the social contexts in which it is implemented and used becomes important. It becomes important because users react to a technology’s materiality—a materiality they perceived as bounded and stable—when translating it from the realm of the artifactual into the realm of the social. All theory about the sociomaterial consequences of technology use, then, begs an understanding of what materiality users confront in their work. Yet as discussed in this chapter’s opening, we know from nearly three decades of constructivist research on technology development that the same materiality that users confront as objective and stable was designed and fashioned through social processes. Consequently, any theory of sociomaterial practices of technology use must theorize materiality by understanding how and why it emerged as it did because it is those sociomaterial practices of technology development that will ultimately shape, at least in part, how the technology is used.
Although the social construction of technology approach may seem like one of the most promising candidates to aid in this quest by explaining the emergence of materiality, I have argued that we know little about how the social construction of a new technology’s materiality takes place in formal organizational settings. Following the work of other researchers who have begun to push SCOT to consider social structural influences, I aimed, in this chapter, to draw on influential organization theories to explore how the micro-level interpretative flexibility of artifacts, the evolution and composition of the set of relevant social groups that contribute to the artifact’s construction, the processes by which the materiality of an artifact reaches a point of stabilization and closure, and the structure of the technological frames shared by designers are influenced by macro-level organizational responses to the environment.

Using the insights of Resource Dependence and Population Ecology provided a useful basis for thinking about how SCOT’s mechanisms may occur differently when technologies are developed in formal organizations than when they are developed by autonomous inventors who are largely free from organizational constraints. The resulting analysis proposed that although the many organization–environment interactions that occur in the context of formal organizing may be initiated or devised without new technology development specifically in mind, they can have the latent effect of altering the mechanisms through which a technology’s materiality is shaped. Organizational scholars interested in adopting a sociomaterial lens should move beyond simple descriptions of entanglement to develop a deeper understanding of the processes of entanglement because it is these processes in which organizations themselves are so implicated.

To move in this direction, theorists interested in the sociomateriality of organizational practice may start to learn much more about the organizational influences on the emergence of materiality by continuing the theoretical exercise begun above with other theories that depict organizations as actively responding to their environments, such as New Institutionalism (DiMaggio and Powell, 1983; Tolbert and Zucker, 1999) and Transaction Cost Economics (Williamson, 1981, 1996), as well as theories, such as Evolutionary Theory (Nelson and Winter, 1982; Dosi and Nelson, 1994), which suggest that organizations are directly acted upon by their environments. Ultimately, however, empirical research is needed that examines the social construction of technology within organizational contexts. Such a perspective would complement existing research on technology innovation (von Hippel, 1988; Christensen, 1997; Hargadon and Douglas, 2001), which explores how organizational arrangements lead individuals to develop...
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breakthrough ideas, and research on product development (Clark and Fujimoto, 1991; Brown and Eisenhardt, 1995; MacCormack et al., 2001), which examines the organizational structures that lead to efficient and robust inter and intra-organizational collaborations, with a perspective that can explain how the material features of a new technology evolve over time and come to be taken-for-granted as the way the technology “has to be.” Understanding organizational influences on the emergence of a particular form of materiality would thus help students of technology and organization to generate a more complete understanding about how the social and material features of organizational practice become constitutively entangled, and why some sociomaterial practices change the process of organizing, and others do not.

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References


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