

Artifacts at the centre of routines: performing the material turn in routines theory

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Abstract: Existing theories of organizational routines have generally had simplistic and extreme views of artifacts as fully deterministic or largely inconsequential. Artifacts have been treated as either too solid to be avoided, or too flexible to have an effect. This paper endeavours to improve our understanding of the influence of artifacts on routines dynamics by proposing a novel and deeper conceptualization of their mutual relationship. In drawing from recent advances in Routines and STS/Performativity Theory, the paper contributes to advancing our understanding of routines dynamics by bringing artifacts and materiality from the periphery to the very centre of routines and Routines Theory.

1. Introduction

Artifacts play key roles in routines (Nelson and Winter, 1982; Cohen *et al.*, 1996; Becker *et al.*, 2005; Feldman and Pentland, 2003; Pentland and Feldman, 2005, 2008; D'Adderio, 2001, 2003, 2008a, b). They can influence their emergence and persistence, both in destabilizing existing action patterns or providing the glue that can hold patterns together; they can perform key functions, including acting as mediators and intermediaries (Latour, 1987, 2005) among the agencies involved in routinized performances, thus supporting or preventing coordination among organizational communities and functions (D'Adderio, 2001; Carlile, 2002; Bechky, 2003); they can act as obligatory points of passage, thus enabling or constraining worldviews and actions (Latour, 1987); and they can make

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explicit or hide actions and viewpoints, thus making connections between practices and their outcomes more or less visible (Orlikowski, 2002; D'Adderio, 2001, 2008a).

Despite their importance, authors have only recently begun to explore the influence of artifacts on routines evolution in a systematic way (Pentland and Feldman, 2005, 2008; Cohen, 2007; Schultz, 2008; D'Adderio, 2008a, b). This lack of attention might appear somewhat surprising when considering the key role attributed to artifacts in the 'first wave' of routines contributions (Nelson and Winter, 1982; Cohen *et al.*, 1996) where authors have focused on the role of 'external objects' and 'artifactual representations' (including formal rules and procedures) on routines. It is speculated here that the relative lack of interest in artifacts in Routines Theory in recent years followed from the conscious effort by authors to focus on the role of agency in shaping routines.

This focus seems entirely necessary when understood within the scholars' efforts to convey the radical shift from thinking about routines as rigid, lifeless entities to routines as generative systems (thus enacting what I call the first 'Copernican revolution' in Routines Theory). Artifacts – at first sight – appear to be taking the routine towards the automatic/mindless end of the spectrum and therefore do not appear immediately useful to a theory whose main objective is to explain how routines are 'brought to life' (Cohen, 2007; Pentland and Feldman, 2008). Agency breathes life into routines in a very immediate and intuitive way. Agency, thus, had to be the focus of this 'second wave' of routines studies that achieved so much progress towards a deeper characterization of routines dynamics.

Within the evolutionary trajectory of the theoretical Routines debate, however, we are now presented with a unique opportunity. Now that the characterization of routines as generative systems (Pentland and Reuter, 1994; Feldman and Pentland, 2003; Pentland and Feldman, 2005) has been firmly (and, hopefully, irreversibly) established, the time has come to take a next and, I would argue, very necessary step forward. This entails performing a second 'small Copernican revolution' in Routines Theory by bringing artifacts in general, and artifactual representations of routines in particular, to the centre of routines and to the forefront of the Routines debate. If the first radical shift in Routines Theory, thus, was about emphasizing the role of agency in routines, the second calls for a much deeper, stronger and nuanced characterization of the role of artifacts and materiality. A focus on how configurations of artifacts and people come together and are stabilized in recurrent – but continuously challenged – patterns of interaction can thus provide valuable insights into routines micro-dynamics.

Achieving those insights requires an improved understanding of the complex ways in which artifacts may influence routinized performances. Enacting the shift that brings artifacts at the centre of attention in Routines Theory, thus, involves moving beyond extant partial renditions of artifacts to study them as multi-faceted entities that can influence the course of routines, while at the same time

themselves evolving as a consequence of their appropriation by certain agencies in specific contexts. This entails moving beyond the dominant characterization of artifacts as opaque, lifeless ‘objects’ that lie *outside* the routine. It also involves moving past their extreme characterization as either fully prescriptive objects that deterministically influence and constrain actions, or as simply descriptive, infinitely malleable and often inconsequential entities, which depend upon the agents’ willingness to include them as part of their performances.

To realize this objective, I will focus on a particularly significant category of artifacts, including formal routines and rules and standard operating procedures (SOPs) (Lazaric and Denis, 2001; D’Adderio, 2001, 2003, 2008a, b; Pentland and Feldman, 2005, 2008). When compared with simpler artifacts, ‘artifactual representations’ of routines – as models of actual routines – can provide vantage points to observe the mutual influence of routines and artifacts. This is because they are easier to observe, typically being written down or embedded in technology (i.e. software, machines), and because they retain an imprint of the agencies that have created and used them, thus helping reveal the deeper influence of agency on routines. A focus on artifactual representations, I posit, will allow us to make progress by revealing the complex dynamics of interactions between routines and artifacts. Dynamics include the relationships between artifacts and the ostensive, and artifacts and performances (Pentland and Feldman, 2005); as well as between artifactual ‘representations’ of routines and actual ‘expressions’ (Cohen *et al.*, 1996; D’Adderio, 2003, 2008a).

In this paper, I therefore argue for the need to bring artifacts to the centre of the routine – and studies of artifacts to the centre of Routines Theory. This shift is important in two ways: (1) theoretically, it focuses attention towards the fundamental role that artifacts play in the production and reproduction of routines, directly influencing the rate and direction of change in routines and therefore their evolution, and (2) empirically, it reflects the key functions that artifacts play in every-day routines performance. It is in fact difficult, if not impossible, to envisage a routine that completes its course without involving any artifacts at all. Talking about artifacts, moreover, does not imply abandoning agency, as scholars in social studies of technology have shown (Orlikowski, 1992), but rather the opposite. By focusing on artifacts, I shall be able to show how the *combined* influence of human agents and material artifacts shapes the course of routines.

To fulfil the artifactual shift in Routines Theory requires some new theoretical tools that enable us to focus on artifacts to uncover the complex interactions between artifacts, human agency and routines. To this purpose, while building on recent advances in Routines Theory, this paper introduces a new theoretical framework which embraces the emergent narratives of Science and Technology Studies (STS) and Performativity Theory. Drawing from examples of the production and reproduction of routines in different manufacturing contexts, this paper demonstrates how the Performativity framework can provide the

key to unlock some of the complex dynamics of interactions between routines, agencies, and artifacts.

2. The role of agency and artifacts in Routines Theory

What is an artifact?

I begin my analysis by reflecting on the role of artifacts in Routines Theory and how, and to what extent, this has evolved over time. The word 'artifact', or 'artefact', comes from the Latin words *arte* (ars, *art*) and *factum* (facere, *to make*). Artifacts are defined as 'anything made by human art and workmanship' (Oxford English Dictionary Online), or 'something created by humans usually for a practical purpose' (Merriam-Webster Online Dictionary, 1990: 105).

There are probably as many characterizations of the nature, properties, and role of artifacts as there are disciplines (see also Vilnai-Yavetz and Rafaeli, 2006). For the purpose of this paper, I find it useful to distinguish among three main perspectives: realist, constructivist, and actor-network theory (ANT).¹ The *realist* argument is that artifacts have stable, inherent properties so that agency can be attributed to them straightforwardly. Realists, for example, have shown how the physical structure or operation of artifacts, such as the design of a technology, constrains or enables practices, beliefs, or social configurations (Mumford, 1964; Winner, 1980). This view has been criticized by constructivists as it plays down the role of social factors in defining an artifact's properties. In contrast, the *social constructivist* approach emphasizes how representations by different social groups play a mediating role between the technology and its social context. The changes in practices that follow the introduction/use of an artifact or technology here depend upon the social representations of what the artifact/technology is and what it does. Technologies, in other words, do not have objective properties: they display 'interpretive flexibility' (Pinch and Bijker, 1987), and can be attributed very different functions and properties depending on the agencies that use or produce them. Absolute physical constraints in this framework do not exist, but what appears to be a constraint is in reality a social construction, a particular reading of the artifact that *seems* objective because it has become obdurate through negotiation and closure (Pfaffenberger, 1992).

According to the *ANT view*, neither realists nor constructivists are able to account for the complex interactions between people and things. Realists underestimate the power of humans when faced with the intrinsic influence of certain technologies, while constructivists underestimate the power of objects. According to ANT scholars (Callon, 1987; Latour, 1987), the properties of artifacts neither are objective facts, as in the realist tradition, nor are they mere social constructions, as in the social constructivist tradition: artifacts and their properties are *both* real and constructed. They emerge from a heterogeneous

¹ See Brey (2005) for a deeper review of the literature than is possible here.

network of social *and* technical elements (including *social* representations and *natural forces/technical* elements) that co-construct them. Any phenomenon in this framework is thus the outcome of the workings of heterogeneous socio-technical ensembles of elements also referred to as ‘hybrid collectives’ (Callon and Caliskan, 2010). Within such collectives, both humans and non-humans (i.e. artifacts) can act, influence, and mediate (Latour, 1987). Thus, in this view, an artifact’s properties are neither inherent nor socially constructed, but relational and emergent: actants can form links with each other and this can give rise to networks of actants. When the associations in a network become stable or solidify, the network stabilizes. Properties emerge as black boxes, as apparently objective properties of actants. In this paper, I hope to demonstrate that this dynamic and emergent characterization of artifacts and their properties can provide vantage points to study routines dynamics. First, however, we need to delve deeper into the relationship between artifacts and routines.

Routines and artifacts

A plethora of artifacts is typically involved in the course of a routine. These may include letters, documents, clocks, calendars, meters, gauges, display boards, forms and invoices (Nelson and Winter, 1982), spatial arrangements of machines, tools and materials, and written codes of SOPs, or computer systems (Cohen *et al.*, 1996). While all kinds of artifacts can play instrumental roles in rule- and routine-following, routines authors have traditionally placed an emphasis on ‘cognitive’ or ‘representational’ artifacts (Cohen *et al.*, 1996). These include SOPs and formal rules, often referred to as ‘artifactual representations’ of routines (Hutchins and Hazelhurst, 1991; Cohen *et al.*, 1996; Lazaric and Denis, 2001; D’Adderio, 2001, 2003, 2008a, b; Pentland and Feldman, 2005, 2008). In Cohen *et al.* (1996), for example SOPs are defined as a kind of representation, a formalized statement of what actions *should* occur. This separates SOPs from the actions occurring as routines are expressed in context, a separation that is desirable as ‘real behavior diverges substantially from formalized SOPs’ (Michael Cohen in Cohen *et al.*, 1996: 673). Thus, in this view, routines can be coded in cognitive artifacts (representations) such as work-flow graphs, which facilitate their manipulation, to be subsequently ‘brought back to the field’ generating new expressions (actual routines). Written rules and procedures can serve as proxies for the ostensive aspect of routines (Pentland and Feldman, 2005; D’Adderio, 2008), or they can be read as embodying specific configurations of views, goals, and dispositions by different agencies (D’Adderio, 2003, 2008a, b). The relationship between SOP, rules, and *ostensive* can thus reveal the extent of divergence, whereas the match between the SOP or rule and the actual routine or *performance* can be understood as revealing the extent of control (Pentland and Feldman, 2005). Increased control can be achieved by delegating the rule or

procedure to machines or software, which tends to make them more persistent and durable (D'Adderio, 2008 a, b; Pentland and Feldman, 2008).

Along the same line of thought, Rafaeli and Pratt (2006) have advocated the need to study 'linked artifacts', such as written procedures and multiple performances, which hold a special relationship as they evolve from one another or are meant to replicate each other. Key issues highlighted here involve understanding how multiple representations co-evolve, what is the relationship between an actual routine and its 'copy', and the implications for performances of introducing a tangible artifact that captures the routine. I will address these key aspects later in the paper. At this stage, it will suffice to emphasize the important role that formal procedures and rules play in routines reproduction. In recognition of their key roles, rules and SOPs will be the main focus of the rest of the paper.

When focusing upon the role of artifacts in Routines Theory I thus identify three approaches: first, artifacts in early Routines Theory (Section 3 in this paper); second, artifacts and agency (Section 4); and, third, artifacts at the centre of the routine (Section 5). This journey will afford substantial progress towards accomplishing the shift required to bring artifacts to the centre of routines.

3. Artifacts in early Routines Theory

Artifacts as 'external memory'

Routines scholars have been concerned with the role of artifacts in routinized performances from the outset. In early contributions, artifacts are part of, and help constitute, the context that provides the background to routinized performances. According to Winter (in Cohen *et al.*, 1996), for example, *context dependence* is a fundamental feature of routines, such that 'their effectiveness is not measured by what is achieved *in principle* but by what is achieved *in practice*; this generally means that the routine might be declared effective in some specific contexts, but perhaps not in others' (p. 662). Winter (*ibid.*) highlights two key aspects of context: *physical*, which is expressed in the local/artifactual complements to the routine, including the material tools and physical plant layout and equipment; and *motivational* or *relational*, which captures the agents' discretion to decide whether, when, and how to perform a routine.

These early contributions emphasize the role of artifacts as 'external memory' (Nelson and Winter, 1982); artifacts help humans deal with solving complex problems by sharing some of the cognitive burden. This notion resonates with the later anthropological notion of distributed cognition (Hutchins, 1995), pointing to the fact that a routine does not reside in any one place, and certainly not solely in the human mind, but is instead distributed *across* people and artifacts, including rules and technologies. I will address these key notions later in the paper. At this point, I want simply to highlight the fact that Routines scholars

have pointed from the very outset to the complex and distributed web of artifacts and coordinating relationships that constitutes and supports a routine (Winter, 1995, Szalanski, 1996).² This bears important consequences for capturing the nature of routines and the role of artifacts.

Artifactual ‘representations’ vs ‘expressions’

There is a further contribution in earlier Routines Theory, which also points to the critical role of artifacts and has been similarly overlooked in subsequent work. Early scholars have devoted specific attention to the key relationship between formalized, or *artifactual ‘representations’* of routines (including SOPs and formal rules) and routines in practice, or *‘expressions’*. Cohen *et al.* (1996), for example, while agreeing that tacit knowledge and non-deliberate behaviour are involved in the operation of routines, also highlight that stability and replicability depend on ‘the following of explicitly stated rules and instructions ... and a carefully designed artifactual environment within which workers can learn coordinated behaviors’ (Warglien in Cohen *et al.*, 1996: 659). According to early authors, thus, artifactual representations of routines – as ‘cognitive artifacts’, which include rules and SOPs – play a central role in the evolution of routines, including their transfer and replication. Transferring ‘best practice’, it follows, rather than involving the straightforward uplift and transplantation of routines to a new site, involves ‘a large effort to set up a “technology of replication” that usually implies (i) learning a language within which to code successful routines, (ii) creating cognitive artifacts that can be diffused (through flowcharts and other replicable representations), (iii) translating the high-level description contained in the cognitive artifact in actual practice, generating a new routine adapted to the new context’ (Hutchins and Hazelhurst, 1991 in Cohen *et al.*, 1996: 674). Thus, in earlier routines work, procedures and rules as artifactual representations of routines are key and intrinsic aspects of routines production and reproduction (see also Schultz, 2008).

The discussion above shows that the exact nature and role of formal rules and procedures (as representations), and the extent to which these artifacts are able to shape the course of actual routines (expressions), were key topics in early routines studies. Nevertheless, this pioneering discussion was limited to identifying ‘interactions’ and ‘tensions’ between these two aspects of routines and thus failed to make significant progress towards assessing their reciprocal influence. To achieve this objective, we need more advanced and finer-grained theoretical tools and methodologies.

² The notion of a routine incorporating artefacts as well as relationships has been carried forward in the routines transfer literature where scholars have highlighted the importance of reconstituting such a web in the new context for the routine to remain operative (Szulanski, 1996; Winter and Szulanski, 2001; D’Adderio, 2008b).

4. Artifacts and agency

Artifacts are 'not the routine'

The strong emphasis on artifacts found in earlier Routines literature was not pursued in subsequent contributions with the exception of a rather narrow stream of routines studies (see Becker *et al.*, 2005; Pentland and Feldman, 2005, 2008; Cohen, 2007; Adler and Obstfeld, 2007; D'Adderio, 2001, 2003, 2008a). The relative lack of interest in artifacts must be understood as part of the authors' conscious effort to move away from a reductive view of routines as 'things' and bring agency back into the picture. This meant attributing artifactual representations a lesser role when compared with actual routines (expressed in context). Thus, the observation that 'what finally generates value is the routine (the expression) rather than the code (the representation)' (Cohen *et al.*, 1996: 674), while entirely accurate, underlies a *representational* view of routines that implicitly relegates their artifactual representations to the lower rank of imperfect imitations. The crux of the matter here is precisely what function can we ascribe to a category of artifacts that plays such a crucial role in the evolution of routines.

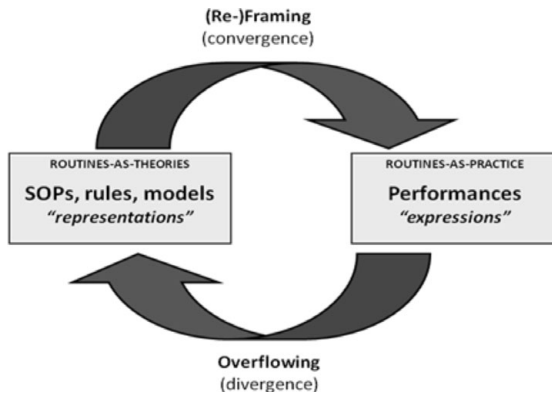
On the one hand, it is important to reiterate that formal procedures, SOPs, and rules *are not* the routine (Bourdieu, 1977; Cohen *et al.*, 1996; Suchman, 1983; Pentland and Feldman, 2008; D'Adderio, 2008a). They are formal, explicit, synthetic, selective, partial representations of routines (D'Adderio, 2003, 2008a). Distinguishing in this way between formal procedures and routines is fundamental to avoid the categorical mistake of assuming that it is sufficient to design a procedure to achieve a certain performance, as presumed in much managerialist literature. Pentland and Feldman (2008), for example, have warned practitioners against 'the folly of designing artifacts while hoping for patterns of actions' (p. 1). While practitioners all too often design artifacts in their attempt to control and prescribe routines, they are committing the clear mistake of confusing artifacts with the routine's 'ostensive' (abstract) aspect (*ibid.*: xx).

At best artifacts can be 'partial representations' containing selected and codified configurations of the multiple (ostensive) views and physical arrangements that make up a routine (D'Adderio, 2008a). Moreover, while such artifacts are designed for the very purpose of directing performances, the actor's complicity in following their course is often required. SOPs, thus, rarely prescribe work, as actors are often able to modify them, or even altogether neglect to include them in their performances. Thus, in Suchman's case (1983), office routines differ from their representations. In Feldman's example (2000), routines are not incorporated into performances; the workflow and freeze processes fail to fully prescribe the routine in D'Adderio (2003, 2008a respectively); and in Lazaric and Denis (2001), SOPs fail to determine actions.

On the other hand, while this distinction is important, there is more to it. Even though artifacts very rarely coincide precisely with the routine, they nonetheless still *play a key role* in their evolution. It is precisely for this

Figure 1. Reciprocal influence of procedures and performances

Source: D'Adderio (2008).



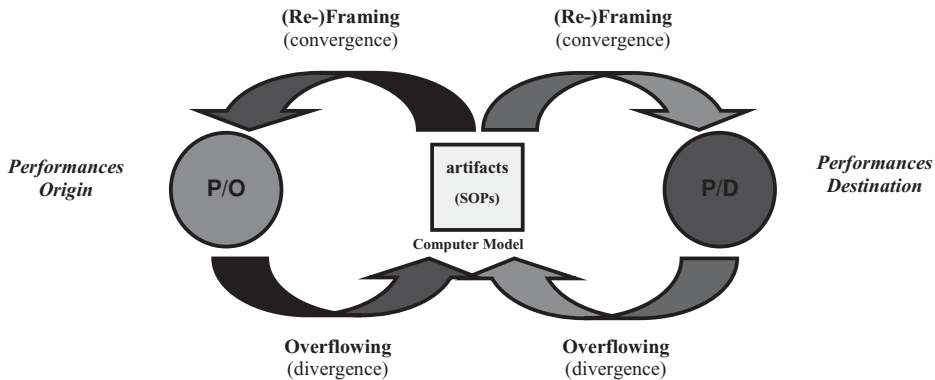
reason that artifacts, in general, and artifactual representations, in particular, deserve further investigation. For example, addressing the relationship between representations (routines-in-theory) and expressions (routines-in-practice) in depth and in detail can provide vantage points to characterize the evolution of routines (D'Adderio, 2003). This includes uncovering the processes of *translation* from formal routines to actual performances and vice-versa, from performances back to procedures, or, in other words, the co-production of procedures and performances (D'Adderio, 2001). By adopting the notion of translation, a term dear to the Sociology of Technology, I intend to emphasize the fact that the movement from formal procedures to performances, and vice-versa, entails not so much a straightforward process of codification and de-codification (of performances into procedures and vice-versa) but one of deep *transformation*, of socio-technical 'actualization' and 'virtualization' involving both actors and artifacts (as in the notion of 'translation routines' in *ibid*).

Building on this line of thought, more recent work by D'Adderio has further theorized the mutual influence of procedures (routines-in-theory) and performances (routines-in-practice) in the cases of the engineering freeze process (2008a) and of the exact replication of routines (2008b) both in high-technology manufacturing contexts. Drawing from Performativity Theory, the first study examines the introduction of software-embedded SOPs in the Engineering Freeze process and shows how (computer-embedded) procedures and rules play a fundamental influence in shaping performances: formal routines are dynamically performed through iterative cycles of framing, by which there is convergence between model and reality, overflowing (by which there is divergence between model and reality) and further reframing (D'Adderio, 2008a,b) (Figure 1).

The second case study builds on these findings to capture the key role of artifacts, or SOPs, as intermediaries and mediators in the transfer of a production

Figure 2. Relationship between procedures and performances in artifact-mediated routines transfer

Source: D'Adderio (2008b).



capability and associated routines in manufacturing. This work characterizes the deeper mechanisms by which procedures influence performances at both origin and destination sites (D'Adderio, 2008b) and shows how similarity between origin and destination is the emergent outcome of iterative cycles by which the formal, computer-embedded, procedures are performed at both sites (Figure 2). These examples demonstrate clearly that, in order to achieve further insights into routines dynamics, we need to go beyond a passive view of procedural artifacts to analyse their complex and active role in the production and reproduction of routines. This role entails enrolling a plethora of other artifacts (including objects, tools, and technologies) that make their reproduction possible, or even likely. Understanding routines, in other words, involves taking artifacts seriously.

Artifacts and routines: dead or alive?

In order to advance our understanding of the role of artifacts in routines' change and stability, we need therefore to turn our attention to the character of artifactual representations and the socio-technical mechanisms that regulate their evolution. Michael Cohen's (2007) distinction between 'dead' and 'live' routines, inspired by Dewey's influential theory (1922), is highly relevant here. While 'dead routines' tend to be rigid, mindless, and are typically codified in artifacts, tools, and technologies, 'live routines' are flexible, mindful, and involve the contribution of actors, their experience and learning. The distinction between live and dead routines delivers a powerful message about the nature of routines and the role of agency in routines, which has been lacking in earlier routines literature. While this analytical distinction is useful, however, it requires further qualification when it comes to characterizing the role of artifacts.

In particular, I suggest that these notions must be treated with care to ensure that the connotation ‘dead’, when attributed to a routine, does not result in obscuring the nature and role of artifactual representations of routines and *their own* internal mechanisms (dead meaning not so much inconsequential, but hardened, solidified). After all, there are entire bodies of scholarly knowledge that draw from ‘dead artifacts’ to inform the way in which we understand and characterize organizations, cultures, and societies. Anthropologists and archaeologists, in particular, are able to reconstruct entire societies from their scattered, partial remains and vestiges. From anthropology, thus, we learn that human agencies leave traces of their knowledge and work in artifacts (Thomas, 1991). Another way to express this is to say that artifacts are front-loaded with the habits, intentions, and rationales held by the agencies by which they have been created, adopted, and adapted.

When extending this thinking to routines, we can see how previous experience and learning by organizational agencies are selected and codified into formal routines and procedures. So-called ‘best practices’³, for example, originate from assumptions that come from sectoral and industrial experience, as well as the knowledge of analysts, regulators, and policy-makers. When they are embedded in artifacts, such as software packages, they also come to incorporate the knowledge, learning, and experience of software users and producers. In this process, layers of rationales, assumptions, and experience become over-imposed in artifacts (D’Adderio, 2003 and 2008b). In D’Adderio (2008b), for example, we can see how configurations of rationales embedded in the central computer model reflect the outcome of performative struggles in which the artifact has been involved.

The immediate implication of this argument for the adoption of standard practices is that rationales delegated to artifacts inevitably interact (meaning that they may either complement or conflict) with the intentions and rationales of the locale where the procedure is used/adopted, as further discussed below. These routines may certainly be dead, but they nevertheless retain traces of previous lives, and, because of this, they are worthy of study and attention. It is in fact their very nature, their relative stability when compared with the variation that is present in performances, and their relative solidity when compared with abstract (ostensive) views that makes them ideal loci for study. Formal routines and procedures, in being often codified and embedded in material artifacts, are relatively stable and easy to observe, and can thus provide invaluable empirical vantage points to explore routines dynamics. Ultimately, artifacts are only part of what makes up the routine; nevertheless, they do play a key role that scholars have only just begun to explore.

³ I use the term ‘best practice’ in brackets in adherence to the well-established critique to the linear, managerialist interpretation of the transfer and reproduction of practices/routines as straightforward diffusion (see Szulanski, 1996; Winter and Szulanski, 2001 for a state-of-the-art critique).

5. Artifacts at the centre of routines

I thus propose that enacting the shift that brings artifacts from the periphery to the centre of routines entails performing four key steps, which I address in the remaining part of the paper. *First*, I begin by highlighting the key role of artifacts through emphasizing the distributed nature of routine- and rule-following. *Second*, by introducing the notion of inscription, I show how artifacts, far from being passive and opaque black boxes, can perform the role of actants in routinized performances alongside human actors. *Third*, once it is established that artifacts can actively shape the course of routines, I analyse the ways and degrees by which artifacts can influence performances. And, *fourth*, I place artifacts at the centre of routines by discussing how artifacts and routines co-evolve through being involved in performative struggles among conflicting and complementary organizational agencies.

Highlighting the key role of artifacts: routine-following is distributed

The first step in our quest to place artifacts at the centre of routines involves acknowledging the important role that they play in routine-following. Routinized performances typically involve not only humans, the focus of much mainstream routines literature, but also non-humans. The key role that non-humans play in the performance and evolution of routines can be usefully captured through the notion of distributed action/cognition (Hutchins, 1991, 1995).

Rooted in Cognitive Science (Hutchins, 1991, 1995; Hutchins and Hazelhurst, 1991), the notions of distributed knowledge and action address the fact that there is more to cognition than what takes place in human minds. By describing processes in terms of functional relationships between brains, other people, and external objects, for example, Cognitive Science places an emphasis on the role of contextual elements in shaping individual and collaborative action and cognition. The role of artifacts as mediators is thus brought to the fore. Artifacts in this framework not only include man-made objects but also representational forms (i.e. spoken language, graphical models, text, etc.) which help propagate information in the material and social environment. Special attention is thus devoted to 'cognitive artifacts', tools developed for enhancing or facilitating human cognition whose close observation can provide valuable insights into the meaningful, constantly evolving practices that specific cultures produce and reproduce (Hutchins, 1995).

Cognitive artifacts are 'objects' made by humans for the purpose of aiding, enhancing, or improving cognition. Scholars have included in this category a range of artifacts including not only forms, flowcharts, worksheets, schedules, and graphs (Hutchins, 1995; Hutchins and Hazelhurst, 1991) but also rules of thumb, proverbs, mnemonics, and memorized procedures, which play a similar role to objects in some cognitive processes (Norman, 1993). Early work in Actor Network Theory (Latour, 1987) has shown how the distribution of cognitive

activity within socio-technical networks and between people and inscriptions accounted for much of the work of science. According to Latour, non-linguistic *inscriptions* or *representations* such as maps, charts, graphs, and tables enable the superimposition of representations of otherwise incommensurable items (1986). The physical and material arrangement of artifacts themselves has also been referred to as a cognitive artifact, including the arrangement of tools and machines on a factory floor (Nelson and Winter, 1982; Cohen *et al.*, 1996; Pentland and Feldman, 2005). A variety of artifacts including diagrams, checklists, forms, SOPs, rules, and procedures, some of which may be subsequently embedded in a software artifact, are often devised by managers to design or redesign a work process (Pentland and Feldman, 2005, 2008). Similarly, ‘intellectual’ or ‘conceptual’ equipment, including models, equations, and calculators, are described as fundamental in sustaining the performance of practices in financial markets (MacKenzie, 2009).

The notion of distributed cognition is not entirely new to Organizational Theory. According to Simon (1969) and Arthur (1994), agents faced with complicated tasks conceive of tools, create rules and routines or set up organizations to relieve their brains and enhance their performance. In so doing, these authors have extended the actors’ cognitive capacities by ‘redistributing their brains, *at least implicitly*’ (Callon and Muniesa, 2005: 1237, emphasis added). In early Routines Theory, analogously, the notion of distributed knowledge has provided ‘the natural locus of attention for lines of research focused on the role of artifacts’ (Cohen *et al.*, 1996: 683).

The implications of treating routinized activity as distributed, however, have not been fully acknowledged in extant Routines Theory. To further our understanding, we thus need to turn to the work of researchers in Science and Technology Studies, especially that based on Actor-Network Theory. According to STS scholars, knowledge and actions are *rarely* individual; they mobilize entities, humans, and non-humans, which participate in the creation of knowledge or the performance of actions. This holds important implications for routine and rule-following: participation in (routinized) performances by artifacts is not quite as *passive* as more or less explicitly assumed in earlier theory and can only exceptionally be reduced to its purely instrumental dimension. According to Callon and Muniesa (2005), thus, the notion of distributed cognition leads us away from standard theories of action, which reserve agency for humans alone, towards the notion of *distributed agency*. Actor Network Theory (ANT) scholar Bruno Latour, for example, shows how calculative agencies are not human individuals but ‘collective hybrids’ (1987, see also Callon and Caliskan, 2010). Latour argues that calculation does not take place solely in the confines of the human mind, but is distributed among humans (equipped with instruments) and non-humans. Analogously, for Callon and Muniesa (2005) agencies’ calculative capacities are not stand-alone but linked to distributed equipment. Distributed equipment includes bodies, tools, and machines

(i.e. the broker's ear in MacKenzie, 2009; the stock ticker in Preda, 2007; trading screens in Knorr Cetina, 2005) as well as models, theories, equations, rules, and procedures (MacKenzie, 2009). Routine and rule-following are, in other words, truly distributed and material processes (Hatherly *et al.*, 2007; D'Adderio, 2008a; MacKenzie, 2009).

A crucial consequence of treating cognition and action, including rule-following, as distributed, I propose, is acknowledging the fact that knowledge and action are not simply '*distributed between*' but '*stretched across*' actors and artifacts. This subtle but key distinction has often been overlooked by organizational scholars. These have traditionally taken a simpler interpretation of distributed cognition, merely as *external* source or repository of information or technology from which actors can arbitrarily draw during the course of their activities. The fact that cognition is distributed, however, bears deeper meaning as well as holding important consequences. The notion suggests that the actor's knowledge, skills, and competences *depend on* – and are at the same time *configured by* – the tools and artifacts they encounter or involve into their routinized performances. In other words, the skills and capabilities of actors are *mediated* and fundamentally *transformed* by the capabilities of the tools and instruments that they use in their work (Latour, 2005). The notion of 'distribution' therefore holds implications for routines far beyond those commonly ascribed in the literature.

This distinction is evident in Hutchins' example of navigation where he showed how the process of piloting a ship in and out of a harbour is a complex, rule-determined activity involving not only the coordination of crew members, but also the use of navigational instruments and maps (1995). A gyrocompass, for example, incorporates some essential rules of sea and land orientation and, for this reason, it requires that the pilots' skills and activities *be adjusted* to its properties (Hutchins, 1991). Similarly, in his ethnography of the two different scientific practices of 'opticism' and 'digitality', Lynch (1992) showed how rule- and routine-following depend on the complex relationships between material devices, theoretical optics, geometry, and modes of graphic representation.

Along the same lines, this author (D'Adderio, 2001) showed how the Virtual Prototype did much more than embody the information and codified knowledge required to design and produce a new vehicle: it allowed for departments and functions across the extended organization (including suppliers and customers) to access development data in real time and feed back their knowledge and expertise into the shared virtual model. The Model also supported new practices and forms of calculation for product design and engineering which involved iterative cycles of 'translations'. Through these translations some of the local knowledge held by local practitioner experts could be incorporated into the Model (virtualization, i.e. by using digital scanning techniques), and the global digital knowledge embedded into the Model could be used to produce local versions of the product (actualization, i.e. by using advanced CAD-printing

techniques).⁴ Translations involved conversions from the ‘language’ of local functions and experts (Galison, 1999), present in multiple and divergent local formats, to the Model’s ‘language’, ordered according to the software format, and back to the local language(s). While the software-embedded prototype *did not* contain all knowledge used or produced by the different functions involved, it nonetheless afforded new flexible ways to share data and learn about the product (ibid.).

Further examples can be found in more recent literatures. Preda (2004), for example, shows how by altering the equipment of traders through the introduction of the stock ticker, new ways of calculating decisions in financial markets could be afforded. In allowing prices to be known in real time and distant places, the ticker favoured new forms of arbitrage and speculation. For example, the availability of prices through displays allowed the development of techniques of graphic analysis of price variations such as chartism. Similarly, to the case of the Virtual Product in D’Adderio (2001), the ticker did more than provide information, it *constructed data* that, owing to their format, produced specific effects of cognition and action Callon and Caliskan (2010). A similar argument is raised by Beunza and Stark (2004) in their study of the trading room of a modern investment bank. Here heterogeneous forms of calculation were produced that depended on the devices used by traders to distribute their calculative activities (including trading robots, telephones, pricing tools, etc.).

The examples above illustrate how understanding routine- and rule-following as cases of distributed cognition can hold important implications for how we characterize artifacts. Artifacts in this light acquire a new role, one that goes beyond the passive *intermediary* role attributed to them in Organizational Theory to the role of *mediators* that participate in the co-creation of knowledge and transformation of actions (Latour, 2005).

Artifacts as actants: the role of ‘inscriptions’

Analysing the role of artifacts as mediators entails moving beyond a characterization of artifacts as opaque, monolithic objects to account for the dynamics by which they are produced and reproduced as they become involved in routinized performances. In turn, this will provide valuable means to understand how artifacts influence those performances in which they are engaged. An important conceptual device to guide our exploration in such an uncharted territory, is to study artifacts in general, and the artifactual (coded or de-contextualized) routine, in particular, as ‘*inscriptions*’.

Authors in the Science and Technology Studies (STS) tradition have shown how a complex range of rules and assumptions are embedded as ‘scripts’ within artifacts and technology during the design and usage stages (Barley, 1986;

⁴ I named these iterative practices of virtualization and actualization ‘translation routines’ as they are recurrent patterns of interactions that allow for the translation of knowledge, activities, and expertise, from the level of local functions to the level of the digital, shared model.

Akrich, 1992; Latour, 1992; Grint and Woolgar, 1992). Creating scripts involves the socio-technical process of 'inscription' (Latour, 1992) by which dominant interests or 'programs for action' are reflected in the form and functioning of a technology. Inscriptions are ways in which specific functions can be *delegated* to artifacts and technologies. Latour's hydraulic door closer, for example, absorbs the energy of those who open the door, retains it, and then releases it slowly in a manner similar to what one could expect from a well-trained butler (Latour, 1992). While this does not imply that the assumptions that designers and users embody in technological artifacts are prescriptive (Latour, 1987), it does point to the influence of scripts and their configurations on future performances that involve that particular technology or artifact. The notion of inscription thus can provide important ways to advance our characterization of artifacts and technologies as *mediators* that perform or influence the practices in which they are involved and the contexts in which they are embedded.

While useful for understanding artifacts in general, the notion of inscription can be especially valuable to characterize the influence of artifactual representations (i.e. formal procedures, SOPs, rules) on routines. Formal routines as *inscriptions* have some key characteristics. First, they are *not neutral* (Barley, 1986; Akrich, 1992; Bakken and Hernes, 2006; Preda, 2007; D'Adderio, 2003, 2008a) but instead reflect the objectives, motivations, values, and dispositions of the agencies that use/produce them as well as the context from which they are abstracted. Second, they are *selective*, implying that the knowledge they contain has been *sifted*, *ordered*, and *classified* according to one or more rationales or 'logics' (Bowker and Star, 1999; D'Adderio, 2003). In D'Adderio (2008a), for example, the software-embedded SOP embodies the Design Engineers' view of the world (expressed in their classification of the product structure according to vertical, parent-child relationships), which clashes with Production Engineers' view of the world (expressed in their classification of the product structure according to horizontal, Boolean algebraic statements). Accounting for the role of technology- and artifact-embedded rules as *inscriptions* implies that focusing solely on actions by human agents to explain rule- and routine-following practice would leave us short of an explanation.

The idea that routines, and their artifactual representations, embody contrasting views, intentions, or logics that belong to various agencies is not totally removed from early assumptions in Organizational Theory, whereby authors have defined SOPs as the outcome of locally solved *conflicts of interests* (March and Simon, 1958; Nelson and Winter, 1982): SOPs embody *social norms* and *worldviews* that belong to the agencies that have created/adopted them and 'because of the reallocative effects involved in the change of rules any change would re-create new internal conflicts that could not be easily solved' (Cohen *et al.*, 1996: 694). The crucial implications of this notion for understanding routine-following, however, have not yet been fully explored in Routines Theory. This is where STS studies become especially useful.

From STS scholars, for example, we learn that, as long as the script finds no problem, the program for action that is expressed in the script is not opposed. When questioned, however, the script becomes visible and *anti-programs* can develop whereby users attempt to react to the assumptions embedded in the technology (Latour, 1987). The implications of this are particularly relevant to routines transfer and replication: what happens, for example, when procedures loaded with embedded rationales that reflect a truce in a specific context are transferred to a new context? What kinds of conflicts are likely to arise as embedded rules and norms that belong to a previous context are performed in a new context, characterized by different rules and understandings? And what are the implications of this for the evolution of routines and their artifactual representations in the new context? In a study of the transfer of a complex capability and associated routines across two units of a global manufacturing enterprise, for example, this author has shown how selected assumptions and (ostensive) views that belong to the origin site are embedded in the shared Computer Model, which contains a codified version of all routines that make up the capability (D'Adderio, 2008b). The assumptions embedded in the SOPs and Model is subsequently performed at a destination where they shape local performances. The study also shows how the Model and associated procedures *themselves* change as a consequence of being performed at the destination. Deeper understandings of the role of artifacts can open up new avenues for routines research.

To make further progress in this promising direction, however, we need a theory that is able to analyse artifacts and chart the specific arrangements of knowledge, views, assumptions, and motivations that have produced them. In the case of artifactual representations, such a theory should allow us to capture the micro dynamics by which formal routines as inscriptions *are brought to life* (Cohen, 2007; Pentland and Feldman, 2008; D'Adderio, 2008a) in a new setting, or in other words how they *perform* the new setting. In addition, our approach should allow us to capture the dynamics by which artifactual routines come into being, or are *created by abstraction* from an existing setting. Such a theory can enable us to capture how specific (ostensive) views and rationales come to be embedded in artifacts (and artifactual representations of routines), and the subsequent effect that artifacts, containing a specific configuration of scripts, have on performances (D'Adderio, 2008b). Applying the notion of script to routines, in other words, allows us to 'situate the ostensive' aspect by acknowledging that views and objectives do not simply reside in the actors' minds but are also embedded in – or delegated to – artifacts. Taking the notion of scripts seriously implies recognizing that agency can be embedded in artifacts, both as traces of actions (as in a step-by-step instructions procedure) and of intentions, assumptions, rationales, and logics, and that this will have crucial implications for routines evolution. Before we can achieve a new theorization, however, a further step is required, one that allows us to capture the ways and degrees in which artifacts can influence routinized performances.

The influence of artifacts on routines: constraints, affordances and the 'power of default'

The third step towards taking artifacts seriously entails analysing more closely the role and influence of artifacts, tools, and technologies on routines. This involves going beyond the current characterization of artifacts as simply 'guiding' and 'constraining'. According to Callon and Muniesa (2005), for example, the artifact does not simply offer passive guidance: it offers *an invitation*. This notion, similar to the notion of *affordance* (Gibson, 1979), implies that the artifact, simply by being there, and available, proposes a specific kind of 'calculation' to the actor, who may accept (or not) the 'invitation' and ask the tool to perform the calculation (*ibid.*). The agencies' calculative capacities are thus linked in complex ways to their equipment, which is distributed. The shift in emphasis towards a more active role for artifacts bears important consequences for routines. Far from implying that artifacts, including rules or procedures, *determine* action, or the course of a routine in our case, this concept suggests a richer and more meaningful role for artifacts than that currently allowed in the literature.

The dominant way in which we understand the influence of artifacts and technologies in Social Science can be traced back to Wittgenstein. Drawing from his work, early social constructivists and ethnomethodologists, for example, have highlighted how (technology-embedded) rules and classifications are never deterministic but always interpreted (Garfinkel, 1967; Barnes, 1982; Bloor, 1997; Hatherly *et al.*, 2007; Lynch, 1992). In their view, and in accordance with one of Wittgenstein's prevailing interpretations, the irreducible interpretive flexibility of rules is such that – at least in theory – it can lead to infinite regression as 'no course of action could be determined by a rule, because every course of action can be made out to accord with the rule' (Wittgenstein, 1967: 81). Due to the logical under-determination of behaviour by rules, there can be no closure as '*The rule is, at any given time, what the practice has made it*' (Taylor, 1993: 57–8, emphasis in original).

Organizational scholars belonging to the stream of Structuration Theory, have drawn on these approaches in conceptualizing the role that technology plays as a source of *constraint* and *enabler* in rule-following (Barley, 1986; Orlikowski, 1992). According to Orlikowski (1992), for example, technology constrains performance by facilitating it in a particular manner. A telephone, computer, hammer, or pencil can thus facilitate the performance of certain kinds of work and not others. The emphasis in these literatures however is firmly on human practices and the *discretion* of human agents to follow a procedure or rule or to *choose to do otherwise* (Giddens, 1993; Orlikowski, 1992). According to this framework, the properties embedded inside artifacts are never predetermined but rather 'the capacity to modify the 'rule' that is drawn on in any action is an ever present possibility' (Cassell, 1993 in Orlikowski, 2000: 411). Similarly, in his study of the introduction of CT scanners into two different hospitals, Barley (1986) showed how, while technologies do influence organizational structures,

their influence depends on the context in which they are embedded. At the extreme, rules in this view exist only ‘virtually’ and are *consequential only to the extent that they are enacted* by users through practice.

While crucial in dispelling technological determinism, this view contains a somewhat partial characterization of the role of artifacts. While in fact, in rule-following as well as in other realms of human practice, artifacts do not determine actions, they nevertheless *play an important role* (Hatherly *et al.*, 2007). Technical systems, for example, make it possible or easy to do certain things, and impossible to do others, so that, while *in theory* there can be infinite regression, ‘the logical open-endedness of the application of terms to particulars and the logical under-determination of behaviour by rules are foreclosed *in practice*’ (ibid.: 11: emphasis added). In other words, once embedded in artifacts, skills and tacit knowledge (Latour, 1992), rules (Hutchins, 1991; Preda, 2000), and procedures (D’Adderio, 2003; Hatherly *et al.*, 2007) tend to become more *stable* and *durable*, and this holds radical implications for rule-following behaviour. So while, in theory, actors can always choose to reject a tool or a rule, or decide to abide by it ceremoniously, *in practice* actors often follow the path of least resistance (MacKenzie, 2006).

This principle can be illustrated by analysing a category of technological artifacts, and is both interesting and relevant: software. Information systems, as bundles of inscriptions, play a fundamental role in influencing rule-following. Such systems are ‘neither merely neutral media nor simply means of increasing the efficiency of what unaided human beings might do’ (Hatherly *et al.*, 2007: 32). They structure work, extend interactions, increase visibility of knowledge and actions, create a common platform for the accumulation of common knowledge, constrain the ability of practitioners to alter the results of another, regulate who has access to making changes, track the progress of changes, link multiple sites in different time/geographical locations, facilitate data sharing and the reception of feedback (Orlikowski, 2002). They *solidify* and *stabilize* rules, procedures, and classifications thus making it more difficult to avert them (Hatherly *et al.*, 2007). Clearly, on the one hand, technical constraint is never absolute, and indeed many systems’ controls can be subverted if sufficient resources and incentives are applied to the task. On the other hand, however, there are reasons why the influence of technologies – in general – and information systems – in particular – is critical. While in theory it is always possible to bypass software-embedded controls, *in practice* this does not occur very often (D’Adderio, 2003, 2008a).

A first reason is that the assumptions, rules, procedures, and classifications embedded in software, both at design and usage stages, tend to become part of the users’ *habitual* background (Bourdieu, 1977), or ‘the way we do things around here’ and as such often go unquestioned. Secondly, as distributed and pervasive technologies, information systems are often entangled into a *thick web of organizational relationships* which make them difficult to avoid. Once adopted, for example, software can influence what kind of information should

be created, selected, and shared, with whom, in which format and in what sequence. What is important here is that, while practitioners can choose to bypass the software, their boycott will hold consequences for them in terms of their ability to have their work taken into account by others in the organization. Thirdly, software tends to *make information more visible* across an organization thus making it easier to control that actions actually comply with the software. Fourthly and finally, while formal software controls can – in theory – be easily modified or entirely averted, in practice this requires the deployment of resources (i.e. time and software programming skills), which are often unavailable. In these circumstances, the ‘*power of default*’ of such artifacts (Koch, 1998 in D’Adderio, 2003; Pollock and Cornford, 2004) will prevent adaptation and customization. An appreciation of the multiple ways and varying degrees to which artifacts and technological systems can influence routines and rule-following calls for the need to bring this analysis to the forefront of Routines Theory. This step involves careful consideration of artifacts and their embedded assumptions and dynamics in order to begin to understand their deeper implications for routines.

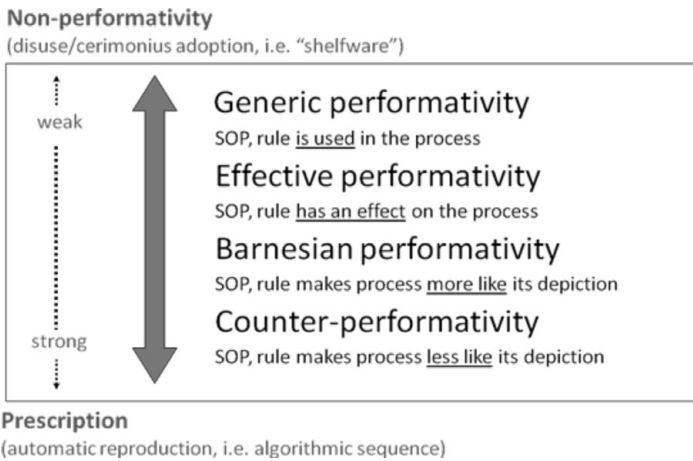
Routines and artifacts: degrees of influence

A deeper characterization of the relationship between routines and artifacts entails moving beyond extremes to study the dynamics that regulate their mutual influence. To achieve this goal we need a finer-grained framework that is able to capture the influence of artifactual representations (routines in theory) on performances (routines in context) that goes beyond the extremes of *prescription* (full influence) and *description* (no influence). Some recent advances in Performativity Theory, and their even more recent application to Routines Theory, can provide a new characterization. According to Performativity scholars (Callon, 1998; Callon and Muniesa, 2005), while the two extreme cases, one where *the tool or artifact is instrumentalized* and the other where *the actor is instrumentalized*, are always possibilities, performativity, which involves some kind of reciprocal adaptation under conditions of uncertainty, is more often the norm. This is especially true when an artifact is entangled within a thick web of organizational relationships, as the earlier example of software illustrates (D’Adderio, 2008a).

This point has been raised in recent studies in the Sociology of Finance. In his studies of the market for financial derivatives, MacKenzie (2003, 2005, and 2006) proposes a fine-grained identification of different categories of performativity (influence of models on reality): ‘*generic performativity*’, when an aspect of economics (a theory, model, concept, procedure, data-set, etc.) is simply used by participants in economic processes; ‘*effective performativity*’, when the practical use of an aspect of economics has an effect on economic processes; ‘*Barnesian performativity*’, when the practical use of an aspect of economics makes economic processes *more like* their depiction by economics;

Figure 3. Procedures, rules and models: degrees of influence

Source: D’Adderio (2008).



and ‘*counter-performativity*’ when the practical use of an aspect of economics makes economic processes *less like* their depiction by economics.

MacKenzie’s framework is especially useful in highlighting how what previous theories considered the norm, are in fact often exceptions (Figure 3). At one extreme of performativity, there is *prescription*, which represents a very strong instance of performativity: automatic reproduction, pure repetition, no more recalcitrance, recurrent events (Sahlins, 1985 in Callon, 2007). Full prescription thus corresponds to ‘*fiat lux et lux fuit*’, as in the case of an automatically reproduced sequence of computer algorithms. At this extreme, which corresponds to the ‘*framing view*’ in Performativity Theory, there is very little adaptation as models are automatically reproduced. At the other extreme, there is the full demise or disuse of a model or tool, corresponding to the ‘*overflowing view*’ in Performativity Theory: the influence of the model is so weak that it is disused or rejected, and therefore not enacted in practice. One way to explain the demise of a tool or procedure, of course, is that individual agents have made the conscious choice to reject the model. Performativity, however, while not denying this possibility, affords us a more interesting explanation: the model as statement has not been able to put into motion a world in which it can function. In other words, the statement or formula has not been able to produce a successful socio-technical *agencement*.

A socio-technical *agencement* is the assemblage of heterogeneous elements that is required for the world contained in the statement to be actualized: ‘A formula that progressively discovers its world and a world that is put into motion by the formula describing it’ (MacKenzie, 2003 in Callon, 2007: 19). According to this notion, a model as statement fails when it has not been able to put into motion a world in which it can function, or, in other words, it

has not been able to produce a successful socio-technical *agencement*. In the struggle between competitive performative programmes, some agencies are able to inscribe their own worldviews in artifacts (i.e. SOPs, rules). These agencies are the most likely to succeed in exerting their own influence: enrolling artifacts tends to create stronger *agencements* that, being tightly interconnected into a web of organizational relationships, are more stable and therefore more difficult to oppose or dismiss. The power of a SOPs or rules, thus, can be theorized as the emergent outcome of struggles among the world that it manages to create and other competing *agencements*. Some *agencements* are more, and some less, able to enrol people and materials and therefore are more or less successful. Through the notion of *agencement*, Performativity allows us to capture the influence of models beyond extremes: while full prescription and mere description are always possibilities, most of the time (and this is especially true in conditions of uncertainty) there is performativity, implying some kind of dynamic adaptation between model and reality (Callon, 2007).

MacKenzie's nuanced classification of the influence of theories and models of reality on reality itself is especially useful when translated to understand the interactions between procedures, rules (models of routines), and performances expressed in context (reality). Drawing from MacKenzie, this author has thus proposed a framework that captures the influence of formal routines or procedures (artifactual representations of routines) over routines in context (performances). The resulting evidence demonstrates that each school of thought, the mechanistic and the interpretivist, has placed itself at one of the extreme ends of MacKenzie's Performativity chart (Figure 2).

At one extreme of this debate (represented by the mechanistic school of thought) is the view that procedures and rules *completely prescribe or determine* actions. In interpreting the role of SOPs and rules as deterministic and equating actors to rule-following automata, this view corresponds to the 'framing' side of our performativity spectrum. This view constitutes an extreme given that, while SOPs and rules frame actions and viewpoints to an extent, full prescription is a rare and extreme outcome that entails automatic reproduction in the complete absence of adaptation or resistance. At the other extreme, is the agency-centred school that sees SOPs and rules as *merely descriptive*: simplified copies of the actual process that they (mostly inadequately) attempt to mirror. This view, centred on the 'overflowing' end of the Performativity framework, highlights the interpretative role of human agents who, in enacting rules, are able to modify or completely dismiss them (rules in this case are non-performative). While this extreme is also possible, this view does not account for the fact that, by incorporating beliefs into material devices, algorithms, procedures, and routines a model can have an effect 'even if those who use them are sceptical of the model's virtues, unaware of its details, or even ignorant of its very existence' (MacKenzie, 2006: 19). While formal procedures and rules can always – at least in theory – be worked around and dismissed, *in practice* they often play a role.

Especially when embedded in artifacts or technologies such as software, they become pervasive, difficult to change or avoid, and can be more easily enforced. Thus, while possible in theory, mechanistic prescription and full interpretive flexibility are in practice two extreme outcomes; to the extent that a rule or procedure is entangled in a web of tools and organizational relationships, some level of Performativity is likely to be at play. Artifact-embedded SOPS and rules thus ‘do not simply describe, do not often prescribe, mostly they are performed’ (D’Adderio, 2008a: 784).

A further important implication of adopting a Performative approach is that representations, models, are not simply a *description* of something resting *outside* the market (reality), but constituent parts of it. In other words, they do not simply *represent*, they have an *effect* on the reality in which they are embedded (Geertz, 1966; Pickering, 1994; Ferraro *et al.*, 2005; Holm, 2007; D’Adderio, 2008a). They are not just passive ‘guiding principles’, setting the boundaries of what can be done and what cannot be done, as scholars have argued so far, but they contribute to shaping actual processes. Similarly, in D’Adderio (2008a), procedures – as artifactual representations of routines – do not rest *outside* the routine as implied by contributions so far, but are important constituent parts of it (Figures 1 and 4c). This observation holds potential for further studies that capture the emergence of routines through the mutual shaping of artifacts and performances. Whilst this move is fully in accordance with Cohen *et al.*’s (1996) focus on the interactions between procedures and performances, Performativity provides the theoretical tools and framework to characterize their mutual influence.

Artifacts at the centre of routines: co-evolution of artifacts, procedures, and performances through performative struggles

I propose that recent advances in Performativity Theory, as informed by both the Pragmatist turn (Schatzki *et al.*, 2001; Callon, 2007) and the Distributed Cognition turn (Hutchins, 1995; Callon and Muniesa, 2005; MacKenzie, 2006) in Actor Network Theory,⁵ and as recently imported into Routines Theory (D’Adderio, 2008a, b), can provide novel and valuable insights into the role of artifacts in routines evolution. In particular, the new approach can provide the key to unlock the dynamics of interaction and mutual shaping between formal procedures (routines-as-artifacts) and actual performances (routines-in-practice). In order to achieve this goal, however, we need to go one final step further to account fully for the role of artifacts and materiality in routines.⁶

⁵ Actor Network Theory is, perhaps counter-intuitively, not at all a theory but a framework to understand and characterize the complex relationships between actors and artefacts/technologies, or in Latour’s words, a mechanism for describing and accounting for everyday living (2005).

⁶ Materiality is understood here as ‘having material implications’. In other words, artefacts and devices *do* things, no matter whether they are physical objects, or cognitive/conceptual devices: they have *material*

A first observation is that artifacts do not simply provide information, they *construct* information and they *classify* it according to specific worldviews that belong to the agencies that have created or used them (Bowker and Star, 1999). In other words, artifacts embody the ways in which specific agencies understand and organize their world (D'Adderio, 2001, 2003). The fact that certain agencies are more successful at this task than others, leads to *asymmetric power distribution* among agencies and their performative programmes (Callon and Muniesa, 2005). According to Callon (1998), the more successful performative programmes are those that manage to enrol an array of materials and tools to create a world in which they can function. Within these performative struggles among competing agencies, artifacts thus play a key role.

An example of this is Pierre Bourdieu's analysis of the real estate market where the encounter between the seller and the potential buyer becomes a tug of war in which the former tries to impose his or her own calculative tools on the latter – often with success (Bourdieu, 2005). In these encounters, 'whether it is the consumer hesitating between two packets of smoked ham or a couple anxiously following the real estate agent's calculations to assess their debt capacity, radically different values are confronted. When a compromise is reached, it has to be interpreted as a compromise not on values but on the instruments that calculate values' (Callon and Muniesa, 2005: 1239). Similarly, this author (2008a) has shown how Programme Management and Manufacturing functions at a vehicle manufacturer manage to enrol the software, and software-embedded SOPs, and thus to impose (at least partially) the culture, goals, and priorities that belong to their occupational communities, including their idiosyncratic 'languages' and worldviews (Dougherty, 1992; Galison, 1999; D'Adderio, 2001, 2003; Carlile, 2004). These examples demonstrate that, while a Performative approach brings artifacts to the centre of attention in Routines Theory, it does not do so at the expense of agency. Rather, it provides a means to capture the reciprocal influence of agency and artifacts. This is where the above-mentioned notion of 'inscription' becomes especially useful: once we accept that artifacts in general, and artifactual representations of routines in particular, as inscriptions, are not neutral, there are important implications for routines and routine-following.

In the examples above, agencies are able to use artifacts to impose their own *classification* and *ordering* of data, and process and decide what is and what is not important, what should be allowed or disallowed. Agencies thus can enrol arrays of artifacts and tools to help strengthen their performative programme. Artifacts, in the case of routines, can include procedures as well as a wide range of objects, tools, and technologies that can be harnessed to actualize their course or 'make them happen'. As argued earlier, technologies and tools can help stabilize statements and classifications, thus giving them solidity – just like the uploading

implications both for cognition and action (Orlikowski and Iacono, 2001; Leonardi and Barley, 2008; Orlikowski, 2010) as well as being liable to material constraints (MacKenzie, 2009).

of the Virtual Prototype and the Engineering Parts List in software (in D'Adderio, 2001, 2003 respectively) and the tracing of price variation curves in Preda (2007). In these examples, software-embedded SOPs and rules, as inscriptions, 'impose a principle of reality; they constitute an obligatory point of passage, a perfectly material reality to take into account . . . They are articulated to socio-technical *agencements* that produce the traces that they use to inscribe the world in which they are participants and on which they will, in turn, make possible to act' (pp. 39–40).

While the above evidence could still be interpreted as a mere clash between conflicting interests, there is, however, more to it. To paraphrase Callon (2007), the various organizational actors attempt to construct the world (or socio-technical *agencement*) they believe to resemble their own assumptions, views, and aims. To do so, they enrol a number of artifacts and tools to strengthen their influence. Confrontation therefore takes place not simply between different *agencies* but between different *worlds* that are struggling to exist, one at the expense of the other. The result of these struggles is that often none of the actors is able to take their programme to its conclusion, since often no one function is able to exclusively frame the process, as in the 'engineering freeze' example (D'Adderio, 2008a). Here Programme Management, IT, and Manufacturing partially succeeded in disciplining actions according to the software freeze rule – therefore enforcing the deadline – and yet the Engineering function retained some of their discretion to make substantial and late alterations. In the end, the evidence showed that each agency had to compromise and at least partially accept the other's programme, meaning that only portions of their world were realized. The world that ended up existing was thus, as in Callon's discussion (2007), a compromise, a patchwork containing elements from competing worlds.

An important implication of acknowledging the struggles among competitive performative programmes is that this lens can be used to uncover the dynamics of convergence and divergence between routines' constituent parts or aspects, such as procedures and performances. In D'Adderio (2008a, b), evidence drawn from the ethnographic observation of the mutual influence between SOPs as artifactual representations and actual performances, showed how rules and SOPs contain abstracted, filtered, and reconfigured traces of actors' knowledge and intent and therefore provide a strong example of distributed cognition in the Hutchins sense (MacKenzie, 2006; D'Adderio, 2008a). Thus, by focusing on SOPs, this author was able to show how performative struggles influence the *direction* of their interactions, i.e. performativity vs. counter-performativity), the *intensity* of these interactions (i.e. weak vs. strong performativity), and, ultimately, the *persistence* of the routinized pattern or *deviation* from its course (depending upon which programme – or configuration of programmes – manages to prevail).

The above considerations led to important conclusions, namely that, in order to understand routines evolution, we need to study how artifacts – and artifactual representations – *themselves* evolve. From the above discussion, it emerges

that artifacts have a *history* which reflects the performative struggles in which they have been involved and from which they have emerged and evolve. In D'Adderio (2008b), we see how the computer model, containing SOPs, evolves as a consequence of being incorporated in the struggles among different agencies that want to prevail. The artifact, as a result, comes to reflect the stratification of different (and possibly contrasting) organizational logics or rationales. Focusing on artifacts, and their evolution, thus can provide us with important new insights into routines and wider organizational dynamics.

6. Conclusions: the artifactual turn in Routines Theory

In this paper, I have argued for a radical framework shift that brings artifacts and materiality to the centre of routines and Routines Theory. This approach involved four steps. The *first step* entailed bringing artifacts to the fore by asserting the key role that they play as mediators in human cognition and activity. The fact that action and cognition are distributed, meaning that they are not simply *divided between* but *stretched across* people and artifacts, calls for a deeper understanding of the role of artifacts in rule- and routine-following. I have thus introduced the notion of 'distributed agency' to better account for the combined influence of human and non-humans on routines. The *second step* involved shifting the focus further away from agency as a property that belongs solely to humans by discussing how actors' assumptions and intentions can become embedded in artifacts. Through applying the STS notion of 'inscription' to artifacts, in general, and 'artifactual representations' of routines (i.e. formal rules, procedures, SOPs), in particular, I have shown how these are *not neutral* but selective arrangements of scripts that reflect the agencies that are involved in their production and use. I have thus discussed some implications for routinized performances. The fact that particular configurations of assumptions and intentions are embedded in procedures holds fundamental consequences for routines (re)production, as in the case of routines transfer and the diffusion of 'best' practices. The *third step* involved characterizing the ways in which artifacts, including artifactual representations, influence performances. This entailed moving beyond the extant view of artifacts as passively 'guiding' and 'constraining', to viewing them as entities that can actively shape the course of routines. I have thus introduced the notions of 'affordance' and 'power of default' to indicate how, while artifact-embedded rules are rarely deterministic, humans do not always choose to bypass the artifact, but often blindly follow their invitation to act in a particular way. The fourth and *final step* involved harnessing the Performative approach, developed in Economic Sociology and the Sociology of Finance (Callon, 1998, 2007; MacKenzie, 2006) to support the material and artifactual turn in Routines Theory. This entailed discussing how artifacts and routines co-evolve through their involvement in 'performative struggles' among competing organizational agencies. This move was made possible by adopting a

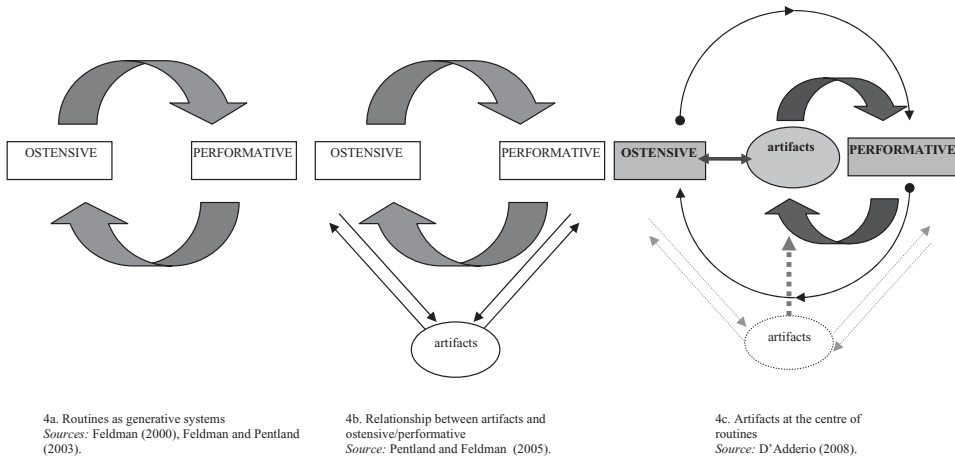
novel characterization of routinized performances as the result of understandings and actions by ‘hybrid collectives’, involving (temporarily stable) configurations of humans and artifacts. Here we have seen how the calculative powers of agencies – for example their ability to influence the course of a routine – are closely linked to the equipment they can access. Therefore, artifacts can make a difference in terms of whether a procedure is followed, the extent to which it is followed, or whether it is rejected altogether.

Performing the artifactual shift in Routines was made possible by adopting new conceptual tools that capture the micro dynamics of interaction among routines, agencies, and artifacts. I have thus suggested that recent advances in Routines and Performativity Theory can help advance our understanding of the role and influence of artifactual representations of routines, including SOPs and formal routines and rules (Cohen *et al.*, 1996). In affording an advanced characterization of artifactual representations as *models* of routines, the Performative approach can allow us to capture the deeper dynamics of interactions between different aspects of routines. This approach allows us to add to both the representations/expressions and the ostensive/performative frameworks which it synthesizes (figure 4a, b, c), thus contributing to further our understanding of routines as dynamic and generative systems.

In the first case, the new approach allowed us to capture with clarity and precision the *co-evolution* of ‘representations’ and ‘expressions’, including their interactions which were left unexplored in Cohen *et al.*’s (1996) pioneering paper. By moving past a reductive characterization of representations as intrinsically imperfect and biased copies of ‘real’ routines, we are able to see them as entities that play a fundamental role in routines’ evolution, and which therefore deserve to be studied in their own right. In the second case, the framework allowed us to add to the extant characterization of artifacts as ‘proxies’ of the ostensive aspect, by demonstrating the usefulness of viewing them as entities containing *selective instantiations or configurations* of ostensive views.⁷ This, in turn, allowed us to theorise, in detail, the dynamic relationship between, on the one hand, ostensive aspects of routines and artifacts, and, on the other, artifacts and performative aspects. Focusing on the relationship between artifacts and ostensive, we were able to capture the micro dynamics by which specific ostensive views are selected and become embedded into artifactual representations of routines (i.e. rules and procedures), and, by focusing on the relationships between artifacts and performative, we were able to capture the micro dynamics by which artifacts influence (and are influenced by) performances.

⁷ The expression ‘selective instantiation’ or ‘selective configuration’ is better suited to our approach than the notion of ‘proxy’, which might be interpreted as implying a negative view of artifacts (as flawed imitations) when compared to actual routines. Through ANT we can characterize an artifactual representation as one of the multiple possible expressions or codifications that an actual routine can assume (on multiplicity see Mol, 2002).

Figure 4. Artifacts from the periphery to the centre of routines



The advances brought by the new focus on artifacts, in the second case, add further to the Routines debate by *grounding* or '*situating the ostensive*' and allowing for a much finer-grained analysis than has been possible so far. We have seen how, for example, by being relatively visible and stable, artifactual representations can provide vantage points to observe routines dynamics, as in the earlier mentioned example of the software-embedded standard operating procedure. This theoretical device thus could open up the way for an entire population of studies focusing on the relationship between ostensive and performative seen through the lens of artifacts (see Figure 4c). In affording new ways to explore the relationship between artifacts/ostensive and artifacts/performative, these studies can provide further evidence to support the artifactual shift in Routines Theory.

I have also suggested that considering the evolution of the artifacts themselves – as important entities in their own right – is valuable as it can shed light over the ways in which artifact-embedded agentic programmes can shape 'live' routines. New insights can thus be achieved by focusing on the process of delegation of intentions by human actors to non-humans. The careful analysis of the process of inscription thus can reveal the hybrid configurations – or layers – of assumptions *and* physical elements through which artifacts are constituted and reconstituted. This approach calls for a situated (Suchman, 1987; Lave, 1988; Lave and Wenger, 1991), almost 'archeological' approach to studying routines and their artifacts, one that entails focusing not simply on the routine itself but also on the interlinked artifacts that contribute to its performances, and to how such artifacts come to be. From this vantage point, we can also analyse how artifacts themselves evolve as a consequence of their participation in performative programmes and the struggles among competing organizational agencies. This involves uncovering the assumptions and views that

artifacts come to embody as a consequence of these struggles, which influence routines dramatically while giving life to new ‘truces’ (Nelson and Winter, 1982; Zbarachi and Bergen, forthcoming). An interesting issue for future scholarly enquiry would thus be to explain the persistence of artifact-embedded meanings and assumptions, and how they change over time as people leave the organization and artifacts are appropriated by different groups for different ends.

The latter aspect is also important for practitioners, both those involved in the design of such artifacts, and those involved in their implementation/adoption. An important implication of our theory for designers and managers is that, while there is no doubt that it is not sufficient to design SOPs in the hope that performances will follow, as Pentland and Feldman have convincingly argued (2008), at the same time the specific classifications and rationales embedded in the design of SOPs can – and often do – bear an influence on the context where they are used or adopted. This observation calls for the need to uncover the ways in which the assumptions and rationales embedded in standard practices, procedures, and rules in the course of their creation, transfer, and adoption stages may clash with or complement the assumptions and rationales in the context where the procedure or rule is adopted. The implication here is that the assumptions and rationales embedded in procedures at design stage are likely to influence the fit between the imported ‘best’ practice and the different implementation locales in which it is adopted. The framework presented here, therefore, provides the tools to begin to unravel complex transfer dynamics.

In conclusion, this position paper constitutes a first systematic attempt to compensate for the lack of attention in Routines Theory towards the key role of artifacts and technologies and their influence on routines evolution. Through a series of examples I have thus shown that, in order to realize the *material and artifactual turn* in Routines Theory, and advance our understanding of routines dynamics beyond the current state of the art, we need to analyse the interactions between artifacts and aspects of routines in depth and detail. This involves analysing the deeper interactions between artifacts and *ostensive*, on the one hand (i.e. which ostensive views are selected, retained, and replicated and how), and artifacts and *performative* (i.e. the convergence and divergence between artifactual representations/routines-in-theory, and expressions/routines-in-practice), on the other. The artifactual focus proposed here is also important in channelling our attention towards the influence on routine of heterogeneous motivations by agencies whose specific knowledge, aims, and objectives can be complementary or competing. Focusing on artifacts, in this sense, does not mean losing sight of agency, but rather it implies acknowledging that the influence of agency is mediated – and partially shaped – by artifacts. This holds important implications for routines.

Acknowledging the central role and influence of artifacts and distributed agencies in routines can thus afford an entirely new perspective over key outstanding organizational issues including the micro dynamics that

underpin organizational stability and change. For example, how do routines and capabilities emerge? How are heterogeneous configurations of artifacts and agencies stabilized in recurrent but perpetually challenged patterns of interaction? What is the influence of artifacts and distributed agencies over the dynamics by which routines and capabilities are created and recreated, codified, transferred, replicated, and maintained? And what is their influence over the organizational ability to dynamically renew and reconfigure its routines and capabilities in order to adapt to change and to innovate? In providing a novel characterization of routines and capabilities micro dynamics, this paper can open up new and promising avenues for future scholarly enquiry. Through its nuanced and dynamic characterization of the relationship between routines, agencies, and artifacts, this work lays out the foundations for a second, 'small Copernican revolution' in Routines Theory, one that brings artifacts in general, and artifactual representations of routines in particular, from the periphery to the very centre of routines.

References

- Adler, P. S. and D. Obstfeld (2007), 'The Role of Affect in Creative Projects and Exploratory Search', *Industrial and Corporate Change*, 16: 19–50.
- Akrich, M. (1992), 'The De-description of Technical Objects', in W. E. Bijker and J. Law (eds.), *Shaping Technology/Building Society – Studies in Sociotechnical Change*, Cambridge, MA: MIT Press.
- Arthur, W. B. (1994), 'Inductive Reasoning and Bounded Rationality', *The American Economic Review*, 84(2): 406–411.
- Bakken, T. and T. Hernes (2006), 'Organizing is Both a Verb and Noun: Weick Meets Whitehead', *Organisation Studies*, 27(11): 1599–1616.
- Barley, S. (1986), 'Technology as an Occasion for Structuring: Evidence from Observation of CT Scanners and the Social Order of Radiology Departments', *Administrative Science Quarterly*, 31: 78–108.
- Barnes, B. (1982), *T.S. Kuhn and Social Science*, London: Macmillan.
- Becker, M. C., N. Lazaric, R. R. Nelson, and S. G. Winter (2005), 'Applying Organizational Routines in Understanding Organizational Change', *Industrial and Corporate Change*, 14(5): 775–791.
- Bechky, B. A. (2003), 'Sharing Meaning Across Occupational Communities: The Transformation of Understanding on a Production Floor', *Organization Science*, 14(3): 312–330.
- Beunza, D. and D. Stark (2004), 'Tools of the Trade: The Sociotechnology of Arbitrage in a Wall Street Trading Room', *Industrial and Corporate Change*, 13(2): 369–400.
- Bloor, D. (1997), *Wittgenstein, Rules and Institutions*, London: Routledge.
- Bourdieu, P. (1977), *Outline of a Theory of Practice*, Cambridge: Cambridge University Press.
- Bourdieu, P. (2005), *The Social Structures of the Economy*, Cambridge: Polity Press.
- Bowker, G. C. and S. L. Star (1999), *Sorting Things Out: Classification and Its Consequences*, Cambridge, MA: MIT Press.
- Brey, P. (2005), 'Artefacts as Social Agents', in H. Harbers (ed.), *Inside the Politics of Technology: Agency and Normativity in the Co-Production of Technology and Society*, Amsterdam: Amsterdam University Press, pp. 61–84.

- Callon, M. (1987), 'Society in the Making: The Study of Technology as a Tool for Sociological Analysis', in W. E. Bijker, T. P. Hughes, and T. Pinch (eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, Cambridge, MA: MIT Press, pp. 83–103.
- Callon, M. (1998), 'An Essay on Framing and Overflowing: Economic Externalities Revisited by Sociology', in M. Callon (ed.), *The Laws of the Markets*, Oxford: Blackwell, pp. 244–269.
- Callon, M. (2007), 'What Does It Mean to Say that Economics Is Performative?', in D. MacKenzie, F. Muniesa, and L. Siu (eds.), *Do Economists Make Markets? On the Performativity of Economics*, Princeton, NJ: Princeton University Press.
- Callon, M. and C. Caliskan (2010), 'Economization, Part 2: A Research Programme 1172 on the Study of Marketization', *Economy and Society*, 39(1): 1–32.
- Callon, M. and F. Muniesa (2005), 'Economic Markets as Calculative Collective Devices', *Organisation Studies*, 26: 1129–1250.
- Carlile, P. (2004), 'Transferring, Translating, and Transforming: An Integrative Framework for Managing Knowledge Across Boundaries', *Organization Science*, 15(5): 555–568.
- Carlile, P. R. (2002), 'A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development', *Organization Science*, 13(4): 442–455.
- Cohen, M. (2007), 'Reading Dewey: Reflections on the Study of Routine', *Organisation Studies*, 28: 773–786.
- Cohen, M. D., R. Burkhart, G. Dosi, M. Egidi, L. Marengo, M. Warglien, and S. G. Winter (1996), 'Routines and Other Recurring Patterns of Organisations: Contemporary Research Issues', *Industrial and Corporate Change*, 5: 653–698.
- D'Adderio, L. (2001), 'Crafting the Virtual Prototype: How Firms Integrate Knowledge and Capabilities Across Organizational Boundaries', *Research Policy*, 30: 1409–1424.
- D'Adderio, L. (2003), 'Configuring Software, Reconfiguring Memories: The Influence of Integrated Systems on the Reproduction of Knowledge and Routines', *Industrial and Corporate Change*, 12(2): 321–350.
- D'Adderio, L. (2008a), 'The Performativity of Routines: Theorising the Influence of Artefacts and Distributed Agencies on Routines Dynamics', *Research Policy*, 37(5): 769–789.
- D'Adderio, L. (2008b), 'The Dependable Transfer of Routines and Capabilities: A Performative View', Academy of Management (AOM) Meeting, Paper No. 15238, Anaheim, CA.
- Dewey, J. (1922), *Human Nature and Conduct: An Introduction to Social Psychology*, New York: H. Holt & Company.
- Dougherty, D. (1992), 'Interpretive Barriers to Successful Product Innovation in Large Firms', *Organization Science*, 3(2): 179–202.
- Feldman, M. S. (2000), 'Organizational Routines as a Source of Continuous Change', *Organization Science*, 11(6): 611–629.
- Feldman, M. S. (2003), 'A Performative Perspective on Stability and Change in Organizational Routines', *Industrial and Corporate Change*, 12(4): 727–752.
- Feldman, M. S. and B. T. Pentland (2003), 'Reconceptualizing Organizational Routines as a Source of Flexibility and Change', *Administrative Science Quarterly*, 48: 94–118.
- Ferraro, F., J. Pfeffer, and R. I. Sutton (2005), 'Economics Language and Assumptions: How Theories Can Become Self-Fulfilling', *Academy of Management Review*, 30(1): 8–24.
- Galison, P. (1999), 'Trading Zone: Coordinating Action and Belief', in M. Biagioli (ed.), *The Science Studies Reader*, New York: Routledge, pp. 137–160.
- Garfinkel, H. (1967), *Studies in Ethnomethodology*, Englewood Cliffs, NJ: Prentice-Hall.

- Geertz, C. (1966), 'Religion as a Cultural System', in M. Banton (ed.), *Anthropological Approaches to the Study of Religion*, London: Tavistock Publications, pp. 1–46.
- Gibson, J. J. (1979), *The Ecological Approach to Visual Perception*, Boston, MA: Houghton Mifflin.
- Giddens, A. (1993), *New Rules of Sociological Method*, Cambridge: Polity Press.
- Grint, K. and S. Woolgar (1992), 'Computers, Guns, and Roses: What's Social about Being Shot?', *Science, Technology and Human Values*, 17(3): 366–380.
- Hatherly, D., D. Leung, and D. MacKenzie (2007), 'The Finitist Accountant', The University of Edinburgh, April 2007.
- Holm, P. (2007), 'Which Way is Up on Callon?', in D. MacKenzie, F. Muniesa, and L. Siu (eds.), *Do Economists Make Markets? On the Performativity of Economics*, Oxford: Princeton University Press.
- Hutchins, E. (1991), 'Organizing Work by Adaptation', *Organization Science*, 2(1): 14–39.
- Hutchins, E. (1995), *Cognition in the Wild*, Cambridge, MA: MIT Press.
- Hutchins, E. and B. Hazelhurst (1991), 'Learning in the Cultural Process', in C. Langton *et al.* (eds.), *Artificial Life II: Studies in the Sciences of Complexity*, Reading: Addison-Wesley.
- Knorr Cetina, K. (2005), 'How Are Global Markets Global? The Architecture of a Flow World', in K. Knorr Cetina and A. Preda (eds.), *The Sociology of Financial Markets*, Oxford: Oxford University Press, pp. 38–61.
- Latour, B. (1986), 'Visualization and Cognition: Thinking with Eyes and Hands', *Knowledge and Society: Studies in the Sociology of Culture Past and Present*, 6: 1–40.
- Latour, B. (1987), *Science in Action*, Cambridge, MA: Harvard University Press.
- Latour, B. (1992), 'Where Are the Missing Masses? The Sociology of a Few Mundane Artefacts', in W. E. Bijker and J. Law (eds.), *Shaping Technology/Building Society: Studies in Sociotechnical Change*, Cambridge, MA: MIT Press, pp. 225–258.
- Latour, B. (2005), *Reassembling the Social: An Introduction to Actor Network Theory*, Oxford: Oxford University Press.
- Lave, J. (1988), *Cognition in Practice*, Cambridge: Cambridge University Press.
- Lave, J. and E. Wenger (1991), *Situated Learning: Legitimate Peripheral Participation*, Cambridge: Cambridge University Press.
- Lazaric, N. and B. Denis (2001), 'How and Why Routines Change: Some Lessons from the Articulation of Knowledge with ISO 9002', *Economies et Societes*, 6(4): 585–611.
- Lynch, M. (1992), 'Extending Wittgenstein: The Pivotal Move from Epistemology to the Sociology of Science', in A. Pickering (ed.), *Science as Practice and Culture*, Chicago: Chicago University Press, pp. 215–265.
- Leonardi, P. M. and S. R. Barley (2008), 'Materiality and Change: Challenges to Building Better Theory about Technology and Organizing', *Information and Organization*, 18(3):159–176.
- MacKenzie, D. (2003), 'An Equation and Its Worlds: Bricolage, Exemplars, Disunity and Performativity in Financial Economics', *Social Studies of Science*, 33(6): 831–868.
- MacKenzie, D. (2005), 'Is Economics Performative? Option Theory and the Construction of Derivatives Markets', Presented to the annual meeting of the History of Economics Society, Tacoma, WA, 25 June 2005.
- MacKenzie, D. (2006), *An Engine, Not a Camera: How Financial Models Shape Markets*, Cambridge, MA: MIT Press.
- MacKenzie, D. (2009), *Material Markets: How economic Agents Are Constructed*, New York: Oxford University Press.
- March, J. and H. Simon (1958), *Organizations*, New York, NY: Wiley.

- Mol, A. (2002), *The Body Multiple: Ontology in Medical Practice, Science and Cultural Theory*, Durham: Duke University Press.
- Mumford, L. (1964), 'Authoritarian and Democratic Technics', *Technology and Culture*, 5(1):1–8
- Nelson, R. R. and S. G. Winter (1982), *An Evolutionary Theory of Economic Change*, Cambridge, MA: Belknap Press.
- Norman, D. A. (1993), *Things that Make Us Smart: Defending Human Attributes in the Age of the Machine*, Reading, MA: Addison Wesley.
- Orlikowski, W. J. (1992), 'The Duality of Technology: Rethinking the Concept of Technology in Organizations', *Organization Science*, 3(3): 398–427.
- Orlikowski, W. J. (2000), 'Using Technology and Constituting Structures: A Practice Lens for Studying Technology in Organizations', *Organization Science*, 11(4): 404–428.
- Orlikowski, W. J. (2002), 'Knowing in Practice: Enacting a Collective Capability in Distributed Organizing', *Organization Science*, 13(3): 249–273.
- Orlikowski, W. J. (2010), 'The Sociomateriality of Organizational Life: Considering Technology in Management Research', *Cambridge Journal of Economics*, 34: 125–141.
- Orlikowski, W. and C. Iacono (2001), 'Research Commentary: Desperately Seeking the "IT" in IT Research – A Call to Theorizing the IT Artifact', *Information Systems Research*, 12(2): 121–134.
- Oxford English Dictionary Online (3rd edn): <http://dictionary.oed.com/>
- Pentland, B. T. and M. S. Feldman (2005), 'Organizational Routines as a Unit of Analysis', *Industrial and Corporate Change*, 14(5): 793–815.
- Pentland, B. T. and M. S. Feldman (2008), 'Designing Routines: On the Folly of Designing Artifacts, while Hoping for Patterns of Action', *Information and Organization*, 18(4): 235–250.
- Pentland, B. T. and H. H. Reuter (1994), 'Organizational Routines as Grammars of Action', *Administrative Science Quarterly*, 39: 484–510.
- Pfaffenberger, B. (1992), 'Technological Dramas', *Science, Technology and Human Values*, 17: 282–312.
- Pickering, A. (1994), *After Representation: Science Studies in the Performative Idiom*, Proceedings of the Biennial Meeting of the PSA (2): 413–419.
- Pinch, T. and W. J. Bijker (1987), 'The Social Construction of Facts and Artifacts, or How the Sociology of Science and Technology Might Aid Each Other', in W. E. Bijker, T. P. Hughes, and T. Pinch (eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA: MIT Press, pp. 17–49.
- Pollock, N. and J. Cornford (2004), 'ERP Systems and the University as a "Unique" Organization', *Information Technology and People*, 17(1): 31–52.
- Preda, A. (2000), 'Order with Things? Humans, Artifacts, and the Sociological Problem of Rule-Following', *Journal for the Theory of Social Behaviour*, 30: 269–298.
- Preda, A. (2004), 'Informative Prices, Rational Investors: The Emergence of the Random Walk Hypothesis and the Nineteenth-Century "Science of Financial Investments"', *History of Political Economy*, 36(2): 351–386.
- Preda, A. (2007), 'Where Do Analysts Come From? The Case of Financial Chartism', in M. Callon, Y. Millo, and F. Muniesa (eds.), *Market Devices*, Oxford: Blackwell.
- Rafaeli, A. and M. G. Pratt (2006), 'Understanding our objective reality', in A. Rafaeli and M. G. Pratt (eds.), *Artifacts and Organizations: Beyond Mere Symbolism*, Series in Organization and Management, Mahwah, NJ: Routledge.

- Schatzki, T. R., K. Knorr Cetina, and E. von Savigny (eds.) (2001), *The Practice Turn in Contemporary Theory*, London: Routledge.
- Schultz, M. (2008), 'Staying on Track: A Voyage to the Internal Mechanisms of Routine Reproduction', in M. C. Becker (ed.), *Handbook of Organizational Routines*, Northampton: Edward Elgar, pp. 228–255.
- Simon, H. A. (1969), *The Sciences of the Artificial*, Cambridge, MA: MIT Press.
- Suchman, L. A. (1983), 'Office Procedure as Practical Action: Models of Work and System Design', *ACM Transactions on Office Information Systems*, 1(4): 320–328.
- Suchman, L. A. (1987), *Plans and Situated Action: The Problem of Human-Machine Communication*, Cambridge, MA: Cambridge University Press.
- Szulanski, G. (1996), 'Exploring Internal Stickiness: Impediments to the Transfer of Best Practice within the Firm', *Strategic Management Journal*, 17: 27–43.
- Taylor, C. (1993), 'To Follow A Rule', in T. R. Schatzki, K. Knorr Cetina, and E. von Savigny (eds.), *The Practice Turn in Contemporary Theory*, London: Routledge.
- Thomas, N. (1991), *Entangled Objects, Exchange, Material Culture and Colonialism in the Pacific*, Cambridge, MA: Harvard University Press.
- Vilnai-Yavetz, I. and A. Rafaeli (2006), 'Managing Artifacts to Avoid Artifact Miopia', in A. Rafaeli and M. G. Pratt (eds.), *Artifacts and Organizations: Beyond Mere Symbolism*, series in Organization and Management, Mahwah, NJ: Routledge.
- Winter, S. G. (1995), 'Four Rs of Profitability: Rents, Resources, Routines, and Replication', in C. Montgomery (ed.), *Resource-based and Evolutionary Theories of the Firm – Towards a Synthesis*, Dordrecht: Kluwer, pp. 147–178.
- Winner, L. (1980), 'Do Artifacts Have Politics?', *Daedalus*, 109(1): 121–136.
- Winter, S. G. and G. Szulanski (2001), 'Replication as Strategy', *Organization Science*, 12(6): 730–743.
- Wittgenstein, L. (1967), *Philosophical Investigations*, Oxford: Blackwell.
- Zbarachi, M. J. and M. Bergen (forthcoming), 'When Truces Collapse: A Longitudinal Study of Price Adjustment Routines', *Organization Science*.