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Research article

Identifying generative mechanisms through affordances: a framework for critical realist data analysis

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Abstract

Critical realism has attracted increasing attention as an alternative to positivist and interpretive research for explaining contemporary phenomena. There are now several sources for information systems' (IS) scholars providing guidance on conducting critical realist studies. However, the most challenging step of a critical realist data analysis, the identification of causal mechanisms, is still insufficiently described. Identifying mechanisms is challenging. Drawing on the concept of affordances as an analytical construct offers the researcher a tool to identify and analyse mechanisms. We present a step-wise framework for identifying structural components of a mechanism, how these components interact to produce an outcome and contextual influences on this outcome. We illustrate the application of the framework through an example of the identification of IS innovation mechanisms in a case study in the airline industry. In doing so, we argue that the approach offers a methodological tool for identifying generative mechanisms, helping the researcher in conducting a more precise data analysis in empirical research.

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Introduction

Critical realism has gained increasing interest and legitimacy during the last decade as an alternative to both positivist and interpretive approaches to Information Systems (IS) research. While the philosophical foundations of critical realism were laid by Roy Bhaskar in the 1970s (Bhaskar, 1998a, b), and the methodological principles were described in the early 1990s (Sayer, 1992), only recently have IS researchers begun to explicitly adopt this perspective in their own work. What those IS researchers who have embraced critical realism need now is clearer methodological guidance on how to employ this perspective in their empirical work.

Broadly speaking, critical realism enables us to bridge the objectivism–relativism chasm between classical positivism and liberal interpretivism through its three key principles: a realist ontology, an epistemic but not judgmental relativity, and methodological pluralism (Mingers *et al.*, 2013). At the intersection of these principles is the search for generative mechanisms. A mechanism is a causal structure that explains an empirical outcome. In open systems these outcomes are not deterministic, but probabilistic and contingent on other mechanisms. At the same time, because mechanisms are viewed as arising from a reality that is external to the observer, they allow for a degree of generalization to comparable contexts.

To this point the adoption of critical realism in IS has progressed through three phases. First, critical realism was introduced (translated) for IS scholars (e.g., Dobson, 2002; Mingers, 2004; Smith, 2006). This work explicated the major tenets of the philosophy for an IS audience. Second, a small number of empirical IS case studies explicitly underpinned by critical realism and providing concrete examples of the new insights this approach offers appeared in the literature (e.g., Volkoff *et al.*, 2007; Bygstad, 2010; Smith, 2010). Third, critical

realism began to be more visible through the publication of Wynn and Williams' (2012) article on critical realist case methodology, and the *MISQ* Special Issue of critical realism in 2013.

Elaborating this methodology would be useful, however, because in its current form it provides the researcher with principles rather than practical guidance. In particular, there are two specific issues that deserve closer methodological investigation:

- *The identification of mechanisms.* In critical realism causality is expressed in the term *mechanism*, simply defined as a causal structure that explains a phenomenon (Bhaskar, 1998a). There are, however, many remaining practical questions facing the IS researcher who embarks on a quest to identify generative mechanisms. What, really, is a mechanism? If it is not observable, how can it be identified? At which level should it be described? How do we evaluate a proposed mechanism?
- *The specific role of technology in mechanisms.* Most documented examples of mechanisms are found in the natural and social sciences. For example, in economics we investigate the *market mechanism*, which explains how the price of a good is caused by supply and demand. The IS field, however, is constituted on the relationship between social and technical entities, and 'our' mechanisms should reflect and explain this; they should be socio-technical. How do we identify the elements of a socio-technical mechanism and the way such mechanisms interact?

Our approach for investigating these issues is based on additional development of critical realist methods and the concept of *affordances.* Initially an idea from evolutionary psychology (Gibson, 1986), affordances were subsequently adapted by Norman (1988) for use in studies on human and computer interaction, and then more recently reintroduced in a form truer to Gibson for general use in IS (Zammuto *et al.*, 2007; Markus and Silver, 2008). Broadly defined, an affordance is a possibility for action.

Our contribution is methodological, not theoretical, that is we explicitly build on recent key contributions on generative mechanisms (Easton, 2010; Smith, 2010; Wynn and Williams, 2012; Mingers *et al.*, 2013) and affordances (Leonardi, 2011; Volkoff and Strong, 2013), in IS research. We start by introducing the core concepts of critical realism and the associated methodological implications. After reviewing various definitions of mechanisms from the literature and the related definitions of affordances we introduce a longitudinal case study to provide a concrete worked example throughout the rest of the paper. We then present and discuss the key critical realist conceptions of data analysis, and synthesize these contributions into a stepwise framework for the identification and evaluation of mechanisms, using the case to illustrate and explain the framework. We then assess the opportunities and limitations of the approach and conclude with some implications for further research.

Critical realism and methodology

Critical realism is a philosophy attributed to the British philosopher Roy Bhaskar. Its ontological assumptions, while not restricting our methodological choices, nonetheless have some important methodological implications.

Principles of critical realism

The basic assumption of critical realism is the existence of a real world independent of our knowledge of it (Bhaskar, 1998a). Reality is conceived as being stratified in three domains; the real, the actual and the empirical. The *real* domain consists of structures of objects, both physical and social, with capacities for behaviour called mechanisms. These mechanisms may (or may not) trigger events in the domain of the *actual*. In the third domain, the *empirical*, these events may (or may not) be observed. Thus, structures are not deterministic; they have the potential to enable and constrain events through their inherent mechanisms (Archer, 1995; Sayer, 2004).

Critical realism combines a realist ontology with an interpretive epistemology (Bhaskar, 1998a). This does not imply a judgemental relativism; since a real world does exist critical realism holds that some theories *approximate* reality better than others, and that there are rational ways to assess knowledge claims.

The relationship between agency and structure in critical realism was developed in Bhaskar's (1998a) *transformational model of social action* (TMSA) and later in Archer's (1995) *morphogenetic model,* which assume that action and structure are an 'analytical dualism' in that social structure exists independently of *current* human activity (Mutch, 2007). This implies that although structure exists only through human activity, it is not reducible to such activity. This should resonate intuitively with IS researchers, as they explore not only user experiences, but also large, durable technical systems and socio-technical structures (Kallinikos, 2004). Structure enables and constrains action, while human action reproduces or transforms structure, although this is not usually the intention of the activity.

A final element in a critical realist perspective is the concept of stratification of the objects or structures themselves (Mutch, 2010; Volkoff and Strong, 2013). Structures can be decomposed into components, or combined into assemblages (DeLanda, 2006). Phenomena of interest and their associated mechanisms may emerge at any level.

Implications for methodology

It follows from these assumptions that critical realism does not aim to uncover general laws that predict outcomes, but to understand the underlying mechanisms that have generated the phenomena of interest and could do so again. As the generative mechanisms arising from objects and structures are usually not observable, they must be identified through abstract research. For example, while we may observe buyers and sellers agreeing on prices and volumes, the underlying market mechanism is unobservable. While the mechanism itself is unobservable and non-deterministic, its effects are observed often, and in that sense a good explanation of how the mechanism works is generalizable. Furthermore, because these mechanisms arise from various layers and the relations among components and layers, understanding the network of interactive parts is essential.

The layered ontology (illustrated in Figure 1) is the key to critical realist-aligned methodology. Contrary to positivist research, the aim of critical realism is not to investigate regularities at the level of events, but rather to uncover and describe the mechanisms that produced these events.

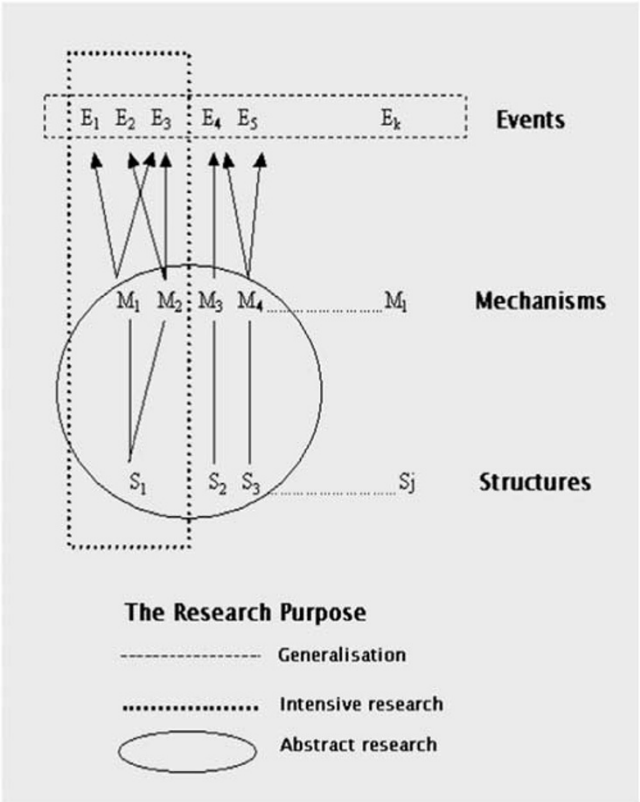

Figure 1 The layered ontology of critical realism and research strategies (Sayer, 1992).

Mechanisms are associated with both the *nature* of the objects of the real and the *relations between them*.

In order to provide a theoretical description of mechanisms that could explain the observed events, a typical critical realist research design would be an intensive study, with a limited number of cases, where the researcher systematically analyses the interplay between the ontological layers, as illustrated in Figure 1, while taking account of the structural layers and components and their evolution over time through social interaction.

The methodological question is; how do we identify mechanisms, since they are not observable? As Bhaskar puts it, 'theoretical explanation proceeds by description of significant features, retroduction to possible causes, elimination of alternatives and identification of the generative mechanism or causal structure at work' (Bhaskar, 1998b: xvii).

This technique is called *retroduction*; we take an empirical observation and hypothesize a mechanism that might explain that particular outcome (Danermark *et al.*, 2002; Sayer, 2004). For instance, if we observe that some IS solutions are more easily diffused than others we may ask which mechanism might explain the phenomenon and propose competing hypotheses such as a mechanism related to the structure of the social network in which the technology is embedded *vs* a mechanism arising from the quality of the technology's deep and surface structures.

There are several benefits from taking such an approach. First, in identifying mechanisms we are identifying regularities without being deterministic. Second, holding structure and action as distinct, although in continuous interplay, allows us to be specific about the technology and to recognize that it has a degree of durability (and thus that there is something interesting to say about it rather than just describing a particular instance), while acknowledging the role of social action in changing it. Finally, the nature of a mechanism means we understand better what is happening in the real world, rather than simply reporting a statistical relationship.

Mechanisms

In the social sciences the search for mechanisms often builds on the work of Robert Merton, who argued for the development of middle range theory focusing on social mechanisms (Merton, 1967). A well-known such mechanism, called the *self-fulfilling prophecy,* can explain human behaviour in such situations as a 'run' on a bank: the belief that the bank may go bankrupt makes customers withdraw their money, and eventually – although the bank may have been relatively solid – cause bankruptcy.

More recently, Hedstrøm and Swedberg's work on social mechanisms has triggered a renewed interest in this approach. They argued forcefully that 'the essential aim of sociological theorizing should be to develop fine-grained middle-range theories that clearly explicate the social mechanisms that produce observed relationships between explanans and explanandum' (Hedstrom and Swedberg, 1996: 281). The point is that a correlation between two observed phenomena is not sufficient as an explanation. For example, while many people are scared of electromagnetic radiation (and certainly some correlation between radiation from mobile phones and medical problems has been shown), medical researchers are reluctant to accept this evidence, because – so far – there is no documented biological mechanism that explains *how* electromagnetic radiation (of this limited magnitude) constitutes a medical hazard.

Mechanisms are at the centre of a critical realist methodology. At a general level a mechanism is a causal structure that can trigger events (Bhaskar, 1998a). However, at a more detailed methodological level the understanding of mechanisms is more challenging. Bunge defined a mechanism as 'one of the processes in a concrete system that makes it what it is – for example, metabolism in cells, interneuronal connections in brains, work in factories and offices, research in laboratories, and litigation in courts of law' (Bunge, 2004: 182). Hedström and Ylikoski (2010) discussed a broad range of definitions, and suggested that a mechanism is a constellation of entities and activities that are organized such that they regularly bring about a particular type of outcome.

The term, mechanism, suggests to some a linear causality, producing the same outcome every time it is triggered. Such a simplification is rejected by critical realists, who emphasize that the outcome of a mechanism is contextual, that is dependent on other mechanisms. Thus, a mechanism may produce a particular outcome in one context, and a different one in another context. This *contingent causality* (Smith, 2010) is inherent in all open systems, and warns us that we can mainly use mechanisms to explain phenomena; not to predict them. Although the term mechanism may be unfortunate in its deterministic connotations, the main reason to stick with it is that it denotes causality in a direct and material sense; mechanisms make things happen in the material world.

Identifying mechanisms

Beyond the general approach of retroduction there is currently no shared body of knowledge on the more specific identification of mechanisms, and one might ask whether retroduction or abduction (as described below) qualify as a *method*. Bunge warns against the possibility of a method or technique for uncovering mechanisms:

'There is no method, let alone a logic, for conjecturing mechanisms. True, Peirce wrote about the "method of abduction"", but "abduction" is synonymous with "conjecturing", and this – as Peirce himself warned – is an art, not a technique. One reason is that, typically, mechanisms are unobservable, and therefore their description is bound to contain concepts that do not occur in empirical data' (Bunge, 2004: 201).

The point is relevant, but it should not be overstated. As noted by Popper, the engine of scientific enquiry is conjectures (Popper, 2003), and many scientific concepts do not 'occur' in our empirical data. The critical realist position is that there are indeed methodological ways to formulate conjectures, building on systematic knowledge. In a layered ontology, we are looking for regularities at the level of objects and structures, not in the empirical data. These mechanisms are associated with the *nature* of the object of study, not with the attributes of events.

While there is no established methodology for the identification of mechanisms, there is some clear guidance that may provide the basis for a consistent methodology: Sayer, (1992, 2000) and Danermark *et al.*'s (2002) work on realist explanations in the social sciences. Unfortunately, neither of these sources have much to say about technology. Therefore we will also draw on DeLanda's assemblage theory (2006), and the contributions of Smith (2010) and Easton (2010), who have been paying particular attention to the socio-technical nature of modern organizations. Specifically, structures are combinations of social and/or technical elements and it is the collection of different elements and how they are related to each other that generates the mechanisms. Furthermore each element is an assemblage of sub-elements with their own relationships and mechanisms.

While these authors have helped to illustrate how technology can be addressed in case study research, they do not provide detailed methodological guidance. An important step to fill this gap is provided by Wynn and Williams (2012) who give a comprehensive adaptation of critical realism for IS case research. They introduce five research steps (in an iterative structure) for critical realist case studies:

(i) *Explication of events:* Identify the key events of the case, building on experience and abstraction. These events are outcomes, which we want to explain.
(ii) *Explication of structure and context:* Identify the human, social and physical entities of the case, and the relationships between them. These relationships may reveal emergent properties.
(iii) *Retroduction:* Identify the mechanisms (powers and tendencies) that explain the outcomes. The analysis should give logical and analytical support for the existence of the proposed mechanisms linking the structure to events.
(iv) *Empirical corroboration:* Ensure that proposed mechanisms have causal power and that they have better explanatory power than alternatives: Assess the explanatory power of each proposed mechanism with the empirical evidence.
(v) *Triangulation and multiple methods*: Use a variety of approaches to identify causal relationships, and build on different sources and data types in order to explore the diversity of underlying structures and to control for bias.

Wynn and Williams (2012) tie this structure nicely to critical realist theory, and illustrate each step with evaluation criteria and case examples. However, the practical research steps are less detailed. The most critical step – as noted by Bunge (2004) – is the identification of mechanisms. Here Wynn and Williams offer the following reflections:

'We portray retroduction as an attempt to link the capacities that are inherent within the explicated structural components and their relationships to the specific events which we seek to explain. (…). Retroduction is largely a creative process for the researcher in which multiple explanations are proposed which describe a causal mechanism, set within a social structure, that must exist in order to produce the observed events. In essence, the researcher conducts what Weick (1989) described as "thought trials" to identify and describe the elements of the causal mechanism and the contextual influences responsible for its activation. Given that mechanisms are rarely, if ever, experienced directly, the retroduced mechanism presents a logical argument explaining how the phenomenon of interest came to be through the emergent properties of the structure interacting within the study context'. (799–800).

Wynn and Williams go on to argue that retroduction is an iterative process during data collection and analysis, which may include corroborating interviews, high-order coding, within and cross-case analyses, process tracing and process modelling. The result of these analyses may be many potential mechanisms at different levels, interacting in different ways. Building on Bhaskar (1998a), exemplified by Bygstad's (2010) case study, Wynn and Williams suggest two key approaches for the identification of causal powers; to retroduce mechanisms from the empirical data collected in the particular case, or to adapt a documented mechanism to the empirical data.

The contribution of Wynn and Williams (2012) represents a landmark for critical realism in IS research, but in order to be really useful for researchers, the process for data analysis should be conceptually clearer and more detailed. In particular there are two key issues that are not sufficiently resolved and deserve closer methodological examination:

- The identification of mechanisms, and their interaction.
- The role of technology as a component of mechanisms.

To go deeper into the process of performing data analysis, in particular in the retroduction step, we draw on the concept of *affordances*.

Affordances

We take the position that in the field of IS the concept of *affordances*, from the field of ecological psychology (Gibson, 1986), offers researchers a concrete tool to identify and analyse mechanisms. Gibson defined affordances as 'action possibilities' that arise in the interaction between an animal and its environment. For our purposes his central contribution was to downplay specific characteristics or features of objects in the environment and to focus instead on what an actor could do with the object. In an IS context this can be thought of as focusing not on specific features of technology but on use case scenarios. Whether Gibson attributed affordances solely to the

environment (or artefact), or used it as a relational term (between the animal and environment), is a somewhat contentious topic in the literature (Robey *et al.*, 2013). In this paper we use it as a relational term.

Affordances first appeared in the IS literature, and in particular in the Human Computer Interaction (HCI) literature, in a form introduced by Norman (1988). Since the questions he was interested in were the way individuals perceive what they see, he focused on perception, not on affordances *per se*. While the affordance construct was enthusiastically embraced in the HCI research community, in its original form it was a poor fit for what they needed (Kaptelinin and Nardi, 2012). Over time the word itself took on new meanings in that literature, building a new link to the socio-cultural context and even expanded to the point where some people used it to refer to objects on a screen, reverting to a focus on features. By 1999 Norman actually disavowed the term as it had evolved, expressing a wish that he could replace all instances in his original writing with the term 'perceived affordances' (Norman, 1999).

This deviation from Gibson's original conception of an affordance as a possibility for action (perceived or otherwise) has been repaired in the more recent IS literature. This stream, which focuses on affordances as a way to explore the relation between technology and organizational actors, began with Markus and Silver (2008). Recently, Robey *et al.* (2013) and Farad and Azad (2013) suggested that the affordance concept offers new opportunities for theorizing within the socio-materiality stream of research.

We define an affordance as 'the potential for behaviours associated with achieving an immediate concrete outcome and arising from the relation between an object (e.g., an IT artefact) and a goal-oriented actor or actors' (Volkoff and Strong, 2013; Strong *et al.*, 2014). Each element of the definition matters. Figure 2 presents the elements of this affordance-based conception of mechanisms, as further elaborated below.

In our context an affordance emerges from the relation between the technology and an actor. This means it is not solely related to the features of the technology. At the same time, until it is actualized, it does not matter who the specific actor is, just that some actor who could actualize it does exist (Chemero, 2003). Furthermore, an actor for whom it may be relevant might not perceive the affordance at all (Hutchby, 2001). The affordance itself refers to the possibilities arising from that relation for actions or behaviours that will lead to a particular immediate concrete outcome. In the same way that a mechanism was described earlier as 'one of the processes in a concrete system that makes it what it is' (Bunge, 2004: 182), an affordance, its associated immediate concrete outcome and the potential actions that lead to that outcome are definitional.

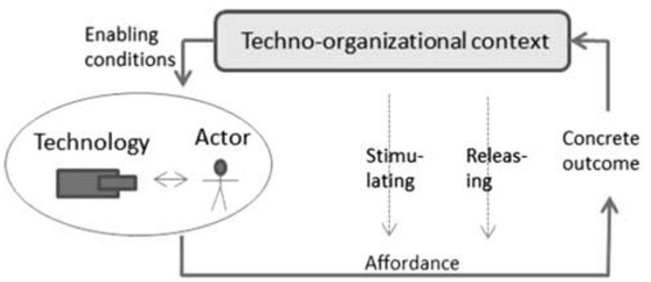

Figure 2 Affordance structure.

Thus, for example, some of the affordances identified by Volkoff and Strong (2013) as arising from the relationship between an enterprise system and a manufacturing company included the potential for recording data, integrating processes or monitoring operations. The associated outcomes are recorded data, integrated processes and monitored operations, respectively. These are the sorts of outcomes that make an enterprise system what it is.

While an affordance itself is an ever-present potential for action, the details of its actualization in a specific instance are contingent on aspects of the techno-organizational context (Hedstrom and Swedberg, 1998), and thus the outcome is indeterminate. The context gives rise to a variety of mechanisms that may act as conditions that initially enable or constrain the actualization of the affordance, or that later stimulate its actualization in a variety of ways, or release constraints (Demetriou, 2009; Fleetwood, 2011).

The specific details of this definition – the need to have both an object and an actor, and the fact that the actor is goal-directed – mean that affordances are a subset of the mechanisms involved in phenomena such as innovation or organizational change (Volkoff and Strong, 2013). Other mechanisms may arise from the various psycho-social elements associated with organizational actors, for example, but would not be affordances. This said, the affordance lens is particularly useful for understanding those mechanisms that arise from the relation between technology and users because it explicitly involves both at the same time, while holding them distinct. The feedback structure of Figure 2 illustrates the point by showing the basic interaction of structure and action: structure enables action and action reproduces or elaborates structure. The techno-organizational context (i.e., structure) consists of networks of human, social and technical objects, which in various combinations enable (or create the potential for) action (i.e., affordances). If actualized, the result of the action is fed back to the structure as outcomes. These immediate concrete outcomes can be defined at any level of granularity, from a new instance of a data element or a completed transaction to a new artefact. Such a cycle builds on and reflects the morphogenetic cycle of Archer (1995) (initial structural conditions exist prior to associated social interaction, which in turn leads to structural elaboration), as well as Bhaskar's (1998a) TMSA and Demetriou's (2009) concept of mechanisms.

The concept of *emergence,* central to the workings of mechanisms, helps us address the relationship between different levels of granularity. Mechanisms arise (emerge) from a combination of objects and the relationships between those objects, and produce an outcome that is dependent on, but not reducible to the objects (Elder-Vass, 2005). Furthermore, each object can be decomposed into its components, which have their own set of relationships and mechanisms. Because a technical object is a complex assemblage of many parts, and an actor may be an individual or a complex collection of individuals, the relation between technology and an actor will be associated with a variety of affordances at various levels. Thus, while Figure 2 shows a single affordance, at any specific moment in time there are likely to be multiple affordances interacting. While the level at which we focus will depend on the questions we are trying to answer, it is the interactions of the various levels that provide an important part of the explanation.

The realization or 'actualization' of an affordance is dependent on the actor's goals, but also on his or her competence and

knowledge, as illustrated by *the affordance joke*:[1] A woman is standing in a street at night, and throwing small stones at a window in the second floor, apparently trying to wake somebody up. A passer-by observes the scene, and approaches the woman with the words 'Hello, I can help you contact whoever is up there. Please use this mobile phone'. The woman looks at him, takes the mobile phone – and hurls it towards the window! In this case, the mobile phone in the hands of the woman represented the potential for achieving the immediate concrete outcome of making contact, the stimulating conditions are present, but, at least from the perspective of the passer-by, the releasing conditions are somewhat distorted. This same example also illustrates the nesting of different levels of granularity. While the phone, in relation to the woman and her goal of contacting someone, does have a contacting affordance, at a lower level of granularity this might be decomposed into two distinct affordances, a calling affordance and a throwing affordance. She elected to actualize the latter, and may or may not have recognized the former.

Thinking of those mechanisms associated with the relation between technology and an actor as an affordance offers two benefits for the researcher. First, it makes the identification of a mechanism (at a low level) less abstract and more understandable as a step in a method. It allows the researcher to start the analysis by identifying concrete outcomes, and then retroducing how they were produced.

Second, an affordance view provides a conceptualization of a socio-technical mechanism as a relationship between a knowledgeable human or social actor and a technological artefact. One may describe this relationship as a meeting between *a need and a capability*, which allows for analysis at various levels: a need for a mobile interface can be met by a mobile app, and a need for systemic integration of enterprise systems may be met by a middleware artefact. We regard this relationship as asymmetrical: humans have an *agentive* relationship to artefacts (Searle, 1995); artefacts can help generate capabilities but have no will of their own, while humans have will and goals, but often lack the capabilities.

An affordance is not the endpoint of mechanism identification and analysis, but a building block of a more complex mechanism (or mechanisms). The outcomes of mechanisms at a higher level will be less concrete, and may emerge from the interactions of several affordances. We return to this interaction in the next section.

Case example: the search for mechanisms in IS innovation research

To illustrate the uses of affordance theory, the importance of mechanisms and the critical realist approach, we present an IS innovation study in which the goal was to understand the interplay of human, social and technical elements that led to a successful innovation. Like Schumpeter (1934), we defined an innovation as a new combination of known products, processes, markets or organizations that is commercially successful. In doing so, we pursued a central question in innovation research: what explains a successful innovation, in contrast to a failed one (Tidd and Hull, 2003)? Current IS research has been investigating this issue in the context of Internet-based services, where researchers have found some extremely successful innovations, such as Amazon and Google (Cai *et al.*, 2008; Iyer and Davenport, 2008), many relatively successful ones, and a large number of failures.

The case

We investigated this question in a longitudinal study of an airline company, AirCorp (Henfridsson and Bygstad, 2013). The longitudinal approach allowed us to conduct a process analysis (Langley, 1999) of how events unfolded over time. But it also allowed us to go deeper and investigate the mechanisms related to innovation in such infrastructures.

AirCorp is an international airline carrier based in Scandinavia. Its strong growth started in 2002, when it established a national network, helped by government deregulation of the airline industry. Today AirCorp operates a total of 313 routes to 120 destinations in Europe and the Middle East, and in 2012 carried 17 million passengers. The company has 2500 employees and revenues in 2011 were $ 1.8 billion. The company pioneered the Scandinavian low-price airline market, and has been quite innovative, as described below.

The focus of the 5-year study was to understand the relationship between IT capabilities and business innovation. In this paper we describe the results of a post hoc analysis to help us present and explain the proposed six-step framework. It should be emphasized that the analysis process was much less sequential than described here; in practice the researcher went back and forth. The researcher also went back to the informants several times and asked for more details during the research process. The steps do, however, give a reasonably precise picture of the analytical process. Table 1 illustrates important events in the case that will be elaborated further in our example analysis.

A stepwise framework for critical realist data analysis

According to Sayer, retroduction is a '… mode of inference in which events are explained by postulating (and identifying) mechanisms which are capable of producing them' (Sayer, 1992: 107). For example, the interplay of humans and technology may trigger a number of mechanisms relevant for

Table 1 Key events in the case

Time	*Event*
2003	Implementation of a service-oriented architecture
2004	Bypassing of travel agencies through Internet sales and printable tickets with barcode identification
2005	Introduction of the low-price calendar
2006	Dialoguing with 90% of customers electronically
2007	Launch of Bank AirCorp
2008–2011	Establishment of Call AirCorp mobile solution

the IS field. Whether the mechanism will be triggered, and which result it will produce, is not predetermined, but will depend on other active mechanisms. However, it will have a *tendency* to produce certain outcomes. For example, the way actors use an enterprise system (and in particular its shared database) affords the possibility of standardized processes – but this does not always occur (Volkoff and Strong, 2013).

Thus, first we need to identify the structural components underlying the mechanism. Then we must understand how these components interact, following which we need to identify and analyse the potential outcome. And finally, we need to identify the context (i.e., other mechanisms) that influences the outcome.

Table 2 outlines our suggested steps and principles for conducting a critical realist data analysis. These steps build on the framework presented in Wynn and Williams (2012), which was based in turn on Danermark *et al.* (2002) and Bhaskar (1998a), but offer more pragmatic details, and incorporate the concept of affordances. The sequence of steps illustrates the analytical structure of the framework; the

Table 2 Stepwise framework for critical realist data analysis

Step	*Explanation*	*References*
1. Description of events and issues	In a critical realist context events are clusters of observations made by the researcher or by the researcher's informants. The level of granularity depends on the phenomenon of interest.	Sayer, 1992, Volkoff *et al.*, 2007
2. Identification of key entities	The key entities are the objects of the case, for example individuals, organizational units, technology and the relationships between them. Together they constitute structures, i.e. networks of entities, with causal powers. Entities may be identified from data, in a grounded way or they may be embedded in a theoretical framework.	Danermark *et al.*, 2002
3. Theoretical re-description (abduction)	Before identifying mechanisms we need to abstract the case, exploring different theoretical perspectives and explanations. The researcher should identify relevant theories 'to observe, describe, interpret and explain [the events] within the frame of a new context'.	Danermark *et al.* 2002: 91
4. Retroduction: Identification of candidate affordances:	Retroduction is 'mode of inference in which events are explained by postulating (and identifying) mechanisms which are capable of producing them'.	Sayer, 1992: 107
a) Identification of immediate concrete outcomes	An immediate concrete outcome is something that is directly achieved (or could be achieved) through the use of technology, and is related to the realization of the actor's goals. For example, actors using an enterprise system can expect an outcome such as some degree of standardization of order entry processes, which is related to the goal of reducing costs.	Volkoff and Strong, 2013
b) Analysis of the interplay of human and technical entities	In the IS field this interplay is often between people and technical objects (identified in step 2), both of which, as stated above, are complex entities in their own right. Technical objects have deep structures, such as the data structures, coded transactions, and authorization tables, and surface structures, such as interfaces.	Volkoff and Strong, 2013
c) Identification of candidate affordances	An affordance arises from the relation between human/social and technical entities and reflects the potential for behaviour that may produce the immediate concrete outcome. The affordance exists, is real, and endures as long as the actors and objects exist, while the possible outcome may never be produced (i.e., the affordance may never be actualized).	Volkoff and Strong, 2013
d) Identification of stimulating and releasing conditions	Whether and how completely or appropriately an affordance is actualized, depends on the contextual conditions. Stimulating conditions are typically organizational arrangements that make it easier to act. Releasing conditions are often specific decisions.	Volkoff and Strong, 2013
5. Analysis of the set of affordances and associated mechanisms	First we need to analyse the interaction of affordances, and the dependencies between them. Some have temporal dependencies, while others have structural or complementary dependencies. Next we should try to understand how affordances are parts of higher-level mechanisms: Macro-micro and micro-macro mechanisms.	DeLanda, 2006.
6. Assessment of explanatory power	A proposed mechanism should be treated as a candidate explanation, and the data collection and analysis should be repeated until closure is reached. We search for the mechanisms with the strongest explanatory power related to the empirical evidence, i.e. the causal structure that best explains the events observed.	Sayer, 1992, Wynn and Williams, 2012

practical research steps will usually be more iterative. Also, the steps will be influenced by the choice of research method, for example whether the approach uses grounded theory methods or has a more theory-driven nature.

The results from points 1–6 do not complete the research process, they constitute the basis for further discussion of (i) the similarities with other mechanisms, and (ii) the theoretical and practical implications of the analysis conducted. According to Easton (2010), 'generalization to theory via case research carried out under critical realist conventions occurs by virtue of clarifying the theoretical nature of the entities involved, the ways in which they act and the nature and variety of mechanisms through which they exert their powers or are acted upon by other entities' (128) (see also Wynn and Williams' (2012).

Step 1: description of events and issues that constitute the phenomenon of interest

The first step was to identify critical innovations, and then to identify events and contributing social and technical structures leading up to them. The identification of events was done partly by the informants, and partly by the researcher. Some events were identified by their direct business importance, while others emerged from a number of observations. For example, the 2003 event of an introduction of a service-oriented architecture was identified after several rounds of interviews, where the researcher tried to understand the interplay of technical solutions and the innovation of new services.

2003: implementation of a service-oriented architecture
As a new entrant into the very competitive airline market, AirCorp started in 2002 with a very basic IT solution. As the company expanded quickly, the need for an IT architecture was acknowledged, and a Chief Information Officer and two IT architects were hired from one of the competitors. They had rather clear ideas on what to do and started in 2003 to construct a new architecture. The aim was to develop a service-oriented architecture by using a simple *enterprise service bus*, enabling easy communication across different technologies and reuse of components. The solution was set into production in 2004, and gradually expanded over the following years.

2004: bypassing of travel agencies through Internet sales and printable tickets with barcode identification
After establishing the service-oriented architecture in 2003, the solution was set into production in 2004. The main challenge at the time was how to make customers book on the Internet, and not with travel agents, whose services were quite expensive for a low-cost airline. This was achieved through an Internet portal and laser printed tickets. At the airport gates the company installed bar-code readers, in order to validate the printed tickets.

2005: introduction of the low-price calendar
A major obstacle for low-price passengers at the time was finding the cheap tickets, which used to be hidden inside a complex pricing structure. Capitalizing on their new architecture AirCorp solved this problem in 2005 when the *low-price calendar* was introduced, which showed the cheapest flights to any chosen destination. The low-price calendar was an outstanding success, increasing the number of bookings substantially. It was later copied by many other airlines.

2006: dialoguing with 90% of customers electronically
This dialogue included email and web marketing, on-line sales, booking and check-in.

2007: launch of Bank AirCorp
In 2007 the company decided to enter the banking market with Bank AirCorp. The aim was to capitalize on the 2–3 million visitors to the airline's web site. The Director of Business Development commented: 'We had established a very flexible IT architecture, and we realized at the time that it would be possible to innovate new services on this. First we were just brainstorming rather freely: how could a combination of brand and technology generate new business?' The establishment of the bank was done over 6 months, serving 50,000 customers in 2008.

2008–2011: establishment of Call AirCorp mobile solution
The aim of the mobile portal was to allow for easy airline booking, and to offer mobile broadband at the airport and (later) during flights. The mobile solution was extended in 2009, when the possibility of having a bar code ticket on the mobile phone was introduced. In 2010 Call AirCorp launched GSM and mobile broadband services. In February 2011 AirCorp was the first European airline to offer broadband services on board.

In summary: to start the investigation into the phenomenon of successful innovation, Step 1 involved identifying specific events that provided evidence of this success. Note that the 'events' are not just a chronological series of incidents or day-by-day activities. Rather they have significance as markers of change that constitute the phenomenon of interest. If the research objective had been to understand the organizational changes associated with the introduction of a specific software package, the events of interest would be evidence of changes to processes and structures. Thus the nature of the question determines the focus and the level of granularity.

Step 2: identification of key entities

In Step 2, for each of these events the researchers identified associated entities (actors, organizational units and objects). Key actors identified included not only managers and specialists at AirCorp, but also partners, vendors and users. We also specified AirCorp's departments and divisions and the associated social structures. The core objects – in this case the IT systems – were mapped, and the IT architecture was documented, as shown in Figure 3. The link to external systems, such as the European Amadeus booking system was documented, and relationships with important partners were delineated.

Step 3: theoretical re-description (abduction)

The events were analysed over time to generalize in abstract terms the nature of the phenomenon. This led to a re-conceptualization of the whole case. Our initial question was to understand how AirCorp came to be so successful. We started by examining the business strategy, but came to realize the importance of AirCorp's information infrastructure (Hanseth and Lyytinen, 2010). This information infrastructure is defined

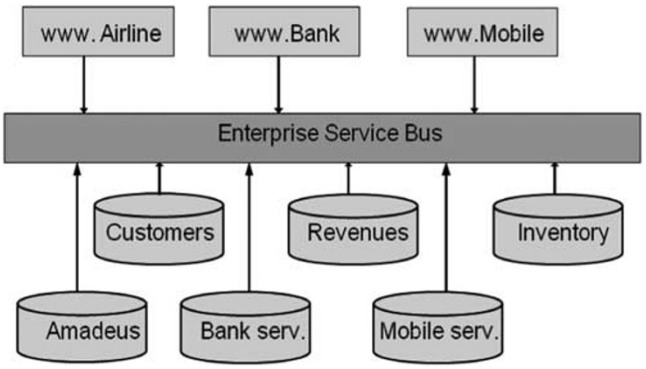

Figure 3 The service-oriented IT architecture.

as the *installed base* of organizations, systems and users, that is the AirCorp company, its partners, the related IT systems and the Internet users of the solutions. This led to reconceptualizing the research question in terms of the growth of a large information infrastructure. The new challenge then became to identify the mechanisms that led to that growth, and thus to the success of the company.

In general, then, the task at this stage is to reframe the initial question about some events of interest and reconceptualize them in more abstract terms that clarify what one is actually studying. Whereas the first two steps are fairly concrete and can be executed somewhat systematically, this is one of the places where a degree of experience and creativity is involved. It is also an area where extant theory can be used as a sensitizing device.

Step 4: retroduction: identification of candidate affordances

After Step 3 the research question in our case could be reformulated as: which mechanisms can explain innovation and growth of information infrastructures? We began by identifying the functional outcomes, then retroducing the affordances.

Sub-step 4.1: the identification of immediate concrete outcomes
Immediate concrete outcomes arise from the actions of goal-directed actors. By considering each of the different types of actors in turn, we identified a variety of relevant outcomes that might result as each of them interacted with the technology.

From the perspective of developers we identified the outcomes as *proofs of concept, prototypes* and *new services.* For users we identified *ticket offers, tickets and registrations.* For partner companies we identified the outcomes as *linked business partners* and *new integrated services.*

Sub-step 4.2: the interplay of human and technical entities
We then examined the entities involved with each outcome. For example, we found that proof of concept depends on the existence of many objects (e.g., data structures, modules etc. in internal and external systems, and the knowledge of them); prototypes depend on surface structures (web pages) and knowledge of market needs and user preferences, and new services depend on interoperability and standard formats for programming components that communicate to other components.

Sub-step 4.3. the identification of candidate affordances
An affordance arises from the relation between entities that may produce the functional outcome. The affordance is the potential action involved in getting to that outcome.

We analysed the candidate affordances in detail. For example, the *developing concepts* affordance is illustrated in Figure 4.

In constructing this figure, we started with the outcome (proof of concept) and then investigated the entities involved. Then we assessed the enabling conditions (the space of possibilities). In the same vein we analysed the *booking affordance*, illustrated in Figure 5.

For the booking affordance we started with the outcome (electronic ticket) and then investigated the entities involved (the customer, the web site, the credit card). Then we assessed the enabling conditions, that is travel opportunity.

Sub-step 4.4: identification of stimulating and releasing conditions
An affordance is a potential for action, and whether it will be actualized is dependent on contextual conditions. Regarding the *developing concepts* affordance (Figure 4) the important stimulating condition was found to be a cross-disciplinary workshop of business developers, the IT architect and business partners, where different concepts were discussed and detailed. The releasing condition was identified to be a formal audit, where the business case was presented, and then accepted by the management group. While we do not discuss them here, a study such as the one being described would do well to analyse these intervening mechanisms more thoroughly. There may, for example, be extant theories that help to explain how they operate.

The *booking* affordance (Figure 5) had a quite different structure. Considering the data (together with IT personnel we analysed the web logs), we found that customers spent a long time on the web pages, assessing alternative prices and travel details. We regard the presentation of these offers as the

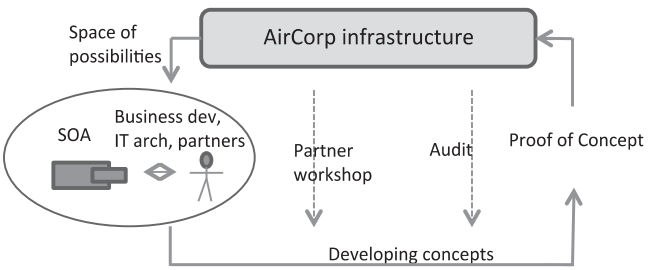

Figure 4 The developing concepts affordance.

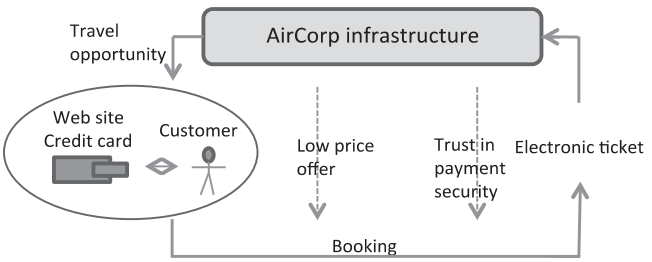

Figure 5 The booking affordance.

stimulating conditions. Further, we found that the key releasing condition was the secure payment solution, which reassured the customer that the transaction was secure, and that the responsibilities for any irregularities were clear.

The other affordances were analysed in a similar fashion. Once again there is an element of creativity, mostly with respect to selecting specific outcomes as being salient from the wide set of possibilities. However, due to the fairly concrete nature of the affordances, as long as the researcher has some depth of understanding of the context, at the very least the identification of the initial set of candidate outcomes and associated affordances is relatively straightforward. The key is checking to ensure that the selections resonate with the actors in the case.

Step 5: analysis of the set of affordances and associated mechanisms

The identified affordances may be regarded as the building blocks of the explanation. Further analysis is dependent on the research question and may take several avenues:

- Analysing the dependencies between affordances.
- Grouping affordances.
- Identifying focal affordances, and their relationship to other mechanisms.
- Abstracting affordances into higher-level mechanisms.

In the AirCorp case we iterated some initial analyses with all these approaches, and assessed the explanatory power of the initial results. We chose to proceed by abstracting affordances into higher-level mechanisms.

Three affordances (i.e., developing concepts, prototyping, developing a service) were abstracted into a generalized innovation mechanism (Figure 6). What enabled the generalization was that the enabling conditions were relatively similar ('space of possibilities'), the affordances are of the same type (processes for creating something new) and the functional outcomes were also relatively similar (could be abstracted into 'new service').

The other affordances were accordingly abstracted this way:

- Searching, booking and registering were seen as an *adoption mechanism.*
- Linking new business partner and integrating new services were seen as a generalized *scaling mechanism.*

Of course, as discussed earlier, the set of affordances, arising from the relation between the technology and the actors, is only a subset of the full set of mechanisms. Beyond the affordances are associated social mechanisms that arise from non-technical organizational structures. These are included in the analysis largely as the enabling/constraining, stimulating or releasing conditions. In other words they are treated as background rather than as the focus of the explanation. While they are undoubtedly important, when the research objective is to understand the role of the technology, we need to highlight the mechanisms (affordances) connected to that technology. Examining the organizational mechanisms more closely has value, but is a different type of study. In this type of study we include them as context.

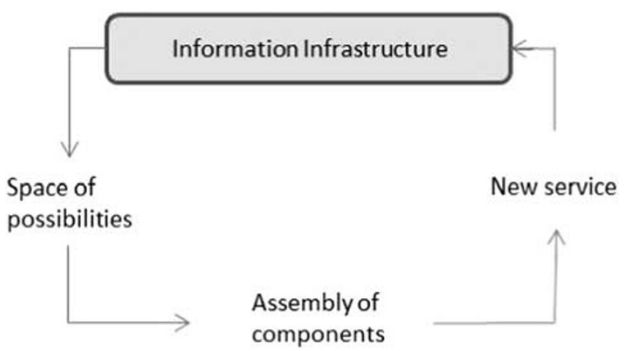

Figure 6 The innovation mechanism.

Step 6: assessment of explanatory power

What makes one mechanism more plausible than another? The short answer is that we should choose the one(s) that offer the strongest explanatory power in relation to the empirical evidence (Sayer, 1992, 2000). Wynn and Williams (2012) described this step as *empirical corroboration*, that is, ensure that the proposed mechanisms have causal power and that they have better explanatory power than the alternatives.

In the AirCorp case other possible mechanisms were systematically evaluated against the empirical evidence. First we assessed whether the innovations could be explained with the *market mechanism*, that is, that the external demand for services was matched with the internal capabilities to satisfy the demand at a competitive price. Certainly, this explanation cannot be dismissed, but it was not well-supported by the empirical evidence. There were no systematic processes at AirCorp to detect and respond to such demand, and the key innovators were relying much more on experimentation than on market analysis.

Alternatively, one might hypothesize that the key mechanism was the *entrepreneurial drive* of the charismatic CEO of AirCorp. Again, this could explain some of the observed outcomes, but was not satisfactory. For example, it emerged through the study that although the CEO was very innovative in the airline industry, he was hardly interested in IT, and was not much involved in the actual innovation processes described here. The result of this analysis was that although several mechanisms were at work, only the three mechanisms described above were consistent with all the data, including feedback from key informants (Bygstad and Munkvold, 2011).

Assessing the framework

In this section we will discuss how our framework contributes to critical realist research, and the research opportunities it offers. We also assess the limitations of the framework, and how these might be addressed in further research. Our framework extends earlier methodological contributions within critical realism (Danermark *et al.*, 2002; Wynn and Williams, 2012), and our comments focus on our specific contribution of identifying, analysing and assessing mechanisms through affordances.

The identification of mechanisms through affordances

The extant literature on identifying mechanisms (Sayer, 1992; Danermark *et al.*, 2002; Wynn and Williams, 2012) describes the identification of mechanisms as a basically creative and iterative task. We do not contest this but we argue that starting

with the identification of affordances makes the analysis process easier. While a mechanism is usually a relatively abstract (and unobservable) chain of causality, an affordance is more concrete; in our context an affordance arises from the relationship between a purposeful actor and an IT artefact (Volkoff and Strong, 2013). By careful analysis of this relationship and its possible outcomes it is often relatively straightforward to identify the affordance, as illustrated in our AirCorp example. This was also shown by Volkoff and Strong (2013), where they identified the affordances related to an enterprise system and a proprietary engineering system, and Strong *et al.* (2014), where they identified the affordances related to an electronic health record system. In order to identify affordances they asked such questions as 'what did the technology enable you to do' (i.e., what were the immediate concrete outcomes), 'what did it make it more difficult to do'? Describing the structure of the affordance, as illustrated in Figure 2, also allows for detailed analysis of contextual conditions whereby the affordance can be activated and realized. Thus, for example, if there are affordances that were envisioned by a system designer that are not being actualized by users, this type of analysis can determine whether the problem is that the affordances are simply not being perceived by users, or if there are other mechanisms that are interfering with actualization.

Does the affordance approach reveal something that other approaches do not?

Could the mechanisms in the AirCorp case have been identified without the methodological overlay of affordances? Perhaps, but with much greater difficulty. The three mechanisms from the case (innovation, adoption and scaling) are relatively high level and generalized, and hard to retroduce directly from the observed events.

Returning to Bunge's (2004) point that there is no method or logic for conjecturing mechanisms, we have proposed that affordances offer ('afford') an analytical bridge between the observed events and the causal structure of mechanisms. The relational nature of this analytical bridge is essential in that it helps us to identify the socio-technical dynamics of mechanisms in IS research, that is the possible interaction between human/social entities and technology. In particular, it allows for a more specific analysis of the role of technology.

The specific role of information technology in mechanisms

The role of technology in mechanisms is a salient issue in current IS critical realist research (Leonardi, 2013; Mutch, 2013). Faulkner and Runde (2013) investigated the nature, position and identity of technological objects within the context of Bhaskar's (1998a) transformational model of social activity, and suggested that technological objects occupy *social positions*. These positions constitute the identity of objects, and can be described in terms of each object's function and structure. For the empirical IS researcher this theoretical framing is useful as a sensitizing device for the analysis of socio-technical mechanisms.

It is necessary, however, to complement this ontological perspective with a more empirical approach. In line with critical realism's emphasis on contingencies, we should not expect that the role of technology in mechanisms can be described in any single way; rather we should expect the role of IT in socio-technical mechanisms to vary, depending on type of technology and organizational context.

This is exactly what the affordance approach offers the researcher. Conceiving affordances as building blocks of mechanisms allows the researcher to describe these relationships (function, structure and identity) in detail, and to analyse their role in both structural and performative aspects. Consider, for example, the role of IT architecture in the AirCorp case. Both the IT and business developers of AirCorp regarded the enterprise service bus as a key enabler for new services, and we observed that it was indeed a central element in most of the events related to innovation. In principle, a modularized IT architecture may offer a very large number of affordances.[2] Starting with the concrete outcomes of our events, our analysis revealed that IT architecture was a constitutive part of the *developing concepts* affordance (where the affordance arises from the relationship between the architecture and the business developers, as shown in Figure 4), while it took the position of a background element for the *booking* affordance (Figure 5), where it acts as a stimulating and releasing condition. Furthermore, this approach allows us to acknowledge the differences between different technologies, and across contexts.

When affordances are generalized into mechanisms (as in Figure 6) these aspects become less transparent, in the sense that the specifics of various technologies get 'bracketed' in larger causal structures. This allows the researcher to zoom in and zoom out in constructing explanations. The more generalized mechanisms are larger building blocks of theory building, while maintaining the empirical consistency through their affordances.

While our focus to this point has been on the role of technology in socio-technical mechanisms, we must not forget the social side, the organizational context in which the technology is embedded. As discussed earlier, while a focus on the technical means the social has been put in the background, mechanisms arising from social structures often act as enabling, constraining or releasing conditions. Methodologically this requires that we include analysis of the social structures in Step 2, which in turn requires deep immersion in the organizational context and getting feedback from organizational members on the findings as they emerge.

Next steps

Several questions remain. One is simply whether our approach, which depends on identifying actualized affordances, is enough, since we know there may be affordances that have not been actualized, or actualized ineffectively. If our interest is identifying all real mechanisms, knowing that they are unobservable, how can we be sure we have all of them? The short answer is simply that we cannot know, but this is less of a problem than it may seem. First, if we have a large number of respondents representing a wide variety of use scenarios, and continue to collect data until we have reached theoretical saturation, then we will have at the very least the core of a good explanation. Just as a positivist would be more worried than delighted with an R^2 approaching 100, a critical realist is happy to understand at least some of the salient mechanisms. Second, the nature of the question means we are sometimes interested in what did happen, not what might happen. Thus, for example, in our case, with a question about what leads to

successful innovation, we may not know all routes, but by selecting a revelatory case of unusually high success we can uncover relevant mechanisms. Finally, in other situations, we may include in the sample of hypothesized mechanisms a number that arise from theory rather than observation. For example if we are looking at the introduction of new technology, we might consider the designed affordances, not just those that are actualized. In the end the issue is largely pragmatic – have we uncovered mechanisms that provide an explanation that is 'good enough', better than the alternatives, and useful?

Another challenge arises with respect to levels. It is not necessarily clear how to determine the level of detail that is most salient for the research. For example, the researcher must decide whether an identified affordance can, or should, be abstracted into higher-level mechanisms. In the AirCorp case we abstracted affordances into three mechanisms (innovation, adoption and scaling) as that helped us understand our phenomenon of interest, but there are also other alternatives. For instance, Strong *et al.* (2014) analysed the functional *dependencies* between affordances in order to draw a larger picture. It is hard to give general guidance on this point; which analytical strategy to choose will depend on the research question, and the researcher's domain knowledge and experience.

A related issue is the interaction of mechanisms across levels. Levels are not simply different degrees of granularity. As shown by Strong *et al.* (2014), higher-level affordances may depend on successful actualization of basic affordances, while remaining distinct from them. Alternatively, higher-level mechanisms may act as stimulating or releasing conditions for lower-level affordances. This can be seen in the booking affordance (Figure 5) above, where 'trust in payment systems' is a releasing condition. This trust is not directly connected with the affordance, but is a more general high-level mechanism. Our relatively tidy framework is offered as a tool to simplify the analysis, but it should not mask that there are a large number of mechanisms in the complex socio-technical structures we are trying to understand. This will be a fruitful avenue for further research.

As presented, the methodology relies on intensive longitudinal study of single large cases, meaning the findings rely on detailed examination of a particular technology in a specific context. While other approaches could be used, when there is only one case involved, the question arises whether any of the findings are generalizable beyond that one case. The answer lies in the distinction between an affordance and its actualization, which can be viewed as the distinction between function and structure or form. An affordance, as the potential for action, is talked about in terms of its functional outcomes. These can be quite generic. Thus Volkoff and Strong (2013), who also looked at only one case, argue that any enterprise system in use by any manufacturing organization will generate the same affordances as the ones they observed in the actual case. This would be true not only for basic affordances such as 'recording data', but also for higher-level affordances such as standardizing, integrating, monitoring and controlling, viewed as potentials. It is in the actualization of the affordances at a specific organization that the differences in form and structure emerge. They note that some of these affordances were also observed in a completely different situation, namely the proprietary CrashLab system implemented at Autoworks (although of course taking on very different form and structure). Similarly, in our case, the affordance 'booking' has been actualized in a specific way at AirCorp, but functionally a booking affordance is likely to emerge when theatre patrons use an online system to purchase seats for a performance or patients schedule a doctor's appointment. Of course they will be actualized differently, but it is an interesting empirical question whether the types of enabling and constraining conditions identified in the AirCorp case apply elsewhere. It is at this 'functional' level of an affordance in the real (rather than the empirical) domain where generalizability is possible. Of course one case study cannot assert generalizability, but it can generate testable hypotheses for future research and propose the nature of other domains where similar conclusions are likely to apply.

Similarly, while the methodology is appropriate for uncovering the affordances and the associated network of enabling, constraining and releasing conditions, together with the relationships between affordances, these findings, once understood, can be tested and used in action research or replicated in alternate environments. The ultimate objective in critical realist research is to identify the generative mechanisms that explain a phenomenon of interest. The methodology will take us there. Such explanations can have enormous practical benefit for improving the implementation of new software or increasing the effectiveness of its use. As mid-range theories, the research outcomes are indeed bounded in their applicability, but in the long run may have greater relevance.

Conclusion

We contribute to the literature on research methodologies and extend the current state of critical realist approaches in IS by presenting a stepwise framework for data analysis that may aid the researcher in identifying generative mechanisms through affordances. We show that the affordance approach to mechanisms offers two distinctive advantages for the researcher. First, it makes it easier and more intuitive to identify mechanisms, and second, it allows for a more detailed analysis of the role of technology in mechanisms.

Notes

1 The joke was told at the socio-materiality panel at ICIS 2013 in Orlando.
2 We thank one of the reviewers for pointing this out.

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