Explaining Persistence and Resilience of Inter-organisational Information Systems: Theoretical and Methodological Considerations

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Abstract

The study of diffusion, adoption and implementation of inter-organisational information systems (IOIS) so far relies on theories which do not address the question of why systems continue to be used once adopted and implemented. We call such theories inertia theories because they imply that continued used can be taken for granted once the adoption decision has been made and the systems are implemented if decision parameters do not change. We identify two distinct aspects of ongoing use, namely persistence and resilience which are in need of theoretical explanation. In order to fill this gap, we aim to build a theoretical framework which specifically asks how systems are reproduced in their day-to-day routine operation. For this purpose, we offer a new conceptualization of IOIS by combining core ideas from Structuration and Practice Theory. Based on this framework, we define the twin problems of persistence and resilience. We find that these issues can be related to two core processes in our theoretical model and thus offer the conceptual tools for their theoretical explanation. We discuss the methodological implications of this framework and suggest possible directions for future research.

Keywords: Post-adoption, Practice Theory, Structuration, IOIS, Persistence, Resilience

1 PERSISTENCE AND RESILIENCE AS AN OVERLOOKED PROBLEM IN THE IS LITERATURE

The empirical study of information systems adoption, diffusion and implementation mostly focuses on the reasons why potential users (people or organizations) decide to use or not use a given technology or system. The assumption is that once a positive decision has been made, subsequent use of the technology or system can be taken for granted. The motivation to use a technology is -- in a sense -- timeless or eternal because, once the adoption decision is made, use will follow as long as the parameters which have led to the original adoption decision do not change significantly. Similarly, non-use is explained as a form of resistance that is the result of a certain calculus regarding individual (organizational) advantages and disadvantages which continues to motivate non-use as long as this calculus is not changed. Thus, explaining diffusion and use patterns is considered accomplished if the adoption/rejection decision can be explained. Depending on the specific theoretical stance, explanation of the adoption/rejection decision rests on an economic, a power, or a "factor" rationale. The economic rationale imputes technology adoption decisions to a cost/benefit calculus (e.g. Beck and Weitzel, 2005) and is sometimes extended to capture timing effects to account for path dependency (e.g. Fomin et al., 2005). The power rationale explains the adoption/rejection decision as reinforcing existing power relationships (e.g. Nagy, 2004) and/or as attempts at changing existing power relationships through use of the technology/system under consideration (e.g. Johnston and Vitale, 1988). The "factor" rationale considers any explanation satisfactory which demonstrates a certain predicted correlation between a set of psychological, organizational, institutional or other factors and an adoption/diffusion pattern suggesting that these factors have caused individual adoption/non-adoption decisions (cf. Fichman (1992) for a review of the broader literature and Koch (2005) for a more recent review in the IOIS context). These theories of technology use (non-use) may be characterized as inertia theories because they predict ongoing use (non-use) as long as a certain balance of factors or conditions which led to the initial adoption/non-adoption decision is not disrupted.

This theoretical stance fails to explain numerous instances of initial adoption of new technologies or systems that were later orphaned (e.g. Kumar and Best, 2006; for a more general account cf. Fortune and Peters, 2005). It is also difficult to reconcile with the notion of institutionalization of a system or a new technology which suggests that it takes some time before ongoing use of a new technology or system can be assumed which is not assured by the initial intention to use it. On a more fundamental level, it is not at all clear what institutionalization of a new technology or system means theoretically, which criteria can be used to establish successful institutionalization empirically and which predictions about future use can be derived from successful institutionalization as institutionalization seems to imply that future use is highly likely while certainly not inevitable. This latter point becomes crucial if one acknowledges that environmental conditions prevalent at the time of the adoption decision are in a state of constant flux which raises the question of whether the initial adoption decision has to be continuously renewed in the face of continuously changing decision parameters. Put differently, many systems and technologies, once successfully institutionalized, seem to be characterized by a certain degree of resilience vis-à-vis environmental changes and even shocks. Resilience does not necessarily or even generally imply that systems do not change in the face of environmental shifts and shocks, but they change in a way which preserves their main traits while ensuring their survival. In sum, theories of technology/system use that were characterized as inertia theories above do not address the issues of persistence and resilience pertinent to the explanation and management of real-life systems. We argue that this is because inertia theories assume that ongoing use can be taken for granted rather than as an active achievement of system participants in need of a theoretical explanation.

In order to address the problem of persistence and resilience of IOIS we present a new theoretical framework which does not follow the inertia paradigm outlined above but a reproduction paradigm characterized by the assumption that in the social world systems need to be continuously reproduced in order to persist, adapt and evolve. In terms of the inertia view on system adoption, reproduction would need to be interpreted as a continuous renewal of the decision to use a system or technology

since all human action is explained as implementation of prior decisions. Once it is acknowledged that a large part of human action is routine in nature -- certainly actions related to operational system use -- this assumption becomes unsustainable. The question then is how system routines are maintained over time and how they adapt and evolve without necessarily implying that maintenance and evolution are the result of conscious decisions while acknowledging that occasionally conscious decision making plays a role in their maintenance and evolution. We present a model of inter-organisational information systems which is based on the notions of system reproduction and practice. Practice Theory provides a rich description of routine work which also allows for reflexive action and decision making. The concept of system reproduction addresses the question of how routines are maintained and how they evolve without having to revert to a continuous decision making process.

In developing our theoretical framework, we are aware of a growing body of literature drawing on the same theoretical perspectives which, however, focuses on explaining the organizational or institutional effects of new technologies or, in the opposite direction, the shaping of new technologies through organizational and institutional factors (cf. e.g. Markus and Robey, 1988; Orlikowski, 1992; Orlikowski et al., 1995; Markus, 2004). Yet, this literature has moved towards understanding information systems as "technology-in-practice" (Orlikowski, 2000) which implicitly provides cues for understanding persistence and resilience of (inter-organisational) information systems. We therefore regard our attempt also as an effort to extend these models so as to obtain a theoretical basis for addressing the twin issues of persistence and resilience. Apart from contributing to an understanding of the issues of persistence and resilience, we contribute to the general IS literature by (1) demonstrating a new way how basic concepts of Structuration Theory can be made operational so as to be applicable to empirical research and (2) clearly positioning the role of technology in a Structuration-theoretic framework. With regard to the first issue, it is often claimed that Structuration Theory is too abstract to be directly useful for guiding empirical work (Rose, 2001; Pozzebon and Pinsonneault, 2005). Regarding the second issue, a failure to clearly position the role of technology in IT research has famously been pointed out (Orlikowski and Iacono, 2001). Both contributions became possible through elaborating the notion of communities of practice in the context of IOIS.

The topic of inter-organisational information systems seems especially in need of such an approach because these systems cannot be explained through existence of a unitary actor (Johnston and Gregor, 2000). A unitary actor, such as top management, is often quoted as the source of system adoption and use decisions in the IOIS area. While this approach is problematic in these cases too, at least it is possible to argue that the hierarchical mechanism of aggregating individual decisions is in principle available for making adoption decisions within an intra-organizational context. In any case, the existence of a similar (fictitious) unitary actor cannot be assumed for explaining adoption and use of IOIS (except in cases where systems are imposed by governments) so that alternative explanatory routes need to be explored. As the model presented in this paper does not start from an individual-based decision-implementation paradigm but from the construct of socially reproduced practice, lack of a unitary actor does not pose a problem in itself for this model.

The model presented in this paper has been developed in an iterative process of collecting data and validating theoretical instruments for the description and analysis of IOIS. Data collection was done within the framework of an international collaboration of researchers and involved the study of IOIS in one industry -- pharmaceutical distribution -- across four countries (Ireland, Australia, Germany, China) over a period of two years. IOIS in this industry are remarkable because they typically have existed for two decades or longer without much change. In our search for appropriate theoretical bases to account for this longevity we came to realize the fact that existing theoretical approaches do not consider the problems of persistence and resilience.

The main part of the paper (Section 2) is devoted to developing the theoretical model in five steps. We first motivate our choice of theoretical bases (2.1), then derive the main building blocks of the model, namely practices (2.2) and connections between practices (boundary objects; 2.3) in order to define IOIS as a constellation of practices connected by a special type of boundary object (2.4) as well as the notions of persistence and resilience and how they can be understood in relation to IOIS (2.5). In the

third section, we discuss methodological implications for empirical research and in the concluding section we summarize the theoretical contributions of the model to the IS literature, relate these to other theoretical approaches based on similar theoretical perspectives and outline possibilities for further research.

2 IOIS AS CONSTELLATIONS OF CONNECTED PRACTICES

2.1 Theoretical bases

As we are concerned with explaining persistence and resilience of IOIS and focus on routine action, we have selected Structuration Theory and Practice Theory as our broad theoretical orientation. Structuration Theory emphasises the reproduction of social structure by claiming that social structure is never created but always reproduced. Through its notion of duality of structure, it attempts to overcome the classical dichotomy between structure and action characteristic of broad swathes of the social science literature. Duality of structure means that, while structure constrains but also enables action, it is at the same time reproduced through the very actions that it enables and constrains (Giddens, 1984). As a consequence, structures cease to exist if they are not continuously reproduced through action. Thus, the notion of duality of structure promises to be helpful in understanding the problems of persistence and resilience of IOIS since persistence and resilience imply the continuous reproduction of structural properties of these systems.

In addition, Practice Theory -- we mostly draw upon the literature on communities of practice as our main reference (Wenger, 2002) -- promises to be useful for our purpose because it describes how routine action is maintained in social interaction. Specifically, it describes the circumstances and conditions of routine action which enable people to solve the myriad problems that occur because of conflicting institutional requirements that they are confronted with in their daily routines as well as to handle the many exceptions that arise because tasks do not fit into the standard procedures prescribed in manuals. Through mutually supporting and learning from each other a community is formed which maintains the routines that are the backbone of the practice while also allowing for these routines to continuously evolve and adapt to ever changing environmental conditions. This mutual engagement is called participation and is complemented by "forms" around which practices are organized. These can be material objects as well as more abstract things such as ideas and norms and are summarized by Wenger's (2002) use of the concept of reification. Practice Theory can be viewed as a more concrete instantiation of Structuration Theory since it shares with the latter the main idea of duality of structure but provides a more specific vocabulary for describing concrete social settings, especially those concerned with routine behaviour. In contrast, Structuration Theory was developed in view of a broader set of social phenomena including those which do not follow routine patterns of action. Our subject -- IOIS -- however warrants that more narrow focus on routine action and will thus benefit from the more specific vocabulary and conceptual apparatus provided by Practice Theory. In addition, through focusing on communities which share and continuously (re-) negotiate a common understanding of their enterprise, Practice Theory also provides a conceptual tool for describing collective action.

2.2 Practices

We define a practice as a common enterprise of a group of people which mutually engage with one another in order to build trust and relationships that can be drawn upon when problems arise and which, through regular interactions, develop a shared language (Wenger, 2002, p. 46). In addition, we draw on Reckwitz (2002) by claiming that a practice is characterized by routinized bodily activities. This emphasis on the role of the body also helps us to clearly position material structures, including technology, in our notion of practices, an issue which has not yet been resolved in Structuration Theory (cf. Orlikowski and Iacono, 2001, and Jones, 1997). The physical environment as a major part of what we mean by material structure interacts with the body in a routine way so that material structures acquire cues which help people to move from one step to the next in their daily routines without having to direct conscious effort at their tasks. As an illustration, consider how the fingers of an experienced (type-) writer "know" how to write once they touch the keyboard without the person having to

consciously select and hit each individual key. Rather, the person can focus on the contents of what she or he is writing and leave the task of typing entirely to the entity formed by the fingers and keyboard. For the fingers (as the relevant part of the body) to be able to perform this task they need to obtain tactile feedback from the keyboard (which anyone will have noticed who has tried to type using a so-called laser-keyboard which is a virtual keyboard projected onto a flat surface on which a visual representation of a keyboard is created but not a tactile one).

In addition to material structure, we distinguish normative and cognitive structure which are reproduced through routine actions within a practice. Normative structure refers to moral rules which help to distinguish right and wrong actions. Cognitive structure refers to mental models of cause-effect relationships which help to make sense of or explicate actions. A similar distinction between these three types of structure can also be found in Structuration Theory where our structural dimensions would be called facility, norm and interpretive scheme (Giddens, 1984, p. 29). However, Giddens does not provide an explicit role for material structure in his framework; rather, the notion of "facility" refers to power structures in social systems. In contrast, other theoretical traditions that also rely on a similar distinction between structural dimensions clearly position material structure as one of them (e.g. Child, 2000).

In order to provide a more fine-grained tool for describing material structure, we further distinguish aspects of material structure, distinctions that we cannot base on existing theoretical concepts and for which we thus can claim only tentative theoretical validity. Material structure can constrain/enable action physically as well as symbolically. For example, a barrier on the street constrains/enables actions of a driver physically while a line does so symbolically. Symbols do also have a physical existence but their physical nature is second-order in nature in the sense that their physical being has come to stand for something else (Stamper, 1997). For example, the physical nature of a bank note comes to the fore when one uses it to scribble down a telephone number; however, the same piece of paper takes on a purely symbolic nature if one uses it for making a payment. Apart from monetary structures we are naturally particularly interested in informational structures, both of which use objects as representations of other objects.

According to Structuration Theory, these structures are reproduced through actions. Since Structuration Theory is not very explicit on how reproduction occurs, we draw on Practice Theory to obtain more concrete concepts that allow us to trace the reproduction process empirically. Practice Theory states that reproduction of structure occurs through a constant process of negotiating meaning (Wenger, 2002, p. 96). The negotiation of meaning, in turn, occurs through the repeated production of patterns (of behaviour) which "give rise to an experience of meaning." (ibid., p. 52). These patterns -- although conceptually distinct from structure -- can then also be distinguished according to the dimensions of structure described above. Actions enabled/constrained by material structures result in a patterned flow of things, symbols, and money which reassure people who observe or create these flows about the properties of the material structures which enabled/constrained the actions; for example, a continuous inflow of new email messages reassures a user that the email infrastructure is working. Regarding the type-writing example described above, the flow of symbols appearing on a screen as one types reproduces the structural properties of the keyboard in so far as these constrain and enable action, in this case typing. Actions which are enabled/constrained by normative structures create a pattern of (positive and negative) sanctions indicative of the norms that guided these sanctioning actions; observing or creating a pattern of sanctions reassures the actor and the observer about the validity of the norms that have enabled and constrained the actions producing this pattern. Finally, actions enabled/constrained by cognitive structures result in discursive or argumentative patterns which reconfirm both the speaker and her/his audience of the validity of the cause-effect schemas that informed her/his arguments (see Fig. 1).

In addition to the vertical relationship of reproduction of structures through patterns of behaviour, the several dimensions of structure can also reinforce or weaken each other. These horizontal relationships can be described as processes of materialization and legitimization (see Fig. 1). The process of *materialization* is the reinforcement of structures in harder or more concrete forms. A cognitive structure

becomes more robust if it is also reinforced by a normative structure, i.e. the rationality (truth) of an idea is stronger if it is also seen as "right". In addition, behaviour which is considered as rational and right might also be suggested through suitable arrangements in the physical environment which is referred to in Actor Network Theory as "inscription" (Akrich and Latour, 1992). Continuing an example used above, a cognitive structure could explain why it is better to not 'cut' a curve when driving on a street; a normative structure may expose such behaviour as socially undesirable and a physical line on the street may additionally guide drivers. However, structures may also compensate for each other as would be the case when a physical barrier on the street prevents cutting curves which could compensate for a lack of suitable normative and cognitive structures. Normative and cognitive structures could also be "inscribed" in symbolic structures such as data structures and digitised processes, a phenomenon which Kelly (2005) refers to as "digiscription".

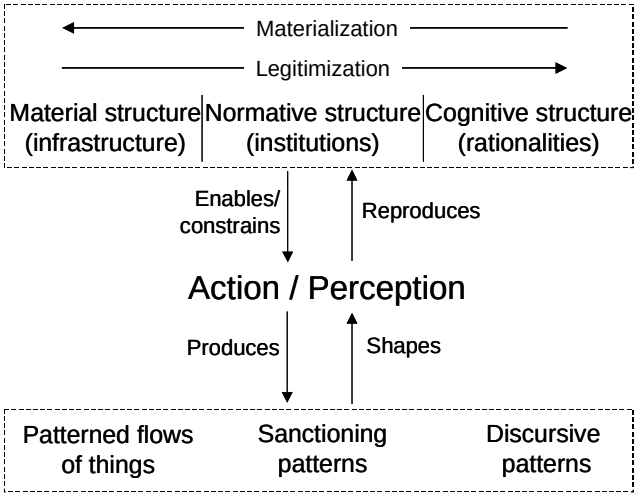

Figure 1: A model of reproduction and reinforcement of structure

In the opposite direction, physical infrastructures will be strengthened if complemented by appropriate normative and cognitive structures. For example, a "soft" barrier on the street is likely to be flattened soon by cars criss-crossing over it if normative and cognitive structures are not in place which would additionally guide behaviour. We call supportive relations in this direction *legitimization* as norms and ideas provide the normative and cognitive backdrop against which material structures are evaluated.

2.3 Connections

Practices as defined above may be linked either through brokers or boundary objects (Wenger 2002, p. 105). Practices are linked through *brokers* if one person is a member in several practice communities. In addition to connecting practices through multiple membership, brokers are able to "translate" meanings between practices, e.g. when a youngster explains to his or her parents what certain actions in his/her clique mean. He/she is able to do this because he/she is also a member of the family which has formed its own practice. Thus, brokers do not only connect practices but also help to align them so as to facilitate transactions between them (ibid., p. 109).

Boundary objects link practices in a similar way, i.e. by populating several practices simultaneously. However, while boundary objects connect practices, they do not also ensure that the interpretations and actions related to them but separated by practice boundaries are also coordinated as is the case where practices are connected by brokers. In Wenger's (2002, p. 108) words: "Jurisdiction over various aspects of a boundary object is thus distributed among the constituencies involved, and using an artefact as a boundary object requires processes of coordination and translation between each form of partial jurisdiction.".

One possibility to ensure alignment between practices is to complement boundary objects with brokers. Wenger (2002, p. 112) recommends this as an effective way of connecting practices. Another

possibility of aligning practices derives from so-called encounters (ibid.). Encounters involve that representatives (delegates) of connected practices meet in order to negotiate meaning, norms and material structures associated with each practice individually. These encounters may then lead to modifications in behavioural patterns reproducing these structures so that connected practices become more aligned. Both types of activities can become practices themselves; *brokering practices* occur in a wide variety of forms and types that have established themselves as distinct communities of practice in economic life. Encounters between practices become *boundary practices* (ibid., p. 113) if their enterprise becomes maintenance of the boundary between connected practices.

2.4 Inter-organisational Information Systems

Based on these concepts, we define an inter-organisational information system as a set of practices residing in separate organizations but connected through a special type of material boundary object, namely either a shared data processing application or a common structure and definition for data to be exchanged between independent data processing applications. Examples for the latter are bi- or multilateral EDI systems and for the former electronic marketplaces. This definition differs from others (e.g. Cash, 1985) because it implies that a condition for the existence of an IOIS is that it is in ongoing use: the existence of certain trans-organisational technologies or procedures is not sufficient. As a consequence an IOIS is never adopted or implemented in the narrow sense implied by the inertia theories discussed earlier: for an IOIS to be said to exist it must be in use, that is, "already-implemented". Practices must exist which are linked through technical objects, but mere existence of these technical objects does not in itself constitute an IOIS. However, IOIS as defined here can certainly cease to exist so that the definition is not tautological with regard to our main research question in the sense that this definition does not already imply continued existence or persistence.

Persistence and resilience become problematic especially in view of the nature of boundary objects which constitute an IOIS in this sense. Star and Griesemer (1989) emphasize that boundary objects need to be interpretatively flexible to some extent so that they allow for differing interpretations (and actions) in connected practices. Data processing applications and data structures, however, are not "plastic" in this sense but "brittle", meaning that their quality as a boundary object hinges on precise definitions and uses that are associated with them. This is because these boundary objects are either pre-structured ways of processing and/or storing data or data structures meant to enable automatic data processing which eliminates the interpretive flexibility that other types of boundary objects, such as geographical maps, have when interpreted by humans belonging to different communities of practice (ibid.). In terms of our connected practice model, boundary objects imply the possibility of divergent reproduction of material structures which becomes a problem if the boundary object is not "plastic" as is the case with regard to shared data processing applications or common data structures. As a consequence, the need for alignment between practices connected by such boundary objects becomes a major vulnerability so that continued existence of IOIS becomes problematic.

2.5 Persistence and resilience of IOIS

Based on our definition of IOIS and the description of alignment mechanisms we can now proceed towards explaining persistence and resilience of IOIS. According to our reasoning above, persistence is problematic even without environmental changes because structural reproduction occurs in two separate communities of practice which implies the possibility of divergent reproduction while these practices are connected through boundary objects. Resilience refers to the ability of constituent practices of an IOIS to absorb environmental changes such as introduction of new rules, technologies, or business models. The notion of resilience can thus be understood as a complement to the concept of persistence. It refers to the same phenomenon (continued existence) but addresses a different problem (adaptation to environmental changes vs. divergent reproduction).

Persistence: The "brittle" nature of boundary objects constituting an IOIS would lead one to predict a short lifecycle for IOIS if there were no alignment mechanisms in place compensating for the possibility of divergent reproduction in constituent practices, i.e. the practices connected by the boundary object. For example, if a product identification code used by a customer is not recognized by a supplier's

internal order processing application, the data flow pattern will be affected (e.g. order confirmation data will not be received or a stream of failure notices may replace it) which indicates a problem with the material structure from which these data flows emanate. Without encounters or brokering activities, these problems cannot be resolved. In contrast, a more interpretatively flexible boundary object such as a written order usually contains more cues which may allow for correct interpretation of the intent of the document. Even in this case, however, brokering actions or encounters may eventually become necessary for people to be able to go on with the task of processing an ambiguous order. As the material structure involved in, e.g., an EDI application continues to not be reproduced through confirmatory data flows, actors may conclude that either manual back-up structures need to be put in place -- thus effectively duplicating the data flow and associated material structure -- or to completely bypass the structure. As reproduction occurs through instances of action/perception by human actors, data flows are always open to deviating interpretations even if, from a technical perspective, they would be considered "correct". A typical example concerns delays in data flows. Consider the frequent experience of PC users whose machines seem to have "stalled" but are in fact just busily processing an extra-large number of near simultaneous commands; this impression may lead the user to prematurely restart his/her computer (because, to the user, the required structural properties are not reproduced). Similarly, failure to receive an urgently expected order confirmation may seem to people in the procurement department to indicate a problem with the EDI application possibly triggering the premature placement of substitute or faxed orders. We therefore propose that ongoing existence (i.e. persistence) of an IOIS requires frequent brokering actions and/or encounters. In fact, persistence of an IOIS would be considered as to be precarious if it depended upon individuals initiating brokering actions or encounters in an ad hoc manner. In contrast, if brokering actions and encounters themselves become practices with their own associated communities -- brokering and boundary practices --, persistence of an IOIS will become much more likely if not guaranteed because communities of practice contain mechanisms for extending their existence in time (Wenger, 2002).

Resilience: Extending an old idea in organization theory, we suggest that resilience of an IOIS increases as (a) there are more mutually reinforcing horizontal linkages which, however, are (b) more loosely coupled (Weick, 1976). If using a *specific* technology is considered as rational as well as morally right in the context of a given practice, introduction of a new technology would be viewed as a severe disruption and threat to that practice. For example, in some computer science circles using Word as a text processing software is seen as morally wrong while using LaTex is seen as morally right (these people will also readily give a number of reasons for this attitude). However, if a given technology would be considered to be broadly in line with accepted wisdom and extant moral rules, replacing that technology by a similar (but not identical) technology would be relatively straightforward. In contrast, a practice tied to a specific technology would be highly stable but severely disrupted if that technology was not maintained any longer, in other words, it would not be resilient. In addition, if several linkages existed among structural dimensions, adaptations to instances of changes in individual structural properties will be easier because more possibilities exist to embed a new rule, technology, etc. in an existing practice through horizontal linkages. For example, if use of a certain technology is justified by a cost saving rationale as well as by an ergonomics rationale, a new technology which would satisfy only the former could still be justified based on the existing cognitive structure. Thus, an IOIS whose constituent practices are characterized by multiple horizontal linkages among its structural dimensions would be relatively more resilient.

On a more general level, persistence and resilience can be related to the vertical and horizontal relationships in our model (see Fig. 1) of reproduction respectively. While persistence concerns effective maintenance of reproduction of structure, particularly across organizational boundaries, resilience refers to the flexibility and multiplicity of linkages among structural dimensions of connected practices. Epistemologically, persistence and resilience are not seen as effects of certain factors; rather, certain processes (effective reproduction of structure, flexible and multiple coupling of structural dimensions) are considered necessary and possibly sufficient conditions for persistence and resilience.

3 IMPLICATIONS FOR EMPIRICAL RESEARCH ON IOIS

The model outlined above points towards a rather different approach towards describing and explaining IOIS than is prevalent in the literature. To start with, focusing on technical aspects of an IOIS will not be sufficient for its description; rather, normative and cognitive structures would have to be included in the description as well. At the same time, descriptions of the material aspects of an IOIS are likely to be much more detailed and precise, specifically with regard to how they interact with the human body. For example, details such as which data that have been transmitted are displayed on which types of screens, to whom, under which conditions, the physical location of displays and how they are separated or not separated from other parts of the workplace would all seem to matter for the question of how material structures are reproduced. With regard to automated processes, specific attention would be drawn to failure messages and other physical cues that allow workers to ensure a more or less smooth functioning of the automated processes. In contrast, description of the automated processes themselves, how certain processes are triggered into action, how data are stored or manipulated, would be considered to be within the realm of the engineer unless these mechanisms also contain cues for maintenance workers in case something goes wrong.

Concerning the "function" of IOIS, a new perspective would have to be adopted here too. Rather than describing the function of an IOIS from an overall, quasi-objective point of view one would have to reconstruct the function(s) of an IOIS through the eyes of people participating in the practices that constitute them. It may make a difference whether the function is described as ordering, re-ordering, replenishment or stock management, although, from a supposedly more objective outside perspective, these objectives would be considered variants of the same operational process. Thus, the function of an IOIS becomes part of the cognitive structure which is reproduced in the connected practices implying that an IOIS does not have an overall function -- because several practices are involved in an IOIS -- unless boundary practices exist which reproduce such an overall perspective on the function of the system. Actually, the objective outside view on the function of a system is always also a normative and a cognitive view in that it prescribes a certain function of an IOIS that it expects its participants to recognize. (Notice the change of language: rather than speaking of users of an IOIS we prefer to speak of participants in an IOIS, a direct consequence of our definition of an IOIS as connected practices.)

Finally, normative and cognitive stances and valuations would have to be described as an integral part of an IOIS. What is the "right" way of doing business (in this culture, in this industry, in this organisation)? What is appropriate business behaviour between business partners or competitors specifically with regard to participation in the IOIS? Which expectations have participants towards adherence to standards or appropriate or undesirable technologies? What is the "rational" way to organise and automate production/distribution according to current technological "visions" influential in this era, culture, or industry (Swanson and Ramiller, 1997)?

As with material structures, one would also have to look for behavioural patterns associated with normative and cognitive structures, specifically sanctioning and discursive patterns. On what occasions do participants complain about the behaviour of others (who might be participants in the same practice or in a connected practice)? Which further measures are initiated on such occasions? Which discursive (argumentative) patterns do participants use in order to justify their actions or criticise those of others? How do they justify, fail to justify the purpose of the IOIS in which they participate?

Methodologically, collecting such data becomes a rather challenging task. While data on supposedly objective structures such as interface specifications, message and database structures, software programs, computers and processes -- the main vocabulary of extant descriptions of IOIS -- are relatively straightforward to collect, data on normative and cognitive structures are obviously more hidden. Specifically, triangulation of data becomes a sine qua none for verifying existence and nature of normative and cognitive structures. Literal transcriptions of interview data cease to be optional. In addition, patterns of data flows, sanctions and discussions need to be captured. While it may be possible to obtain such data from the recollections of interviewees, direct observation would seem to provide more valid data on behavioural patterns. In addition, deep immersion techniques like participatory observation

and shadowing may be considered as these methods are aimed at uncovering normative and cognitive structures which are not easily explicated in interviews or readily accessible to direct observation.

Analytically, horizontal and vertical relationships need to be reconstructed. This can only be done interpretatively. The researcher hypothetically takes the position of a participant in a practice and considers the possible effect of observing/engaging in the production of certain behavioural patterns as well as interpreting the relationship among instances of structure associated with different structural dimensions. Thus, the main method of analysis is hermeneutic. The result of such analyses are statements about whether certain structures are reproduced and reinforced.

Bounding an IOIS also becomes a difficult but manageable task. It is done by iteratively identifying practices and boundary objects. For the task of identifying practices, Wenger's (2002, chapter 5) list of criteria may be helpful. Boundary objects are such objects which are simultaneously reproduced in two or more practices. IOIS are constituted through a specific type of boundary object -- a shared data processing/storing application or a structured data format -- identification of which, however, rests on an accurate description of reproduction processes in a practice. Therefore, empirical identification of an IOIS has to proceed in a lock-step fashion which iterates between data collection (regarding structures and patterns) and data analysis/interpretation which establishes whether a community of practice and a supposed boundary object actually exist. Thus, the result of the description of an IOIS is at the same time the result of its analysis.

Explanation of persistence and resilience of an IOIS would then have to trace how adjustments in connected practices were brought about so that boundary objects continued to be reproduced over the period of observation. This could be done either through tracing single actions of brokering and encounters or through describing brokering and/or boundary practices if these have emerged. If the latter is the case, one may also attempt to predict the likelihood of continued persistence/resilience in view of expected environmental changes and with knowledge regarding reproductive effectiveness, multiplicity and flexibility of horizontal couplings among structural dimension in constituent practices.

4 DISCUSSION AND OUTLOOK

In this paper, we have developed a new model of IOIS which specifically addresses the question of how to explain persistence and resilience of IOIS, a phenomenon prevalent in many industries in which IOIS have persisted over long periods spanning two or more decades and adapted to massive changes in technological, regulatory and competitive environments. Apart from contributing to this direct concern, we claim to have contributed two major theoretical insights to the IS field in the course of developing our model through combining Structuration and Practice Theory. Regarding Structuration Theory, an often voiced criticism is that it is too abstract to be used for empirical research (cf. Pozzebon and Pinsonneault, 2005; Rose, 2001; Jones, 1997; Walsham, 1993). By combining it with concepts from Practice Theory, we were able to derive conceptual tools that facilitate empirical work as well as data analysis. We therefore consider our first major contribution to consist of showing how Structuration Theory can be usefully applied to the empirical study of IS phenomena. The crucial step consisted of the insight that Practice Theory provides a requisite bridge between the abstract concepts of Structuration Theory and the need for concrete descriptive tools in the realm of IS.

Secondly, we claim that our use of Practice Theory has contributed to solving a major problem in the application of Structuration Theory to technology studies, namely to clarify the ontological position of technology in information systems. The emphasis Practice Theory puts on the role of the body in social action provides the conceptual handle that was needed to demonstrate the material structure (including (information) technology) is reproduced in exactly the same way as other structures (normative, cognitive), namely through behavioural patterns created through actions which are enabled/ constrained by structure(s). This contribution not only satisfies the theoretically inclined researcher but has practical consequences for the type of data to be collected. Specifically, the focus of data collection is on the on-going active accomplishment of skilled participants in the face of frequent failures and interruptions in a supposedly largely automated process such as order or invoice processing, such

as their responses to exception handling and breakdown cues (Weick, 1990). Observation of such interventions exposes the material, symbolic, normative and cognitive structures implicated in the social embedding of automated data processing that is being reproduced (or not reproduced) which provides the crucial empirical lever for explaining persistence and resilience. In contrast, descriptions of IOIS from the perspective of the functional (intended) logic have almost no place for human agency (other than in the form of system development and handling those bits of operational processes that are not yet automated); as a consequence, operations (of an IOIS or other system) become machine-like. From a Practice Theory-perspective, it is only through describing (and observing) how humans (with their bodies) interact with material structure that the materiality of the system becomes visible.

In the course of developing our model, we have found many parallels and similarities to other approaches. For example, our use of cognitive structure as an integral part of an IOIS can be usefully related to the concept of the "organizing vision" as developed by Swanson and Ramiller (1997) and its materialization to the idea of the "spirit of technology" proposed by DeSanctis and Poole (1994). The role that patterns of behaviour play in the reproduction of cognitive and normative structure has been elaborated by Weick and Roberts (1993). The importance of skilled participants in the operation of automated systems has been demonstrated by Weick (1990) in his discussion of "technology as equivogue". These approaches, however, focus on single aspects of our model which integrates these and others in view of the study of IOIS.

We propose three directions for further research which appear to us a especially promising. So far, we have treated data (and data flows) as a special (symbolic) form of material structure. This, however, merits a deeper investigation with regard to the general role of symbols as material structures which have come to stand for something else. This seems to be especially important for the IS field since manipulation of symbols is the core process performed by computers which arguably are an important part of information systems.

Secondly, we have limited the scope of our paper to discussing the conceptual tools for explaining persistence and resilience. However, evolution seems to be a closely related issue that probably could usefully be tackled on the basis of our model. One idea is to view evolution as the emergence of new practices associated with an IOIS or the merging of existing practices. However, how such processes could be explained in terms of reproduction, materialization, legitimization, connection and alignment -- the processes that we have articulated so far and which turned out to be relevant for explaining persistence and resilience -- is an open question. It might also be necessary to define new processes in order to satisfactorily explain evolution of IOIS.

Finally, we are strongly interested in explaining the influence of context variables such as regulatory or cultural environment in which IOIS persist, adapt and evolve. However, it is not yet clear how to model such context variables. On the one hand, it would seem straightforward to model them as part of structure which constrains/enables action relevant for the reproduction of an IOIS. However, it also seems to be the case that these context variables are not reproduced in the same sense that other structures more immediately associated with the IOIS are. Thus, the question arises how to incorporate different contexts in our model of IOIS so as to be able to explain the way that IOIS persist, adapt and evolve in these different contexts while not violating the basic premises of Structuration and Practice Theory, namely that the structures which enable/constrain action are also at the same time reproduced by such action.

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