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THE USE OF AN EXPLICITLY THEORY-DRIVEN DATA CODING METHOD FOR HIGH-LEVEL THEORY TESTING IN IOIS

Usage d'une méthode de codage des données explicitement théorique pour tester une théorie abstraite en matière de SI inter-organisationnels

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Abstract

As part of an international empirical study we have developed a high-level theory of the structure and evolution of inter-organizational information systems (IOIS), but face two issues in testing this theory; the very large set of factors possibly influencing IOIS and need to bound a complex research object. We describe a novel solution involving an explicitly theory-driven coding of our raw empirical data to produce a new interpreted "meso-level" ground upon which to derive and test predictions. To justify this approach, we first give a pragmatic analysis which traces the problem to the traditional choice between top-down (deductive) and bottom-up (inductive) methods for linking theory and data. We then assess the validity of our approach against standard philosophical positions. We find that a hard Empiricist view commonly espoused in information systems would not admit our approach but that Critical Realism does and suggests a conceptual interpretation of our meso-level.

Résumé

Nous décrivons une nouvelle approche pour valider une théorie très abstraite dans le domaine des Systèmes d'Information Inter-Organisationnels (SI-IO) en utilisant un codage explicitement théorique de données empiriques brutes pour produire une nouvelle interprétation de niveau meso, à partir duquel nous pouvons déduire et valider des prédictions. Nous discutons le choix pragmatique qui nous amène à notre approche et que nous validons contre les positions philosophiques communes.

Keywords: Research methods, inter-organisational information systems, Critical Realism, data coding

Introduction

Explaining the structure and evolution of information systems is a relatively recent endeavour. Traditionally, the study of information systems has focused on such topics as: success of information systems, economically and against other objectives; effects of information systems on the structure of organisations/industry/inter-organisational relations, power relations, skills and other dimensions; implementation processes; strategic issues; and management implications. In addition, there is a vast literature on the diffusion and adoption of specific information technologies. In contrast, there are few studies that attempt to understand the influences which shape the structure and evolution of individual information systems (Meier and Sprague, 1991; DeSanctis and Poole, 1994; Monse and Reimers, 1995; Crook and Kumar, 1998; Payton, 2000; Manske and Moon, 2003; Ravichandran et al.; 2007). This relative lack of academic interest in this topic has obscured two problems involved in such studies, namely a very large set of factors possibly influencing structure and evolution of information systems that need to be considered and the issue of bounding and describing information systems. Both problems thus need to be addressed as a precursor of such studies. We have done this by developing a high-level theory of inter-organizational information systems (IOIS) which has been presented elsewhere (Reimers and Johnston, 2008; Reimers et al., 2008). The purpose of this paper is to analyse the challenge of testing high-level theories, and to develop and evaluate a method for testing high-level theory in the realm of inter-organizational information systems.

There have been some efforts towards using high-level theory in the IS literature which, however, have restricted the use of high-level theories to function as a research lens or a 'sensitizing device', i.e. for informing the researcher about the type of problems or issues to be addressed as well as providing guidelines for interpreting research results (Barrett and Walsham, 1995; Orlikowski, 2000; Johnston and Gregor, 2000; Rose, 2001; Pozzebon and Pinsonneault, 2005). However, no effort has yet been made in the IS field to develop a systematic method that guides the researcher from high-level theory to data collection procedures to data coding to data interpretation.

Using empirical data we have collected in field interview-based research in the pharmaceutical industry, we describe a novel solution to testing our high-level IOIS theory using an explicitly theory-driven coding of our raw empirical data to produce a new interpreted "meso-level" ground upon which to derive and test predictions. The paper presents a systematic analysis of the problem which led us to this approach and discusses the validity of our solution. First we give a pragmatic analysis which traces the problem to the traditional choice between top-down (deductive) and bottom-up (inductive) methods for linking theory and data. We illustrate this point by analysing the limitations encountered in two published accounts (Ravichandran et al. 2007; Crook and Kumar, 1998) of similar research in IOIS, one top-down and the other bottom-up. We then assess the validity of our approach against standard philosophical positions. We find that the Empiricist view commonly espoused in information systems would not admit our approach. However, Critical Realism as applied by Mingers (2000, 2004, 2006a, 2006b) to the IS realm does, and suggests a conceptual identification of our meso-level with the domain of Actual events in that framework. Critical realism also allows us to define high-level theory precisely. The novelty and contribution of the paper is that it proposes a method for bridging the gap between high-level theory and empirical data in the domain of IOIS, and discusses its validity against standard philosophical positions.

Practical Problems of Studying Large IS Phenomena

We set out by describing our intellectual journey as we planned and then conducted an international comparative empirical study of inter-organizational information systems and encountered practical problems in relating theory to data that we had collected or were planning to collect. We first discovered that the traditional approaches, which we will call top-down and bottom-up, did not work for us. We then proceeded by developing a theory which seemed to emerge from our case study experiences, because we felt that this was necessary to address the size of the problem that we had presented ourselves with. Finally, from our efforts to connect this theory with our data in a more complete and rigorous way emerged a method which combines the top-down with the bottom-up approach. In this section, we present these steps in chronological order and will raise the question of the validity of our resulting procedure in later sections.

Attempts to Use Traditional Approaches

In our attempt to understand structure and evolution of inter-organisational information systems we started in the traditional way of selecting a theoretical framework and deriving testable hypotheses from it. Our research design consisted of a multiple case study of inter-organizational information systems in different industries and countries since we believed that important influences on the structure and evolution of inter-organizational information systems would reside on the level of industries (such as industry structure) as well as of whole countries (such as national culture and government policy). The multiple case study design allowed for theoretical replication (Yin, 1994) since different factors should have a predictable influence on the structure and evolution of inter-organizational information systems. However, the broad set of possible influences implied that we used a large number of theories to predict the influence of individual factors. In total, ten theories were used to generate 61 hypotheses, (including 13 hypotheses concerning the interaction among independent variables) based on 40 variables, including dependent variables (see Figure 1 for an illustration). This large number of hypotheses clearly ruled out a statistical modelling approach while we also believed that we should not reduce this number because all hypotheses had a high level of plausibility with regard to our research question; thus, selecting individual hypotheses or theories out of the total set seemed to be arbitrary.
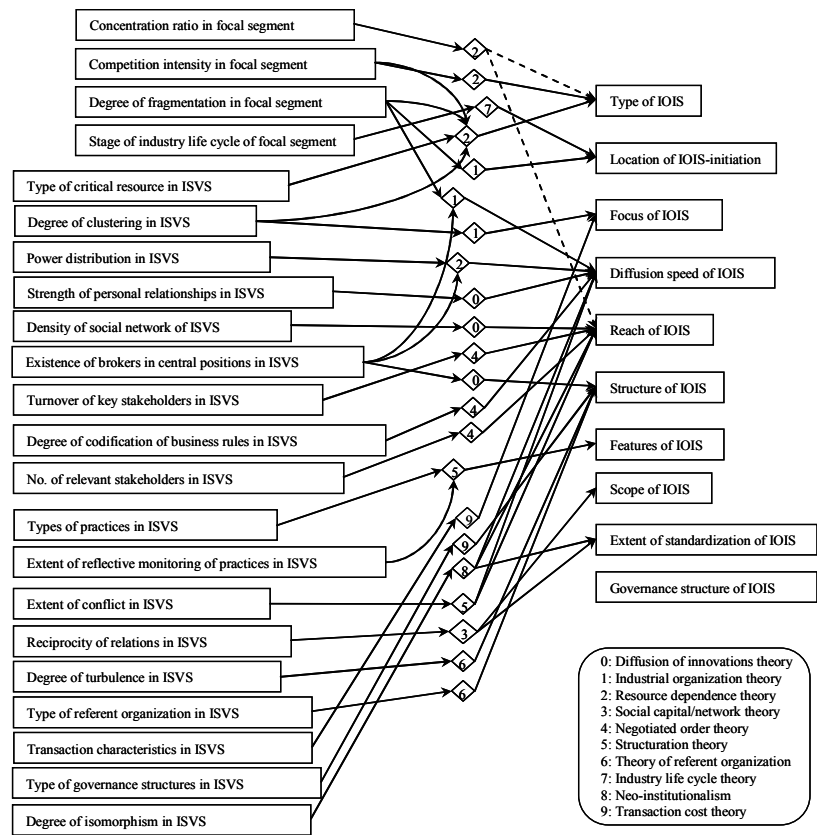

Figure 1. Partial view of our early factor-model concerning the influence of industry-level factors on IOIS

We also ruled out Grounded Theory (Glaser and Strauss, 1967; Strauss and Corbin, 1990), i.e. a bottom-up approach which might seem to offer a feasible alternative approach.[1] The reason for this decision was that our research object, inter-organizational information systems, is highly abstract. Specifically, it requires that a theoretical boundary condition be specified since organizational boundaries cannot be used for this purpose (Reimers et al., 2004). While, for

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[1] In the following, acknowledging that there is a significant debate about what actually constitutes GT in the wake of the conceptual split of its two founders -- Glaser and Strauss (Glaser and Strauss, 1967; Strauss and Corbin, 1990) -- for our purpose it is sufficient to define GT as a strict bottom-up approach, meaning that it is forbidden to theoretically derive hypotheses (Glaser and Strauss, 1967).

practical reasons, IOIS are generally defined in technical terms such as the exchange and automated processing of electronic data (see e.g. Swatman and Swatman, 1992), it is also generally understood that non-technical aspects (such as use knowledge and business processes) are an integral aspect of inter-organizational information systems. Our focus on explaining the structure and evolution of IOIS implies that we could not focus on particular aspects of IOIS such as use of certain standards or number of electronic linkages, a strategy which often suffices when investigating narrower research questions. In addition, our comparative approach required that we used a standardized way of bounding our research object so as to ensure that the systems that we identified were indeed comparable. We used industrial organization theory to bound our research subject which then suggested the other theories which we used for derivation of hypotheses. Since we had some precise theoretical concepts in mind (as described above), and because of the way we needed to bound our research object, a strict grounded approach was not possible. The deeper reason for this problem lies in the large empirical phenomenon that we intended to investigate.

Theory Development Phase

Discouraged by the apparent impossibility of testing a wide range of traditional IOIS theories in the usual way or inducing theory directly from detailed data, we used informal methods to develop a high-level theory for explaining and describing evolution and structure of inter-organizational information systems, based on our ongoing case study immersion in the phenomenon. This allowed us to integrate all variables that we considered to be important in explaining structure and evolution of inter-organizational systems while also enabling us to bound our research object theoretically and thus solved the two problems that we had encountered. We will define high level theory precisely in a later section. For now, we have in mind theories that attempt to elucidate causal explanations of rather widespread phenomena (Type II and Type IV theories in Gregor's (2006) taxonomy).

Our theory aims to describe inter-organizational information systems, to explain why specific characteristics persist and how IOIS respond to environmental changes. It does so by (1) showing the internal linkages between structures characterizing IOIS and by showing how these structures are interwoven with the environment and by (2) showing how these structures are reproduced in day-to-day processes. Uncovering the fabric of internal and external linkages allows for addressing the way that a given IOIS adapts to changing circumstance while at the same time maintaining its function and identity, a property which we call resilience, while uncovering reproduction mechanisms addresses the issue of persistence of an IOIS, which refers to the ongoing existence of certain aspects of systems which are characteristic for them.

The theory has been fully developed elsewhere (Reimers and Johnston, 2008; Reimers et al., 2008). We therefore outline it here only to the extent that is necessary to motivate the method that was developed to link the theory with our data. We started by identifying Structuration Theory and Practice Theory as our broad theoretical orientation which we then extended and integrated into a model of practice which is shown in Figure 2. The model distinguishes between structures and patterns -- which are linked vertically -- as well as between different dimensions of structure -- which are linked horizontally --. The vertical linkages describe the reproduction process while the horizontal linkages concern processes of materialization and legitimization.
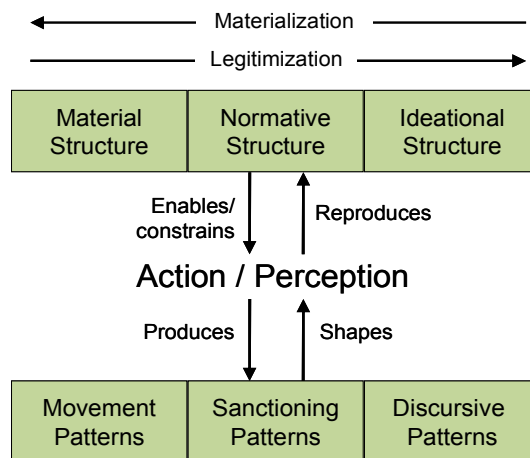

Figure 2. A model of practice

Based on Wenger (2002), we assume that structures are reproduced in communities (Communities of Practice (CoP)); new members to a CoP become attuned to these structures through apprenticeship, i.e. by observing the behaviour of experienced members and their responses to own engagement in action. New members try to identify patterns of behaviour, attempt to make sense of these observed patterns, i.e. sense possible structures which could have enabled/constrained the actions resulting in the observed patterns and then tentatively engage in their own actions, continuously adapting and updating their sense-making regarding rules and affordances. As such behaviour is repeated, parts of it become routine and automatic, i.e. some parts of behaviour are relegated to "body memory" which makes use of the affordances of the physical environment, including technology. Actors also develop a "moral sense" which helps them to distinguish right from wrong actions without the need for cognitive processing of information. Finally, actors learn how to rationalize their actions in view of ideas that are reproduced in that CoP.

The three dimensions which emerge through these distinctions (material, normative, ideational structures) have a counterpart in corresponding patterns, namely patterns of flows of material things (including movements of the human body), sanctioning patterns and discursive patterns. Actors may accidentally, consciously or strategically change these patterns which may affect the reproduction of structures; in addition, actors may change their perceptions of patterns which could also affect the reproduction of structures (Giddens, 1984). Thus, the process of structural reproduction allows for changes while structures cannot be changed arbitrarily. We further propose that, within a Community of Practice, the three dimensions of structure tend to be mangled together in the reproduction process, i.e. material structure is not reproduced in isolation through movement patterns and so forth. Rather, actions and perceptions always involve bodily movements, sanctioning patterns and, generally, the exchange of arguments. This mangling together stabilizes the reproduction process through processes of materialization and legitimization.

Several CoPs can be connected through brokers or boundary objects (Wenger, 2002; Star and Griesemer, 1989). Both brokers and boundary objects do this through multi-membership in the several communities. Brokers can also affect the reproduction processes in these several communities and thus align practices if that should become necessary, for example in view of transactions between communities. Boundary objects lack this ability but may have a high degree of interpretive flexibility, i.e. they may be interpreted differently and thus lessen the degree of requisite alignment between practices in cases of transactions. We define an inter-organizational information system as a set of CoPs located in separate organizations which are connected through specific boundary objects as well as through brokering or boundary practices. Boundary objects can be either a shared definition of data to be exchanged between data processing applications or a shared data processing application, including a shared database. Such boundary objects are "brittle", i.e. they are not interpretatively flexible, and thus need to be frequently aligned which can be done through brokers or so-called "encounters", that is meetings between delegates of the involved practices (Wenger, 2002). Both, brokering and encounters could become practices themselves which would be called brokering practices and boundary practices respectively. Figure 3 illustrates our definition of an IOIS for the case of aligning connected practices through a boundary practice.
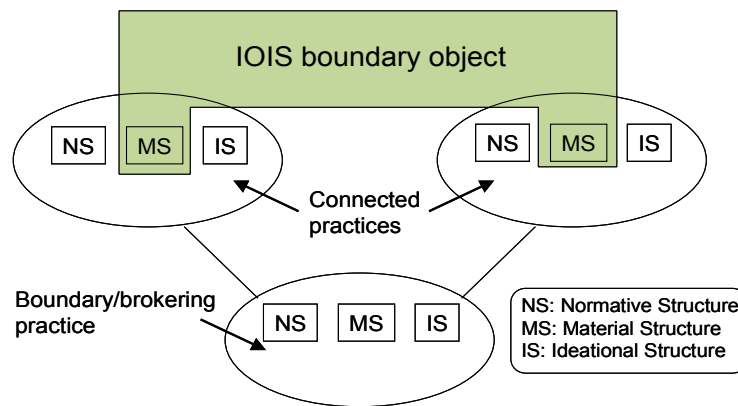

Figure 3. Illustration of an IOIS (instances of patterns are not indicated)

Using our theory, we aim (1) to explain why either of these IOIS types persist in a given context (property of persistence) and (2) to explain how they have responded to environmental changes in the past and their propensity of being affected by future environmental changes (property of resilience). Ideally, one would also like (3) to predict which type of IOIS would be sustainable in a given environment. However, the inherent openness and indeterminacy of reproduction processes would warn of such an effort. Yet, it may be possible to venture into predictions of

this sort if some prototypes already exist in a given context; specifically, if structural elements that have been found to be interwoven into the fabric of other IOIS can be identified in emerging situations it might be possible to anticipate with which other structures these elements will link up to forming a full-fledged IOIS.

Attempting to Test Our High-level Theory

We found that relating this high-level theory to our data is a huge challenge and next we will present the procedures which we have developed in response to this challenge. While we intended to identify instances of patterns and structures that are implied by our theory, it was clear that these were not immediately apparent in our data. Therefore, we had to interpret the data (in a way similar to GT) to detect them. Then we hoped to develop predictions from the theory at the level of these patterns rather than the raw data. Hence, what emerged was a meso-level (or a new interpreted ground) where high-level theory was to be tested.

We will set out by describing how we identified instances of actual structures and patterns in our interview data and how we built models of IOIS as sets of connected practices from these instances by linking them horizontally and vertically, identifying boundary objects and other categories of structure and showing how they are interwoven in the fabric of inter-linked structural incidences. We will also describe the coding principles that we have developed as we proceeded in our efforts to code the empirical data. We will illustrate the method we developed based on interview data on IOIS in the Australian pharmaceutical distribution industry. These data consist of transcripts of in total nine interviews with pharmacists, wholesalers, and vendors of pharmacy software yielding about 200 pages of text. The interviews have been conducted between April 2006 and September 2007.

Table 1. Example of a structural instance and its generic type

Short name	Generic Type	Actual Instance	Description by interviewees
Aggregation rationale	Replacing a n:m structure of links by a n:1:m structure reduces overall costs	The main advantage of the PharmX initiative is that it promises to replace the modem-based point-to-point connections through an Internet-based hub (p, q; N)	SG: Yes exactly, the biggest expense is trying to maintain the [communications systems]. Because from their end, from our point of view, we are maintaining thousands of individual connections, versus in the PharmX model, we are maintaining one connection with their gateway, and the vendor is managing all their connections with the pharmacy. [SG_API, p. 17]
			K: is that correct? Because maintaining one hub, it is much easier than maintaining 500 installations? PM: Yes I expect that is to be one of the things that is driving them and they share it as a common service between them and take a few extra bucks out of the system for themselves. So that is the sensible approach, it was probably first put forward about 10 years ago ... [PM_SYM, p. 14]
			PA: So we are a partner with PharmX, or a joint venture with PharmX and that has taken precedence. So instead of all the software vendors developing their own Internet computer to computer protocols, the Joint venture is so that we do not have to all duplicate the same code and features. [PA_COS, p. 3]

Note: lower case indexes of actual instances identify practices of which this instance is a part while capitalized indexes identify whether the instance refers to a system currently in use or a planned system (p: system maintenance at wholesalers; q: system maintenance at software vendors; N: planned system (PharmX))

Based on our model of practice, we first attempted to identify actual instances of the six types of structure/patterns described by this model in our interview data. We did this by developing short descriptions of such instances which are close to the descriptions used by interviewees and also by creating more abstract descriptions which would be applicable to other situations as well; we called these latter descriptions "generic types" while the former may be called "first level" descriptions. In contrast to the approach recommended in Grounded Theory (Strauss and Corbin, 1990) the purpose of creating generic types was not to build theoretical categories, i.e. this was not strictly an exercise of induction, but an attempt to develop a "coding language" to facilitate identification of actual instances of structure/patterns for triangulation and future coding efforts. Similarly, our first-level descriptions are not meant to be more abstract descriptions relative to the formulations used by interviewees; rather our formulations are intended to capture what the several interviewees whose words were used for developing our formulations would agree to as an accurate description of what they referred to in their words. As a consequence and in contrast to Grounded Theory, we used the first-level descriptions for further analyses.

As we triangulated instances of structures/patterns, descriptions of these instances and the generic types with which they were associated were updated. Each instance was indexed with the practice to which it supposedly belongs and

whether the instance refers to current systems or future systems. Table 1 renders an example including the generic type, the actual instance, and excerpts from the interview transcripts from which both were built.

In the course of coding instances of structure/patterns we had to distinguish between the different dimensions of structure according to our practice model as well as between structure and patterns. While in most cases, these distinctions were easily made, we also encountered cases which seemed to allow for several possibilities of classification. In these cases, we developed a principle or rule that was to be applied subsequently. Occasionally, we also revised these rules and the classifications which were made using the earlier version. Table 2 gives two examples out of a total of so far ten such rules, one concerning the distinction between two types of structure, the other concerning the distinction between patterns and structure.

Table 2. Examples of our coding principles

Distinguishing between material and ideational structure	If the effects of a certain material structure are just anticipated by extrapolating or assuming a certain material structure into the future, the resulting structure is an ideational structure because it as well as its effects are only imagined.
Distinguishing between material structure and flow patterns	In order to identify a material structure it should be possible to characterize it as a structure, level, scheme, dimension etc., i.e. through a noun which suggests invariability; in contrast, data or financial flow patterns, while stable to some extent, are only empirically so, not conceptually (examples would be flow, pattern, stream composition, (flow of) fees/costs/incentives, trend, stable/changing (market) shares)

In total, 136 instances of structure/patterns were identified in our coding effort based on ca. 200 pages of transcripts of which 51 instances were triangulated at least once. In addition, we also triangulated between two researchers with one doing a first round of coding and the second reviewing the results. The resulting descriptions of instances of structure/patterns were then used for further analyses. We performed two types of analyses corresponding with horizontal and vertical relationships in our practice model. Building a series of two-dimensional matrices we related all instances of structure to one another as well as all instances of structure to those instances of patterns in similar dimensions (material, normative, ideational). Doing so required that the analyst hypothetically takes the position of members enrolled in the practices that we were studying and asks himself/herself how, from this hypothetical position, he/she would evaluate the relationship between two instances of structure/patterns. Again, in the course of doing this we developed principles, some of which are shown in Table 3.

Table 3. Examples of principles for evaluating relationships between instances of structure/patterns

Evaluating the relationship between two instances of material structure	When considering the relationship between two instances of material structure, the analyst should imaging how his/her body would be involved in both instances; based on the results of this introspection, the analyst should decide whether using the one structure would be made easier or simpler through also using the other structure. For example … [provides examples from our coded interview data]
Evaluating the relationship between instances of material and ideational structure	When considering the relatedness of instances of ideational and material structure, the analyst should ask himself/herself whether the actions enabled/constrained by a given instance of material structure would be rationally justified by the idea under consideration.
Deciding whether a relationship is positive, negative, or neutral	If one structural instance suggests an action which would be excluded by another structural instance, the association between the two instances is seen as negative. Similarly, if the two actions suggested by the two instances of structure contradict each other, the relatedness between the two instances is negative. If one instance suggests an action which does neither contradict nor be in line with the action suggested by another instance, the interrelatedness between the two instances of structure is neutral.
Evaluating the relationship between instances of ideational structure	When considering the relationship between two instances of ideational structure, a positive relationship is constituted if the substance of one argument positively interacts with the substance of the other; in contrast, if both instances are based on the same principle or mechanism but refer to different areas of application or subjects so that both could not be used to support each other in an argument, then a neutral relationship should be assumed.

Based on these analyses, we then built models of the individual practices by combing instances according to our practice model, i.e. through selecting instances of material, normative and ideational structure which had a positive relationship among each other and complementing these with instances of patterns that would, from the hypothetical position of a member of that practice, reproduce these structures. We call such a cluster of three instances of (material, normative, ideational) structure and corresponding instances of patterns (flows of things, sanctioning patterns, discursive patterns) a 'sextuple'. It turned out that only a relatively small number of models of these expected sextuples could be 'filled' while most of our partial models contained fewer than three filled cells.

We then identified boundary objects among instances of material structure according to our definition of IOIS and arranged our sextuples so as to be linked through boundary objects. For this, we only used sextuples which had been

shown in the previous step to have a high count of cell-fills because only these sextuples are seen as stable since they are reinforced through horizontal relationships (materialization/legitimization) as well as reproduced through vertical relationships. The practice models were then classified as a 'constituent' practice, that is a practice linked through a boundary object with another practice, and/or as a brokering/boundary practice. In addition, we distinguished between further categories of structure which link constituent, brokering and boundary practices to their environment, specifically with regulation, national culture, and industry customs. Based on our matrices of relationships among structures we were then able to assess the extent to which certain instances were interrelated with all other instances of structure.

Through this coding process we have created a meso-level, theory-laden view of our data which allows us to uncover -- from the information contained in the data -- a glimpse of the actual structural dimensions and their relationships in the multiple actual circumstance of the practices of participants. Upon this new ground we can develop predictions and explanations regarding, for instance, the influence of environmental forces in the evolution of the IOIS. For example, these environmental forces may be related to the type of IOIS that have evolved in terms of which type of IOIS boundary object exists to connect constituent practices and which type of practice has evolved for aligning constituent practices (brokering or boundary practices). We follow up the issue of whether this is valid in the next two sections. Figure 4 summarizes what we have done.
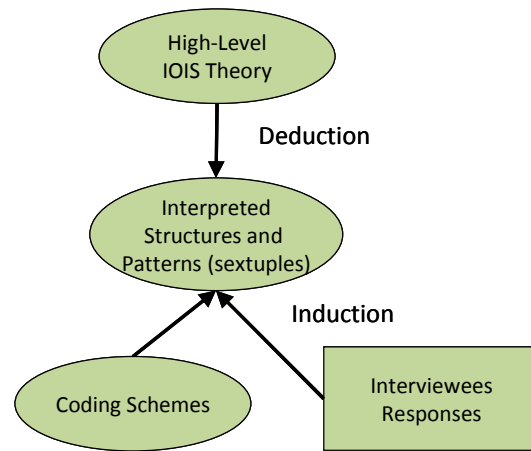

Figure 4. A meso-level approach to connecting high-level theory and empirical data

Pragmatic Analysis of the Problem

By attempting a traditional top-down approach we were confronted with a large number of possible variables impacting structure and evolution of inter-organizational information systems which, in turn, reflects the large number of candidate theories that arguably have a bearing on our research question. This approach would have forced us to select a smaller number of theories and thus ignore variables that we also considered to be important. We could have abandoned theory testing altogether at this point and used some form of bottom-up approach, such as Grounded Theory to allow a new theory to emerge from the low level data we were collecting in the field. However, because of the scope of the research object we were investigating, IOIS, we felt that it was unlikely that a theory of sufficient scope could emerge using induction over such low level data. Consequently we found ourselves in a dilemma between top-down theory testing and bottom-up theory building with neither approach capable of bridging the gap between the level of theory we thought was necessary to adequately explain the phenomena and the level of data which we could collect from practitioners in the field.

We find that these practical problems are mirrored in limitations that characterize the small literature which addresses similar research questions. In this section, we briefly demonstrate the existence of similar problems in this literature by selecting two published studies that have adopted a top-down and bottom-up approach respectively. This allows us to identify the pragmatic limitations of these two approaches that give rise to our dilemma.

Ravichandran et al.(2007) have presented a study of the influence of industry structure and product characteristics on structural properties of IOIS based on a strict top-down approach. They have distinguished between several types of 'vertical hubs' and explored the statistical associations between these and four variables describing industry struc-

ture and product characteristics traded on these hubs. They found modest support for their proposition that characteristics of vertical hubs are likely to be shaped by industry structure and product characteristics. Specifically, they found that five of their 12 hypotheses relating their selected variables with the dimensions describing vertical hubs were supported by the data.

These authors encountered two constraints which limited their study. First, the authors had to exclude IOIS from their study which could not be described from a single organization's perspective, i.e. they were limited to IOIS the boundaries of which coincided with organizational boundaries of an operator of the system. The reason for this limitation is that the characteristics of the IOIS were not obtained through synthesis of data but through eliciting answers from respondents. Therefore, they depended on respondents which had a sufficiently complete knowledge of the system being studied. Systems which are only partially visible to the informants -- e.g. multi-lateral EDI systems -- therefore cannot be studied in this way. One would have to focus on describing partial views of these systems which correspond to the partial views of respondents (which is actually true for many EDI studies which focus on the perspective of one or at most two adjacent organizations involved in such systems; see e.g. Beck and Weitzel, 2005; Lee and Lim, 2003; Henriksen, 2000).

The second limitation results from the need to select a small number of explanatory variables for testing purposes. In this case, the authors had chosen variables concerning industry structure and type of product traded on the vertical hubs. However, there are a number of other variables which would have equal face validity in explaining the structure of the systems investigated. For example, regulations regarding ownership of such systems may constrain their structure. The authors chose independent variables based on their choice of theory -- in this case industrial organization theory -- but other theories would also have been good candidates such as political theories concerning the distribution of power in an industry. The authors therefore had to make a choice which, if a large number of candidate theories and implied independent variables exist, becomes arbitrary. Other sets of variables are also highly likely to contribute to explaining the structure of the system. This choice is necessary because, given a limited sample size -- which might be the result of difficulties in collecting data or of a relatively small number of cases in the total population -- only a small set of variables can be tested. In addition, under a strict top-down approach the researcher is not allowed to explore further explanatory variables should the results be unsatisfactory in terms of the number of hypotheses that can be supported by statistical evidence because there is a risk of interpreting spurious associations as causal effects, as will be discussed in detail below. As we will argue, the reason is that associations between variables are obtained through a mechanical process (statistical calculations) rather than through a process of interpretation.

A study of IOIS based on Grounded Theory has been presented in the literature as well (Crook and Kumar, 1998). The authors explored a broad range of issues including causal conditions for and types of EDI use. As was the case with regard to a top-down approach, a bottom-up approach was found to encounter difficulties describing an IOIS; the reason is that these researchers had to rely on the partial descriptions of informants in order to bound their research object; they could not use a theoretical construct to identify and bound a larger unit which is not, as such, visible to their informants. As a consequence, Crook and Kumar had to limit their study to one part of the system, that which was experienced, and thus describable, by their informants.

Regarding the issue of explaining system use and types of use, while the authors were able to identify different causes of EDI use, environmental facilitators, strategies and types of system use, as described by their informants, their attempts to link across these categories were restricted by the need to develop theory through iterating between data and literature; by contrast one might wish to specify which environmental factors caused which types of system use. However, if the data contain no hints that can be interpreted as a causal relationship between the several concepts of interest to the researcher, he/she must end his/her analysis of the data at this point. Therefore, a bottom-up approach cannot reach a high (abstract) level of theoretical explanation, i.e. it is limited to explanations which stay close to the data. If the research question is such that it addresses highly abstract causal relationships, i.e. relationships which do not leave direct empirical traces, it is beyond the reach of a pure bottom-up approach. Indeed, while Crook and Kumar have actually attempted to integrate their several theoretical categories into a high-level logic model, they did not specify the relationships that supposedly exist among these several categories.

To summarize, the top-down and the bottom-up approaches are restricted in two different ways. The limitations encountered by a top-down approach are related to the size of the empirical problem that we want to study and that has been studied by Ravichandran et al. which, in their study, necessitated an arbitrary selection among a large set of possible explanatory variables. In contrast, the limitations encountered by a bottom-up approach, as exemplified by the study of Crook and Kumar, are related to the highly abstract nature of our research question which, in the case of

Crook and Kumar's study, resulted in a failure to specify high-level relationships among the several conceptual entities identified in their study.

In addition, the top-down approach can only investigate objects which are potentially visible to respondents (while it may be difficult to elicit their observations directly so that what they perceive may only be indirectly accessible through, e.g., factor analysis); the bottom-up approach is similarly bound to limit its study to research objects which are visible to its informants. Thus, both approaches have limitations concerning both theoretical explanations and also research objects that cannot be observed.

We therefore submit that the size of the empirical object as well as the abstract nature of our research question and of our research object necessitated a hybrid approach. Jointly, these two aspects prevent the researcher from building explanations of observed behaviours that stay close to the data, such as associations between variables or common themes emerging in textual data. Rather, a more abstract theory is required that manifests itself only through its effects in the data but whose inner workings are not directly observable, thus creating a larger ontological distance between the data and the theory, one which cannot be bridged by a top-down or a bottom up approach.

In the following section we will explore the philosophical reasons that underpin recommendations to use either a strict top-down or a strict bottom-up approach and which give rise the general suspicion directed at hybrid approaches.

Philosophical Analysis of the Problem

In this section we will first analyse the problem from the perspective of the Empiricist tradition which, according to Mingers (2006a), dominates positivist IS research. Next we will evaluate this coding method from the perspective of the philosophical position of Critical Realism. We first briefly summarize the position of Critical Realism as described by Mingers (2000, 2004, 2006a, 2006b) and also recapitulate the critique that has been levelled against CR in the IS field; we find that CR offers new theoretical concepts that allow us to better understand the philosophical underpinning of our coding process. We will then argue that although the overt theory-driven nature of data coding might seem to challenge validity, a reinterpretation of standard validity issues from the perspective of CR suggests otherwise.

The Problem from the Perspective of the Empiricist Tradition

Mingers (2006a) has formulated a critique of statistical modelling in management science and information systems by showing that this approach is characterized by an impoverished view on causality which is inherited from an Empiricist tradition. Empiricism, according to Mingers (2006a), goes back to Hume's postulate that the most one can hope for in science is to discover regular patterns, i.e. events that follow on one another in a fixed sequence. This view states that in such patterns the preceding event will be considered to be the cause of the subsequent event. Science then consists of discovering and (ideally mathematically) describing these patterns. This 'naïve' form of positivism has later been modified in response to Popper's critique which maintained that science can never discover (induce) and confirm theories (mathematical laws) but only refute predictions which have been derived (deducted) from some theories. While the dependence of scientific work on theories was thus accepted, it was questioned whether theories could exist at all since only direct observation was seen as a proof of existence of something (Mingers, 2004, p. 90). Regarding the IS literature, Mingers (2006a) demonstrates that this literature -- insofar as it concerns positivist research -- is dominated by a view of theory as a mathematical description of (observed) events. Thus, theory does not exist as a set of inter-related statements about an un-observable mechanism which causes patterned events but only as a mathematical regularity of predicted or observed events.

We propose that this narrow understanding of causality underlies the suspicion directed at hybrid approaches forcing researchers to adopt either a top-down or a bottom-up approach. The enforced choice between a strict top-down and a strict bottom-up approach follows from the philosophical position of Empiricism as shown below while the need for choosing between them has generated significant practical problems for researchers as illustrated by our own problems as well as by the limitations encountered by the studies discussed in the previous section. While the top-down approach is usually referred to as theory-testing, the bottom-up approach pursues theory development.

Regarding the top-down (deductive) approach, the main concern is that of falsely interpreting spurious associations between patterned events. On the one hand, only observable patterns are considered as real; on the other hand, not

every observable patterned sequence of events implies causal relationships, as many spurious statistical associations richly illustrate. For this reason, it is generally seen as necessary to first develop hypotheses about possible patterns and then compare these to actually observed patterns; if one were allowed to build hypotheses from observed patterns, there would be no way of knowing whether these are spurious or not. While there can still be no certainty about the results regarding causality, one will at least have avoided adding to the problem of spurious results by building theory from observations since, in the realm of theory, there are no means available to the researcher to separate spurious from real associations -- such as logic and judgement -- since the realm of theory does not have a real existence of itself.

Regarding a strict bottom-up approach, the main concern is seen as imposing pre-conceived -- and therefore possibly unreal or fictitious -- theoretical concepts on the data and thus distorting results. As theoretical concepts can only be validated through data, any theoretical concept must be treated with suspicion unless it is supported by some data. Therefore, the researcher should ideally start without pre-conceived theoretical concepts but rather let these emerge from the data. While it is acknowledged that theories necessarily 'leak' into observations, this process should be postponed to later research stages when the researcher has developed some solid foundations as represented by a pool of supposedly unbiased data.

The need for either a strict top-down or a bottom-up approach in Empiricism thus follows from the need to relate observable empirical entities to conceptual entities in the mind of the researcher because only empirical entities are real whereas conceptual entities in the mind are potential fantasies.

As demonstrated above, the need to choose between either a top-down or a bottom-up approach has created significant problems for researchers. Regarding the first, it is mandatory that the researcher chooses among a set of possible relations among events those that he/she wants to test. This severely limits the range of research objects that can be meaningfully studied since research objects that imply a very large set of possible relationships between events would force the researcher to arbitrarily choose a subset among them. Therefore, research objects are restricted to issues that supposedly involve only a limited set of possible relationships among events. Regarding the bottom-up approach, researchers have also been limited in terms of the issues they can meaningfully address; specifically, they can only investigate phenomena which are easily identified from observations, documents or oral utterances, i.e. which do not involve the need for theoretical bounding. Phenomena that can only be defined in view of a certain theory thus cannot be investigated. These are the problems that we encountered in our own research and that were also evident in the study of Ravichandran et al. (2007) regarding a strict top-down approach and of Crook and Kumar (1998) regarding a bottom-up approach.

Thus, a hybrid approach, such as the one we described above as a pragmatic solution to this dilemma, is not supported by the philosophical position of Empiricism as described by Mingers because theory is not considered as having real existence unless supported by data (observations) since only data can lay claim to existence. As, in our approach, theory resides on a higher level which is not directly accessible to observation, the gap between data and theory cannot be bridged through a strict top-down or bottom-up approach. Therefore, it has to be concluded that our approach is either not tenable or a different philosophical basis needs to be identified, one which offers a richer set of ontological categories with which to connect theory and data than does Empiricism. Following Mingers and others (Dobson, 2001; Carlsson 2003 and 2005) in the IS domain, who proposed the philosophical position of Critical Realism as a fruitful alternative to Empiricism for IS studies, in the next section we will report our attempts to justify our approach based on key concepts from Critical Realism.

Critical Realism

Critical Realism starts with the claim of the existence of human-independent and un-observable structures/mechanisms/forces that do account for patterned and observed events (Mingers 2000, 2004, 2006a, 2006b). These structures are thus seen as the causes for the appearance and order of events which is why they are called the Generative Mechanism (GM); Mingers (2006a) contrasts this concept of causality with that of Empiricism as a fixed relationship of preceding and subsequent events. Moreover, Critical Realism acknowledges that any attempt to discover and describe the GM is affected by interests, myopia and error (Mingers, 2004). Thus, there can be no 'objective' way of knowing whether one has correctly identified -- or refuted -- the GM, much in contrast to Empiricism which assumes that the mathematical order of events allows for generating objective knowledge (Mingers, 2006a).

The position of CR can be summarized through the three ontological concepts of the Real, the Actual, and the Empirical (Mingers, 2004). The Real includes both the GM and our ideas about it; the Actual is nested in the Real and

includes all events (and non-events) that are caused by the GM. The Empirical is nested in the Actual and includes all observations/experiences of the Actual by human agents. In view of this conceptualization, the difference between Empiricism on the one hand and CR on the other hand consists of CR's claim that both, the GM as well as our ideas about it, are real. In contrast, Empiricism only views empirically observed patterns as real and our ideas about them as potential fantasies as long as they are not confirmed through rigorous experiments or other accepted forms of empirical testing.

Critical Realism thus provides a genuine realist position such that not only observable data are seen as having real existence but also our ideas and theories about the world. Therefore, we do not expect to encounter similar problems in relating data to theory even in the case of highly abstract theories since both have the same ontological status of existence. Moreover, Critical Realism provides a new ontological concept, that of the Actual in addition to the Real and the Empirical, which we can identify with the meso-level of interpreted data that we have created through our coding process. Finally, high-level theory can be related to the concept of Generative Mechanism. Both reside in the realm of the Real, albeit in different domains. High-level theory exists within the domain of research practice and refers to a Generative Mechanism which exists in the domain of IOIS practitioners. In the next section, we will draw on the concepts of the Real, Actual, and Empirical in order to find and discuss equivalents for the traditional concepts of internal and external validity and reliability in view of which our coding method can be examined.

Critical Realism, as described and recommended for the IS field by Mingers, was criticized by Monod (2004) and Klein (2004) in a special issue of Information and Organization devoted to CR; Mingers has also replied to these criticisms in the same issue. Monod's critique is mostly based on modern physics which, supposedly, has done away with the concept of causality entirely, and Kant's transcendentalism that, as seen by Monod, provides a philosophical basis for the new form of explanation in modern physics. Klein's critique is mostly levelled against Mingers' refusal to acknowledge the distinct ontological status of the social (as opposed to the natural) world and his alleged failure to formulate a clear approach specifying how moral norms are reflected in the approach causing the approach to be a-critical. Despite these criticisms we will show below that CR provides useful ontological categories for discussing the validity of our hybrid approach. Regarding the issue of the ontological status of the social, Mingers has addressed this issue at length (2006b). Regarding the issue of causality, we submit that the principle of causality is generally admitted in the IS literature.

Mapping Our Hybrid Approach onto the Categories of Critical Realism

The hybrid approach towards analysing and synthesising data described in the previous section can be characterized in terms of CR's three realms (the Real, the Actual, the Empirical) in the following way (see Figure 5 below). The IOIS theory outlined above refers to a putative Generative Mechanism in the realm of the Real that accounts for actual events which are responses of certain characteristics of an IOIS to environmental changes. Specifically, the Generative Mechanism explains why certain characteristics of an IOIS -- as described by some salient structural instances -- persist and how the environment influences the evolution of these characteristics or -- as an equivalent formulation -- why these characteristics are resilient towards changes in its environment. The core concepts of the Generative Mechanism are structural reproduction, legitimization and materialization; structural reproduction refers to the vertical relationships in our model of practice; legitimization and materialization to the horizontal relationships (see Figure 2).

The clustering of instances into sextuples and the arrangements of practices linked by boundary objects and other practices refer to the realm of the Actual. These clusters cannot be observed directly but, according to Critical Realism, can only be glimpsed through a theory-laden interpretation of the necessarily inadequate empirical data. Finally, the transcripts of the interview data correspond to the Empirical.

In terms of Critical Realism, theory testing is showing that the proposed Generative Mechanism explains phenomena at the actual level. In the context of our research question, prediction as a testing strategy thus concerns either the response of a given IOIS to certain anticipated environmental changes, e.g. a regulatory change that allows for the establishment of pharmacy chains in the case of IOIS in pharmaceutical distribution, or the likely evolution of a certain planned IOIS in a given environment.

While the process of synthetising sextuples and constellations of sextuples from the raw empirical data also relies on a theoretical understanding of the mechanisms of reproduction, legitimization and materialization, the relationship between the Generative Mechanism and these actuals (constellations of sextuples) is not tautological. The reason is that predictions and explanations do not refer to the clustering of instances but to changes or non-changes (resil-

ience) of certain instances in response to environmental changes. For example, we may find that a certain IOIS boundary object, while being reproduced by some patterns of data flows, seems to be fragile because that boundary object is in conflict with other (material, normative, ideational) structures in the practices that it connects. Similarly, we may find that certain environmental characteristics are extensively interlinked with salient characteristics of a given IOIS so that changes of these environmental characteristics in the past should be expected to have affected the evolution of these characteristics.

Validity of the Coding Approach from a Critical Realist Perspective

In order to discuss the level of confidence that one could have in explanations or predictions about actual events obtained through our hybrid approach, we want to use the familiar concepts of construct, internal and external validity and apply them to our hybrid approach.

Whereas in Empiricism construct validity refers to the relationship between empirical measures and theoretical constructs, in Critical Realism construct validity can be interpreted as concerning the relationship between the Empirical and the Actual. In our hybrid approach, as represented by our model of practice, the Actual consists of linkages within sextuples and constellations of sextuples connected by specific boundary objects which we call an IOIS comprising constituent practices and brokering/boundary practices. From the perspective of Critical Realism, there is no principle problem regarding real existence of the Actual, as would be the case from Empiricism, since CR acknowledges the existence of events which cannot be observed but only inferred from empirical data. However, CR also acknowledges the distorting effects of interests, myopia and error. We have attempted to mitigate these effects by developing coding principles (see Tables 2 and 3) that are documented as part of the research and can thus be reviewed by other researchers. We submit that these coding principles, rather than repeated coding by independent analysts, establishes construct validity. From an empiricist perspective, this would not be acceptable since only observations, in this case observations of the several coding results, can be ascribed an objective existence. However, from a CR perspective, the main test of any object constructed from observations would be critical assessment of the way this synthesis has been done. By documenting these underlying principles and making them available to interested researchers we allow for such critical auditing and thus create the basis for establishing construct validity.

Internal validity concerns the logical consistency of connecting explanations or predictions with research results (Yin, 1994) which in Critical Realism would be a relationship between the Real and the Actual. The main question is whether the predicted or explained patterns of actual events follow logically from the Generative Mechanism that the theory describes. From the perspective of Critical Realism, internal validity is contained in the very idea of a Generative Mechanism. In order to establish internal validity from the perspective of Critical Realism, it is necessary to show how actual events follow logically from the workings of the Generative Mechanism. While providing logical links between any two variables is relatively straightforward, internal validity can be strengthened if a broad set of predictions can be derived from a single theory; this, at least, would seem to be implied by Critical Realism for which the logical linking of events is a crucial test of existence of causal relationships (as opposed to Empiricism which only considers observed data as evidence of such linkages). By developing a theory of IOIS resilience and persistence we have attempted to increase internal validity. This allows us to infer what is happening in the Actual follows logically from the Generative Mechanism proposed by our theory.

External validity concerns the question of whether results obtained for one specific situation or context will also be true for other situations or contexts (Yin, 1994). From the perspective of Critical Realism it thus concerns a two-step relationship Actual-Real-Actual. From this perspective the question is to what extent the Generative Mechanism that has been shown to explain events in one specific context is also the Generative Mechanism explaining events in a different context. The main problem is that explanations will always be partial, i.e. the Generative Mechanism is not intended to explain all events in the specific context that has been selected for study but only the phenomena of interest to the researcher. While the explanation may work for one situation, it may not work for other situations because some unaccounted for interactions may have been absent or weak in the former but strong in the latter. This problem may be mitigated by carefully selecting and bounding the unit of analysis so that all relevant interactions are captured in it while those that are not can be specified. While we have developed a precise method for delineating our unit of analysis -- not reported in this paper (Reimers et al., 2004) --, this was done based on a different theory than we later selected for explaining IOIS. With hindsight, this may turn out to be one approach towards strengthening external validity since we thus ensured that we did not select phenomena so as to fit with our preferred theoretical explanation of them. In other words, if we generate our results based on a definition of the unit of analysis that is broader in terms of possible interactions than would be suggested by our main theory, there seems to be a

smaller risk that we have missed some relevant interactions due to blind spots of that theory. This, however, is an open question and requires further discussion and research. Figure 5 summarizes what we have done in view of Critical Realism.
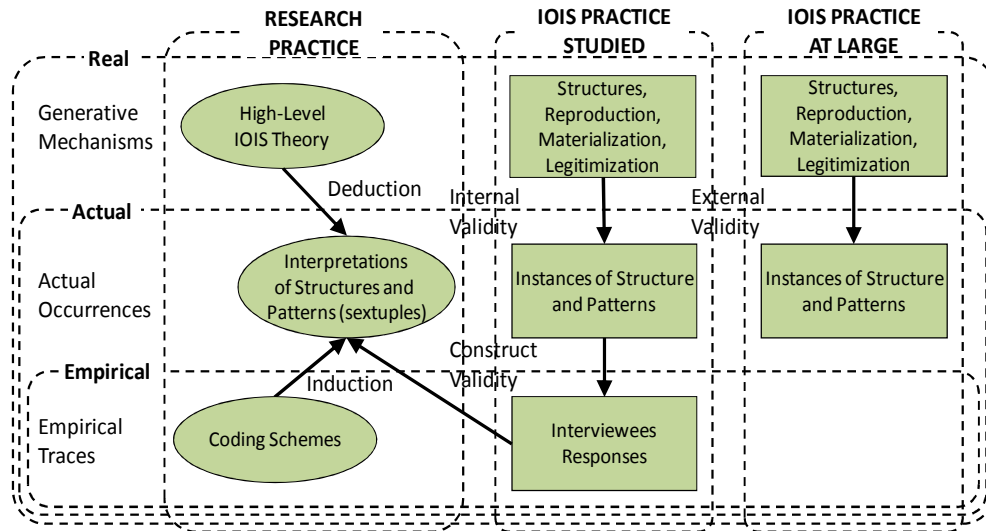

Figure 5. The meso-level approach mapped on to the categories of Critical Realism

Discussion

While the problem that we have tackled in our research project, structure and evolution of inter-organizational in-formation systems, is unusually large in relation to research questions generally addressed in the IS field, we submit that similar problems occur in the more common types of IS research as well, namely a need to fill the gap between data and theory by developing ad-hoc, informal additions to theoretical reasoning or to interpret raw data so that they become meaningful in the context of a certain theoretical argument. Such measures may be accepted if made sufficiently explicit but, from a strict reading of Empiricist research principles, would not be tenable. Thus, the di-lemma of bridging the gap between data and theory within the tradition of Empiricism is often solved in a pragmatic manner so that a practice has developed which allows researchers to largely comply with the imperatives of Empiri-cism while accommodating the difficulties which have been pointedly presented in this paper. However, this prac-tice also establishes limits regarding the type of research question that can be practically addressed and it seems that, with our exceptionally abstract question addressing a very large empirical phenomenon, we have exceeded these limits and were thus forced to either abandon our project or find an alternative philosophical basis on which we could ground our coding and testing effort. We found such a basis in the -- at least in the IS realm -- relatively novel philosophical position of Critical Realism and are therefore encouraged that, based on this position, larger phenom-ena and more abstract research problems can be addressed that many scholars and practitioners feel are relevant for the field. However, this basis is contended as has been shown by our brief summary of two criticisms levelled against Critical Realism. Kivinen and Piiroinen (2004, p. 231) have characterized Critical Realism as "committed to the heavy ontological furniture of metaphysical transcentalism" as it refers they claim to an in principle unobserv-able causal force. We do not want to engage in the debate on the problems of Critical Realism or other philosophical positions but simply to point out that Critical Realism has trodden contentious ground and that scholars who adopt and adapt it to their needs should be aware of the heavy "ontological baggage" (ibid.) that comes with it. On the other hand, we propose that Critical Realism provides useful concepts for understanding and explicating the phi-losophical (particularly the ontological) underpinnings of what we have done in our pragmatically inspired efforts to address the dilemma. Furthermore, we propose that, to the extent that researchers deviate from the dictums of Em-piricism in the direction of our overt theory driven coding approach, they implicitly make use of positions that are formulated and discussed in Critical Realism. Critical Realism offers a realist position that, although relatively new to IS, is thoroughly documented in its literature for researchers who, driven by practical necessity, have significantly deviated from Empiricism and may otherwise fill the philosophical void with some ad-hoc and naïve realist assump-tions.

Second, Critical Realism offers a specific solution for developing and testing high-level theory as was sketched in this paper. The main idea is to create a new middle level, an "interpreted ground", against which theories can be tested by developing predictions concerning events and non-events on this level (the Actual in terms of Critical Realism). In an empiricist tradition, theory testing generally means testing the existence of predicted patterns in the raw (empirical) data; our coding method creates a theory-laden layer of interpreted data which is justified from the perspective of Critical Realism -- albeit not Empiricism -- and thus offers a new ground for testing theory by developing predictions concerning the future direction of evolution rather than the existence of certain patterns in the present. While this point is closely related to the first point above, it goes beyond a general strategy in terms of bridging the gap between data and theory in that it encourages a different way of viewing the usefulness of theory in IS research. While we do not want to claim that predictions of similar precision as obtained in the natural science will be possible in social science, we still submit that it is sensible to derive predictions about likely future consequences of design choices and that therefore developing high-level theories that would enable such predictions -- type IV theories in terms of Gregor (2006) -- is a worthwhile effort. In this paper, we have outlined the contours of such a theory and shown how it can be legitimized based on the position of Critical Realism, an approach which we recommend to other researchers in the IS field.

Conclusions

In this paper, we have shown why the top-down and bottom-up approaches dominant in Empiricism cannot handle large empirical information systems problems in combination with abstract research questions and we have described our attempt at developing a hybrid method combining the top-down approach with the bottom-up approach for the study of inter-organisational information systems. We have also argued why and how this hybrid approach is able to generate valid research results, despite the use of overtly theory-driven coding principles, by drawing on the philosophical position of Critical Realism.

The paper makes a number of novel contributions to IS theory and practice. It is the first attempt to perform a systematic analysis of the methodological difficulties of attempting empirical testing of high-level theory in the IS field. Normally, high-level theories are relegated to the role of sensitising devices (lenses) for other lower level empirical work. From this analysis we define a novel hybrid approach for testing high-level theory which involves an explicitly theory-driven coding of raw empirical data to produce a new interpreted "meso-level" ground which can be used for deriving predictions and explanations which can then be tested against actual events. We illustrate the approach with an actual case and provide tentative guidelines for implementation of the method. We have justified this approach in terms of practical necessity given the complexity and size of the research object under consideration, but we also use Critical Realism to interpret and justify the validity of this approach, and specifically interpret this meso-level as the level of Actual in that position.

In our discussion of the validity of the proposed method, we encountered difficulties in determining a satisfactory procedure for ensuring external validity. In our trial-and-error process of developing the method proposed in this paper, a new possibility for ensuring external validity emerged which suggests that two different theories be used for analysing the phenomenon of interest and for bounding the unit of analysis. We suggest to explore this possibility in further studies of research methods in the IS field.

Acknowledgement

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