

Beyond Mutual Shaping
-- Rethinking Symmetry and Causality in the Treatment of Socio-material Systems --

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Abstract

Inter-organisational Information Systems (IOIS) are computer-based systems shared by, or connecting, several organisations. The on-going use and evolution on long time scales of these large scale socio-technical systems challenges naive theories that give causal primacy to the material constraints and affordance of the technology, or to social forces such as power and norms, or to rational impetus such as visions of efficiency through standardisation. Recently, several authors have drawn on a “mutual shaping” approach which posits that the causal impetus of the material and social can be considered as interleaved episodically in time. While this approach attempts a more balanced treatment of the social and the material it does so by enforcing an asymmetry between these, both conceptually and temporarily, in a desire to maintain a unidirectional theory of causality that is at odds with both systems theory and reproductionist social theory.

In this paper, we present a theory of IOIS in which the on-going persistence and evolution of these large scale systems is treated as a practical and socio-material accomplishment of communities through boundary practices and structures. We draw on the structure/action reproduction paradigm of Structuration Theory to account for the persistence of these systems, while using the embodiment of action from Practice Theory to treat the material nature of these systems. We distinguish three dimensions of structure -- material, normative and ideational -- and we also distinguish patterns of actions (along these three dimensions) from constraining and enabling structures. However, we attempt to treat these three structural dimensions and their reproduction processes symmetrically throughout. This symmetrical treatment leads us to propose that these action/structure dimensions are not reproduced in isolation but rather undergo an intimate mixing, or mangling, in the process, which in turn suggests a new kind of two-way causal accommodation between the various aspects of structure that we term “resonance”.

We use a case study of the evolution of e-commerce in China’s drug distribution industry to illustrate the constructs of our model and to contrast our form of explanation with existing approaches. We show how the IOIS practices change over time through the waxing and waning of resonance and dissonance between competing material affordances, moral positions and rational visions, while the mangling of these in the reproduction process ensures that episodes of change cannot be solely attributed to any one dimension alone.

Introduction

Studies of the impact of technology on society necessarily treat technology as an exogenous variable, a *deus ex machina*, as they are interested in understanding a one-way causal relationship which points from technology towards social systems and interactions; similarly,

social shaping perspectives on technology need to take interests, power or some other social force as a prime cause of technological development. It does not seem to be a very fruitful approach to criticize these approaches for neglecting one causal direction in their models and theories as focusing on a single causal direction is an analytic strategy geared towards coping with the complexity of the problem at hand.

However, privileging social over technical forces or vice versa does not yield satisfactory explanations when considering complex assemblages of technical components embedded into large-scale social systems over extended periods of time. In such cases, neglect of one causal direction fails to account for phenomena such as persistence and resilience -- as opposed to, for example, pace of change or adoption -- of systems which result from mutual interactions among social and technical forces. Such phenomena therefore need a theoretical approach that recognizes the simultaneous influence of both technical and social forces. Specifically, such an approach needs to address two issues, the notion of causality involved in the relationship between technology and social forces and the asymmetrical treatment of technology and materiality in the social sciences (Orlikowski and Scott, 2008).

Boczkowski (2004) argues in favour of a combined approach -- called mutual shaping -- in which social shaping and technological determinist approaches complement one another and illustrates this approach for the case of the evolution of videotex-based news media. Methodologically, this is done by combining partial analyses in which the outcome of a social shaping process is seen as the constraint of a subsequent technology diffusion process (which stands, in his analysis, for the broader class of technological determinist models) and vice versa. This analytic strategy of reconciling the dual causal potential of technical and social forces may be characterized as episodic shifts of causal primacy between the two. A similar strategy has been suggested by other authors, e.g. Volkoff et al. (2007) for the case of enterprise systems and Orlikowski (1992) for the case of an incident handling system in a consultancy. Volkoff et al. use a distinction between three stages of technological development -- in this case creation of an enterprise information system --, namely structural conditioning (designers dominate), social interaction (users dominate), and structural elaboration (designers dominate) in order to account for both, social shaping and technological determining effects; Orlikowski distinguishes between a design and a use mode to achieve a similar result albeit insisting that these modes do not represent different stages. Yet, she also claims that the freedom to change or modify a developing technology decreases over time, suggesting that the design mode diminishes in relevance over time while the use mode increases in importance.

We argue that combining technological determinist and social shaping perspectives in this way, albeit practical for certain purposes, does not resolve the theoretical problem of integrating technology -- in a symmetrical fashion -- into social science. Technology is still being viewed as an alien concept that may enter the world of humans and there have certain effects on social systems but is never part of these systems, i.e. there is a deep-level asymmetry between social forces and technology (Orlikowski and Scott, 2008). This deep-level asymmetry is also not mitigated by the recognition that technology is an artefact, i.e. a product of human action, because then, once established as technology, it stops to be part of the social world and enters that of an alien, physical world from which it impinges on the social world as a transformed force, albeit one built by humans, a *deus ex machina*.

The mutual shaping lens (Boczkowski, 2004) combines social shaping and technological determinism based on the notion of one-way causality. In such a model, technology causes certain effects in the social world and social interaction is the cause for the appearance of

specific technologies. We argue that it is because of this retention of the notion of one-way causality which forces anyone who adopts a mutual shaping lens to resolve the interaction of technology and social forces by structuring time into episodes such that in one episode technology takes on the character of a hard, external force while in the subsequent episode it becomes soft and is being shaped by social forces.

In order to elaborate on these issues, we present a theory that we have developed in the context of the study of large-scale socio-economic systems which allows us to treat technology, as materiality, symmetrically with regard to other social forces such as norms and ideas. We also attempt to come to grips with the complex two-way causality implied by a symmetrical treatment by developing a new concept which we refer to as resonance and dissonance. To make contact with the materiality of IOIS as technologies we have elaborated Structuration Theory (Giddens, 1984) with ideas drawn from Practice Theory (Wenger, 2002) to include a material dimension along with normative and ideational dimensions to the structure-action-duality. However we try to do this in an explicitly symmetrical way which denies the causal primacy of any one dimension and consequently equally denies technological, social or rational (economic) determinisms.

Rather than developing a theoretical model that, supposedly, applies to all types of technology, we choose a specific technology as our theoretical and empirical focus, inter-organisational information systems (IOIS) which can be defined as information systems shared by several organisations or connected across organizations. While we do not want to argue that it is in principle impossible to develop a comprehensive theoretical concept of technology as an integral part of social theory, we submit that often disagreement on the proper role of technology in social science can be traced to incompatible concepts of technology that refer to different levels of analysis (e.g. infrastructure vs. specific applications), allow for different degrees of physical manifestation (machines vs. technological knowledge), or imply different degrees of 'systemness' (program code vs. information systems), to name just a few dimensions along which -- often implicit -- definitions of technology can vary in fundamental ways.

Basing our IOIS model on Practice Theory is also a response to existing theories in the information systems literature which view IOIS as purely technical systems and often focus simply on the management decision to "adopt" these systems. Consequently they fail to capture the importance and challenge of problematising the continued post-adoption use and persistence of the systems as an on-going, human, practical accomplishment. In this sense our approach resonates with the aims of social studies of technology.

In the course of our theory development we have introduced extensions to Practice Theory -- as elaborated by Structuration Theory -- to show how meso-level social systems can be modelled from this orientation, using inter-organizational information systems as a specific case. We propose that this approach could be fruitfully extended to develop a fresh theoretical perspective on meso-level organizational phenomena such as supply networks or large, divisionalized and multi-site firms. Practice Theory provides us with conceptual tools to specifically address inter-organizational issues and elaborate different ways how Communities of Practice can be linked to each other.

We set out by building a theoretical model of IOIS drawing from and combining Practice and Structuration Theory. We subsequently introduce the concepts of practice and Community of Practice, materialization and legitimization as relationships between structural dimensions, and behavioural patterns as the mechanism through which structural properties are

reproduced. We make contact with the inter-organisational nature of these systems by considering constellations of practices which are aligned through a variety of mechanisms (boundary spanning, boundary practices) and which alignment results in the emergence of boundary objects that can be used for deriving a novel definition of inter-organisational information systems. These are the elements from which we build our theoretical model which is then used to elaborate the idea of resonance as a new theoretical concept describing the mutual and continuous interaction of technology and (other) social forces. We then present a case study of e-commerce systems that have evolved in China's drug distribution industry over the course of more than ten years. By mapping our model onto this case we show how the evolution of the systems can be understood as simultaneous, mutual and ongoing interactions of material, normative and ideational structures. We compare our theoretical explanation based on the concepts of resonance and dissonance with the theoretical alternatives based on power, technological determinism and their combination in the mutual shaping lens.

A Practice Theory of IOIS

Technology is a material structure which, in social systems, is intertwined with other dimensions of structure that jointly enable and constrain action (Orlikowski, 2000). In order to understand the role technology plays in shaping social systems it is necessary to understand the nature of this association between technology and other dimensions of structure. At the same time, structure (including technology) does not exist independent of action in social systems. Therefore, understanding the evolution of social systems (and the role played by technology in that evolutionary process) also requires an understanding of the relationship between structure (including technology) and action.

While there have been multiple approaches towards theorizing the relationship between technology and other dimensions of structure on the one hand and between structure and action on the other hand, only relatively recently have scholars attempted to consider these entities in a symmetrical way. To our knowledge, however, there are no models which achieve symmetrical treatment of both the relationship between structure and action as well as that between technology and other dimensions of structure. By invoking the term "symmetry" we refer to a theoretical treatment which does not, per se, privilege one theoretical entity over another in a relationship. In this paper, we introduce a theory-based model that aims at such a symmetrical treatment and which has been developed elsewhere in more detail (Reimers and Johnston, 2008).

We started developing our model 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 1. A novel feature is that 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 reproduction processes while the horizontal linkages concern processes of stabilization of structures through materialization and legitimization.

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, thus continuously validating (or invalidating) 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.

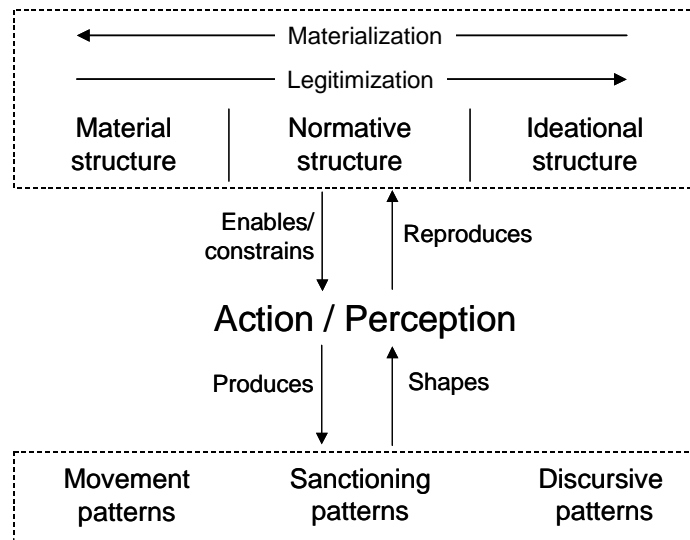


Figure 1: A model of practice

The three dimensions which emerge through these distinctions (material, normative, ideational structure) have a counterpart in corresponding patterns, namely patterns of flows of physical 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. We will expand on this idea below.

So far we have just considered reproduction of a practice within a single community. To make the connection to IOIS we must now consider how multiple distinct practices can become and remain aligned. Different kinds of practices are distinguished by the differing enterprises in which the members of the communities engage and around which they form their identities. Examples from our context are the product ordering (procuring) practice and product provision (supply) practice. These are distinct Communities of Practices with separate procedures, objectives, legal restraints, languages, stories, norms, operating methods, etc.; in addition, these Communities of Practice are often -- but not necessarily -- located in separate commercial organisations, as is the case for a supply chain. However, the differing enterprises

of these communities are necessarily connected through the “product” which must be passed from one to the other effectively if they are to fulfil their respective enterprises. Consequently, the connected communities must achieve some alignment of their practices which must be maintained over time along with their separate reproduction in each community. When these practices are located in different organisations, maintaining this alignment is problematic because the individual practices will tend to drift to accommodate changing circumstances in the particular organisations. Some possibilities for maintenance of such an alignment are discussed by Wenger (2002), and range from the brokering actions of individuals to full-blown separate practices whose enterprise is such an alignment.

According to the three dimensions of structure described above, several communities of practice can be connected through patterns of sanctioning behaviour and discursive patterns in addition to patterned movements of things (such as products). As things, sanctions and arguments cross from one CoP into another, they contribute to the reproduction of structure in both communities. For our study of IOIS, the case of practices being connected through flows of things is the most relevant one. These things are primarily goods, money and data. We call flows of things across practices a transaction.

The material structures reproduced through transactions can be viewed as one type of boundary object (Wenger, 2002; Star and Griesemer, 1986). Bowker and Star (2000) describe a boundary object as an interface between different communities of practice; more specifically, they describe it as an entity which is shared by different communities of practice but viewed or used differently in each of them; this property, we argue, enables connections between the several practices through transactions. Using an example from Star and Griesemer, the description of a certain location attached to an animal’s body found by a hobby collector and passed on to museum personnel can be interpreted by the latter in view of an abstract geographical map, thus reproducing the map which, in this case, is the boundary object. According to Star and Griesemer (1986), boundary objects should possess 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. However, in the context of information systems, boundary objects tend to lack interpretive flexibility as automated data processing is involved. While boundary objects can be material, normative, and ideational structures (Wenger, 2002), we focus on material boundary objects as we are interested in understanding how communities of practice are connected through data flows. Also, we prefer to substitute the term “boundary object” with the term “boundary structure” for the general case and reserve the term “boundary object” for a specific perspective on boundary structures, as explained below.

Patterned flows of things within a practice are, according to our theory, mangled together with the reproduction of norms and ideas. In contrast, if two practices are connected only by material flows, these horizontal stabilization processes of materialization and legitimization will be lacking. One could also say they are overly rigid or “brittle” as they concern only the material dimension. This brittle nature of material connections between practices -- if not compensated -- would lead one to predict that any resulting alignment will not be stable as they may become inconsistent with structures reproduced in the separate practices and, with no accompanying flows of discursive and sanctioning patterns that would make these material flows more plastic, they will not adjust to these changed structures.

Thus, since purely material boundary structures are brittle, maintaining connections through transactions frequently requires additional effort which helps to make sense of transactions or otherwise meaningfully relate to transactions. Such effort could consist of translation,

coordination, or alignment actions (Wenger, 2002). Wenger describes such activities as brokering and encounters. Brokering is a unilateral activity, involving a member of one practice participating in the reproduction process of another practice through negotiation, translation, and coordination activities while encounters refer to a bilateral action in which “delegates” of two practices meet. We prefer to subsume both concepts under the more established notion of boundary spanning (Thompson, 1967). Boundary spanning can evolve into a separate practice (Levina and Vaast, 2005) which would be called a boundary practice (Wenger, 2002). The enterprise of a boundary practice is the alignment between the connected practices. The boundary structure is not a structure which is reproduced in the boundary practice; rather, the boundary structure becomes the object of actions enabled and constrained by other structures reproduced in the boundary practice. That is, a boundary structure becomes a boundary *object* only from the perspective of a boundary practice. The reason for this terminological distinction is that actions performed as part of a boundary practice cannot directly affect the reproduction process of the boundary object (as structure) as it is manifested in the connected practices; however, they can modify the boundary object (as an artefact) in view of the knowledge of these reproduction processes. Such actions include facilitation of negotiations and translations.

We define an inter-organizational information system as a set of CoPs located in separate organizations which are connected through specific technological (i.e. material) boundary structures so as to facilitate transactions between these CoPs. IOIS boundary structures can be either shared definitions of data to be exchanged between data processing applications or shared databases, which connect data processing applications maintained in separate practices. A particular IOIS can then be characterized by the identity and constellation of practices which are aligned with each other as well as by the structural properties of each involved practice. Evolution of an IOIS can be described as changes in the structural properties of involved practices and as changes of the identity and constellation of practices forming the IOIS. Figure 2 illustrates our definition of an IOIS.

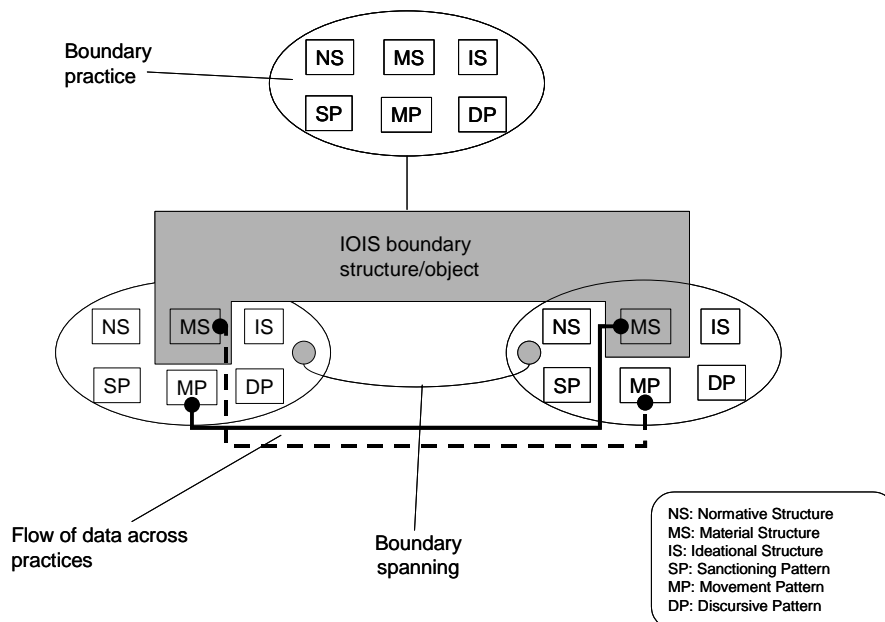


Figure 2: Conception of an IOIS in our practice theory model. Practices share an IOIS boundary structure. Alignment of the practices through the boundary structure requires either ad-hoc boundary spanning activity or a full-blown boundary practice (which views the boundary structure as a boundary object)

In order to understand the way the structural constitution of practices change, the horizontal relationships among structural dimensions need to be analysed more explicitly. Structural dimensions are not reproduced in isolation; rather, the reproduction process mangles together the several dimensions, thus creating a mechanism through which structural dimensions interact with one another. For example, as one uses an ATM for withdrawing cash, one may be reminded of the efficiency and convenience with which transactions in small-scale shopping are possible using cash payments; thus, the idea that using cash for shopping is (still) efficient ‘resonates’ with the experience of (successfully and quickly) obtaining cash from ATMs. In terms of our practice model, (successfully) using an ATM not only reproduces the material structure that we call an ATM but also contributes to the reproduction of the idea that cash-based payments for small-scale shopping are (still) efficient. We call such mutual confirmation or reinforcement of structures “resonance”. It occurs because structures, under the right circumstance, can be co-reproduced. Co-reproduction is possible, in turn, because the dimensions are mangled together in their reproduction, i.e. they are not individually reproduced in isolation. In sum, mangling is the process that, under the right circumstance, leads to co-reproduction which is seen as resonance. Conversely, the mangling can also lead to dissonance if reproduction of structure in one dimension denies reproduction of structure in another dimension.

The development (“implementation”) of an IOIS can then be reconceptualized as a process of embedding IOIS boundary objects in existing practices (thus extending the boundary objects into boundary structures). “Embedding” means that boundary objects are modified so as to resonate with existing structures in the several practices. Dedicated boundary practices may evolve that are concerned with maintaining and adjusting the boundary structure implying that the boundary structure becomes the object of their enterprise. Alternatively, boundary spanning activities must occur which affect the reproduction of the boundary structure as it manifests itself in the several connected practices. Over the lifetime of an IOIS, individual instances of (material, normative, ideational) structure may be replaced, added, or removed from the practices that -- together -- constitute the IOIS.

From a technology determinist perspective, material structure would be considered to be privileged in explaining the development of an IOIS; for example, the initial technical characteristics of the IOIS might be considered to have a determining influence on its further evolution. A social shaping perspective would privilege some other structural aspects (such as power structures) in explaining the development of an IOIS (we recognize, though, that social shaping theorists generally avoid any reference to the notion of structure in their explanations). From a rational perspective (such as economics) explanation of IOIS evolution would rely on the influence of some ideas, especially of improved efficiency through standardisation. In contrast, based on our model we explain the evolution of an IOIS as a processes of adding, removing and replacing instances of structure through reproduction processes in individual practices connected by boundary structures and/or in boundary practices that may have evolved. Agents are constantly trying to appropriate and manipulate structures to extend their influence while at the same time relying on the stability of structure to be able to act at all (for instance to keep transactions happening).

Case study: Development of e-commerce in China’s drug distribution industry

In order to evaluate the usefulness of our model, we will present a case of IOIS evolution. This allows us to gauge our model against the mutual shaping lens which combines social

shaping and technological determinism. The case concerns an IOIS involving pharmacies and drug distributors in China. We have studied this system as part of a larger, international comparative project which aims to explain structure and evolution of inter-organisational information systems. Data were collected mostly through interviews which were complemented by publicly available documents about the industry and the systems. In total, 14 interviews have been conducted between October 2004 and July 2007. Among these are four interviews with the initiator and main sponsor of the IOIS, Mr. Li, that were conducted on an annual basis from 2004 through 2007. Other people interviewed were from distributors, the pharmacy and wholesaler (distributor) industry association, governmental organizations, manufacturers, and e-commerce intermediaries (in addition to the interviews conducted with Mr. Li). Interviews lasted between 45 minutes and 2 hours. The interviews have been documented through notes taken during the interviews and interview minutes prepared immediately after the interviews were conducted. The interviews were facilitated by a native-speaking colleague who is intimately familiar with the research project and, in most cases, were supported by several students who took notes.

A vision driving an e-commerce initiative in Henan province

In China, there is no institutional separation between dispensing drugs and prescribing them; therefore, hospitals -- as the main organizations delivering healthcare services -- earn a high percentage of their income (around 40%, cf. Huang and Yang, 2008) by selling drugs. This creates incentives to prescribe high-margin drugs which are usually also expensive and this drives up healthcare costs. In order to curb healthcare costs, the provincial government in Henan province centralized all drug procurement related to hospital demand in 1993. Resistance by hospitals to this measure, however, led to the discontinuation of the practice two years later. Then in 1996, the person in charge of implementing this measure, Mr. Li, visited the US in order to study drug distribution there and became convinced that centralization of drug procurement was the “direction for the future of China” but that this was only possible by making use of the then current e-commerce idea of an electronic marketplace. After two years of preparation, an e-commerce system for procuring drugs commenced operations, initially with good results -- according to Mr. Li -- but operations were shut down after just half a year upon being declared illegal by central government under then premier minister Mr. Zhu Rongji because business operations had to be separated institutionally from their regulation. The software underpinning the system was then sold to a private company -- Haihong -- which would re-launch the system in Henan and develop similar systems in other provinces, among them Guangdong, Hainan, and Beijing (Beijing is a city as well as a province).

The logic of control driving the system's incarnation in Beijing

In Beijing, a centralized, e-commerce-based procurement system for drugs began operating in 2004. However, institutional reforms preparing for that system go back to the year 2000 when the ‘Beijing Bidding Centre’ was set up as a joint effort by nine government agencies involved in the regulation of drug distribution to hospitals. These agencies include, for example, the Beijing Health Bureau (which has a role similar to that of a national Ministry of Health albeit on a provincial level), the Beijing Price Bureau and the Beijing Traditional Chinese Medicine Bureau. Based on experience with similar systems in other provinces, most of them supported by Haihong’s software and services, a process for drug procurement was established; while the core elements of this process are similar across the whole country some elements show distinctive characteristics distinguishing the process from those implemented in other provinces. In general, drug distribution is still a highly localized business; distributors

who are fierce competitors in one province may therefore be business partners in another province. The following account focuses on the practices in Beijing.

The bidding centre usually initiates a bidding process once per year. The process steps are depicted in Figure 3. The core step consists of evaluating competing bids by manufacturers on individual pharmaceutical agents (chemical substances) according to multiple criteria, including price and service quality of distributors (who must be assigned by manufacturers in advance and who often take over the paperwork associated with participation in the bidding process). Manufacturers can bid on a list of about 15 thousand items. A group of experts evaluates bids for each of the province's six hospital groups which have been set up according to certain differences in their demand for drugs. Once bids have been selected, hospitals are required to place purchase orders for drugs only among the winning bids. The main purpose of this process is to control price and to ensure that hospitals use high quality drugs.

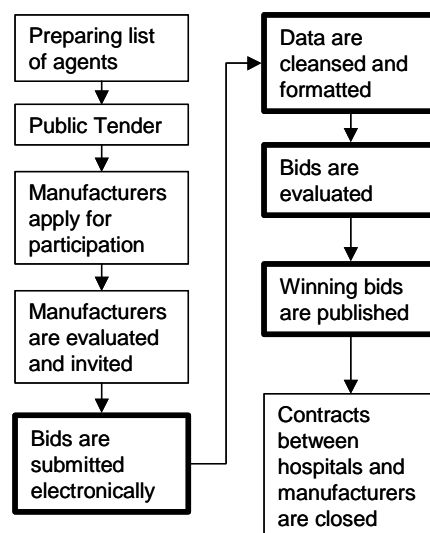


Figure 3: The bidding process (bold boxes indicate steps supported by the system's software)

The bidding process is facilitated by a number of intermediaries which have been certified for that purpose. While seven intermediaries have received such certificates, only three are active. Each hospital group selects one of them to help them with the bidding process. The largest among them -- serving four hospital groups -- is Haihong. The requirements according to the certification process also include operation of an e-commerce system. The intermediary collects all documents which need to accompany a bid and which have to be submitted electronically. The intermediaries then pass these data -- after some data cleansing and format adjustments -- on to the bidding centre. Once winning bids have been selected, the results are published online.

Hospitals are required -- according to stipulations by the Beijing Health Bureau -- to submit orders through the several intermediaries' e-commerce systems. For that purpose, they log onto the systems over a web interface and enter their orders directly into the systems. Distributors then download order data from the systems -- also by logging onto the systems through a web interface -- and hospitals are automatically informed that distributors have downloaded order data. However, distributors cannot confirm or change purchase orders.

Use of the systems evolves from control to transaction processing

Prior to using the e-commerce systems distributors took drug orders from hospitals by phone. (Orders from distributors to manufacturers continue to be placed over the telephone or by fax.) The services of intermediaries complement their e-commerce system's functionality, mostly by offering a 'screening service': if a distributor does not respond to an order the intermediary will help the hospital to procure the drugs through other channels. The intermediaries also improve the efficiency of the ordering handling process of distributors by harmonizing data. For example, hospitals often use internal codes to identify drugs. The intermediaries then match these codes to standard drug identifiers defined by the China Food and Drug Administration (FDA) so that distributors can use the FDA codes for their internal processes rather than having to cope with multiple proprietary codes used by hospitals.

Thus, while the functional scope of the three e-commerce systems is rather narrow, they indeed improve the operational efficiency of the ordering process as can be seen from the changing response of distributors to the centralized, e-commerce-based bidding process. Whereas in 2004 the association of drug wholesalers (distributors) and pharmacies received broad support by its constituency when submitting a petition to government objecting to introduction of the e-commerce-based distribution system, that support was waning one year later as large distributors were discovering operational benefits of the system and because the system has been credited with speeding up industry consolidation favouring the larger players. Specifically, the number of distributors in Beijing fell from around 200 in 2004 to about 120 at the beginning of 2007.

When developing Haihong's e-commerce system in Beijing, supporting the evaluation process through it was proposed as the main rationale for using the technology as the system would automatically add data needed for evaluating drugs for the vast majority of agents and thus reduce the burden of manually evaluating the huge amount of agents (15 thousand) while the most heavily used and expensive drugs would continue to be evaluated completely manually. However, after the first year of operation (in 2005) Mr. Li, who continues to advise Haihong regarding further development of its e-commerce system, pushed the system's supply chain management functions as part of the ordering -- as opposed to the bidding -- process as he became convinced that the system would become a comprehensive platform for modernizing the whole industry.

As the vision of Mr. Li evolved to provide a comprehensive platform for managing the whole drug supply chain from manufacturers to hospitals, the systems' functionality remained quite limited (as evidenced by a lack of an order confirmation or change function). For example, the system was intended to enable zero-inventories in hospital pharmacies. However, hospitals were not interested in such a capability because they do not have to pay manufacturers for unsold inventories. (While Haihong's system was the first to be developed, the systems of all three intermediaries are rather similar in terms of functionality and capacity and do not constitute a main competitive differentiator for them.)

As these difficulties emerged, the systems' advantage to facilitate the monitoring of compliance with the rules of the bidding process was emphasized more strongly. Specifically, as the bidding centre is charged with the task of monitoring hospital purchasing activity in order to ensure that hospitals only buy 'from the list', i.e. do not circumvent the drugs which have been selected in the evaluation process, it was supposed to do so by drawing on the several systems' databases of completed transactions.

However, in spite of Mr. Li's emphasizing the systems' capability to monitor compliance with the bidding results, they are actually not used for that purpose. Specifically, the bidding centre does not make any use of its ability to log onto the systems in order to check hospitals' compliance with the bidding rules (as reflected in their ordering behaviour). While the bidding centre claims that 50-60% of all purchasing transactions are reported to it by intermediaries, it turns out that this feedback is based on aggregated data which are provided by intermediaries to the bidding centre on paper and this only upon request which occurs infrequently and usually only once per year. The intermediaries suggest that the bidding centre lacks the technical skills required for making sense of the data provided by the systems directly. The bidding centre itself indicates that its ability to sanction hospitals (through exposing non-compliance) is rather limited because it is difficult to tell violations of rules from "market behaviour", a view shared by Mr. Li. It was also frequently mentioned that hospitals often have sufficient "market power" to resist any sanctioning efforts. Mr. Li cited yet another reason for the failure of the bidding centre to directly use the e-commerce systems to monitor purchasing behaviour of hospitals. The data in the systems cannot be easily analysed because of a lack of data standards (apart from the use of proprietary product codes by hospitals mentioned above, other data such as names of manufacturers are not standardized either). Moreover, some hospitals ask intermediaries to provide them with so-called 'soft systems' for their data input which are tweaked so as to make it even more difficult to monitor their purchasing behaviour.

There were several shifts in moral stance throughout the evolution of the systems. Initially, Mr. Li saw bribing by manufacturers as the root cause of the problems that plagued the Chinese healthcare sector and which he intended to (partly) solve through the e-commerce system (this normative stance probably reaches back to the system's origin in Henan province). Later on, he identified doctors as the prime culprit as they used to overcharge patients. Most recently, he blamed government for creating inconsistent and sometimes even contradictory incentives which force hospitals to purchase overpriced drugs.

In 2008, continued use of the several e-commerce systems was cast in doubt again. While the percentage of drugs sold/procured through these systems has increased continuously since their inception in 2004 and was estimated to be close to 100% in 2006, the bidding process has been suspended; the last bidding round was completed in 2005 and all transactions that have taken place since then were based on the prices that had been established in that bidding round. The Beijing government has yet to decide whether to resume the bidding process.

Case analysis

Mapping the e-commerce systems to our IOIS practice model

Based on our model, three IOIS can be identified in Beijing's drug distribution industry (built around the three active intermediaries' e-commerce systems) with each consisting of six practices grouped around a boundary structure which was referred to as the e-bidding or e-commerce system in the above account; among these six practices are five "constituent" practices and one boundary practice. Our data are not sufficiently fine-grained for identification of possibly existing boundary spanning activities. As the three IOIS are basically similar in terms of their constituent elements, we subsequently describe the generic structure of all three while relying on data about Haihong's service when describing the evolution of the boundary practice.

The practices involved in Beijing's distribution industry connected to the IOIS boundary structures comprise

- the bid placing practice at distributors or manufacturers,
- the bid evaluation practice at the groups of experts,
- the procurement practice at hospitals,
- the order taking practice at distributors,
- the order monitoring practice at the bidding centre, and
- the data cleansing and system maintenance practice at the intermediaries (boundary practice).

The boundary structures consist of the database containing bids, product codes, and records of transactions (purchase orders) as well as the web-interface used by hospitals, distributors and, supposedly, the bidding centre. The main task of the boundary spanning activities by intermediaries is to maintain these databases, mostly by translating codes and “data cleansing” so that the data provided by hospitals (purchase orders) and distributors/manufacturers (bids) can be sensibly interpreted on the systems used by distributors (regarding purchase orders) and the group of experts (regarding bids). In addition, the bidding centre was supposed to also make use of the databases containing transaction data to monitor hospital purchasing behaviour which, however, it did not do. This constellation of practices is depicted in Figure 4.

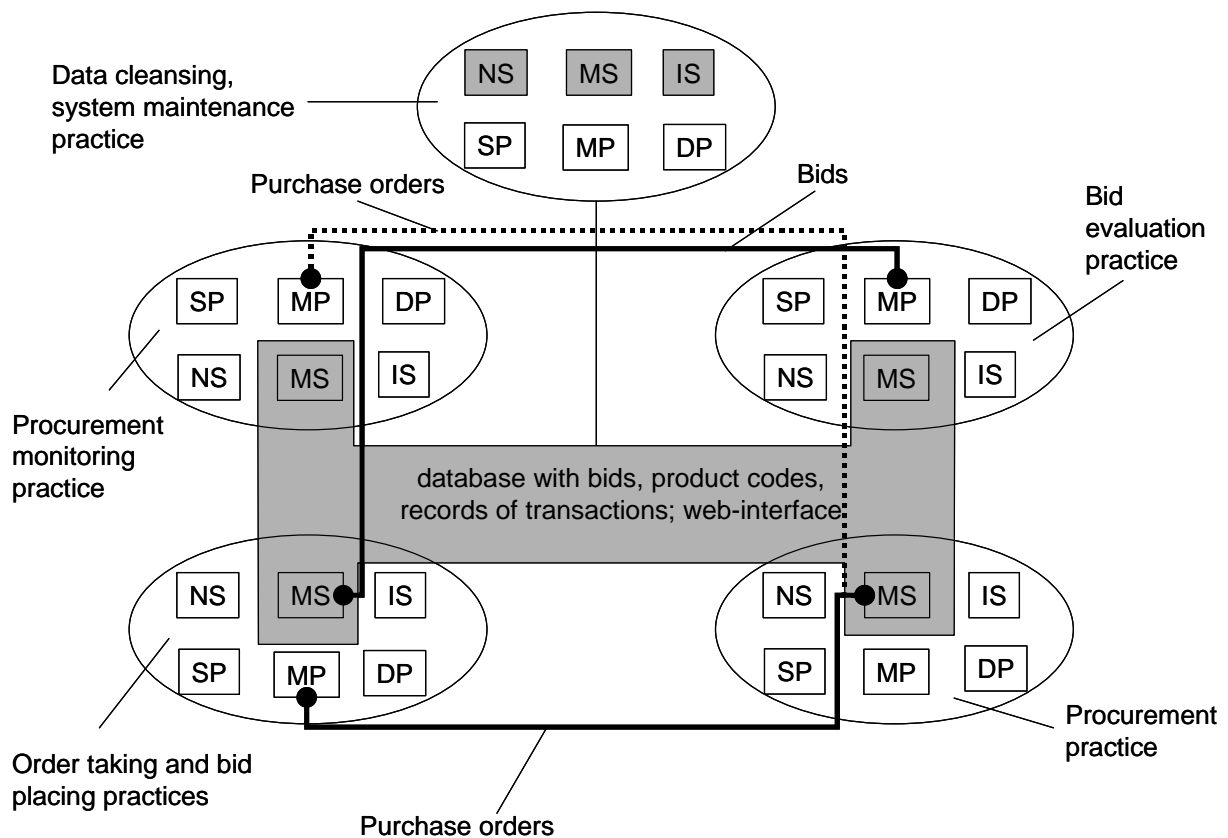


Figure 4: The generic constellation of the IOIS in Beijing's pharmaceutical distribution industry (legend see Figure 2)

Evolution of the boundary structure

The main boundary structures are the databases containing bids, product codes and records of past transactions. As these databases are used within the several connected practices, they are reproduced as a boundary structure. However, type of use has shifted over time. Use of the databases for ordering purposes has increased while use of them to support the bidding process has been suspended since the end of 2005. Thus, the nature of the boundary structure has drifted from one which mainly supports the bidding process to one which mainly supports the ordering process.

From a functional perspective, the boundary structures -- the databases -- have hardly changed over the period of observation but from a practice perspective, they have drifted; the structures increasingly constrained and enabled order taking and placing activities, thus expanding their role in the related practices while their role in structuring price negotiating activities was drastically diminished; the databases almost discontinued to be a material structure from the perspective of price negotiating practices. This shows the distinction between physicality and materiality. The structures are unchanged in their physical manifestations but they decreasingly have significance for practitioners because their constraining and enabling role for relevant bodily movements is decreased.

Yet, the databases could hardly function as a boundary structure were it not for additional activities that moulded them in view of the needs of the practices. These additional activities are performed by the intermediaries and mostly consist of data mapping and “harmonizing” actions so that the databases can be used in the several connected practices. However, the drift outlined above is also visible in the way that the boundary objects are maintained. For example, the intermediaries’ databases containing past transactions are described as almost unusable because of the confusion regarding manufacturer names and product codes used in purchase orders. Regarding bids, the intermediaries claim that data cleansing of bids facilitates the work of the group of experts (who have to evaluate bids on 15 thousand chemical agents) and, according to statements by the distributors, their mapping services improved operational efficiency of processing downloaded orders by distributors. Thus, while the intermediaries’ data mapping and related activities, i.e. their manipulation of the boundary objects, suffice to support reproduction of the boundary objects as boundary structures in some connected practices (procurement, order taking, bid evaluation), they do not for others (order monitoring). Difficulties relating to maintenance of the boundary objects concern the sheer effort required to ensure data consistency in the face of proprietary codes used by hospitals and manufacturers but also the desire of hospitals, who choose intermediaries to serve them while not having to pay for their services, to render records of transactions opaque to the bidding centre.

Evolution of the boundary practice

In order to understand and explain the three systems’ evolution, it would be necessary to describe how the reproduction processes concerning the several dimensions of structure have evolved in all six practices for all three systems. However, as we have longitudinal data on ideational and normative structures and (partly) their reproduction process only regarding the data cleansing and system maintenance practice of Haihong through our series of interviews with Mr. Li, the promoter and advisor of Haihong, the largest intermediary, we can describe changes regarding the normative and ideational dimension of the systems only for this specific boundary practice. The first interview was conducted in September 2004 but through

historical questions we could identify earlier ideational and normative structures. The subsequent changes in ideational and normative structure emerged directly from the interviews as in each year slightly modified ideas and norms were suggested by Mr. Li. Figure 5 depicts the system's evolution in terms of changes in the three dimensions covering the time span from 2001 to 2007 as seen from the perspective of the boundary practice as it existed in Haihong's organization (the structural dimensions captured in this tabulated summary are indicated as shaded boxes in the boundary practice in Figure 4); we have also added partial information on the system's earlier evolution in Henan province as it was captured through retrospective description by Mr. Li. However, we will refer to this earlier phase only in the subsequent discussion of alternative explanations.

Regarding material structure, we have depicted changes in regulation and industry structure -- both of which we regard as aspects of material structure -- which have a direct bearing on the boundary practice, i.e. which are reproduced in that practice and structure it. We have also indicated usage rates of the intermediaries' e-commerce systems indicating to which extent the intermediaries' e-commerce systems are reproduced as a boundary structure. Note that the term 'e-commerce system' is the name that interviewees have given to the web-based application that is developed and operated by the intermediaries. In terms of our IOIS model, this entity coincides with the IOIS boundary object and the boundary structure respectively.

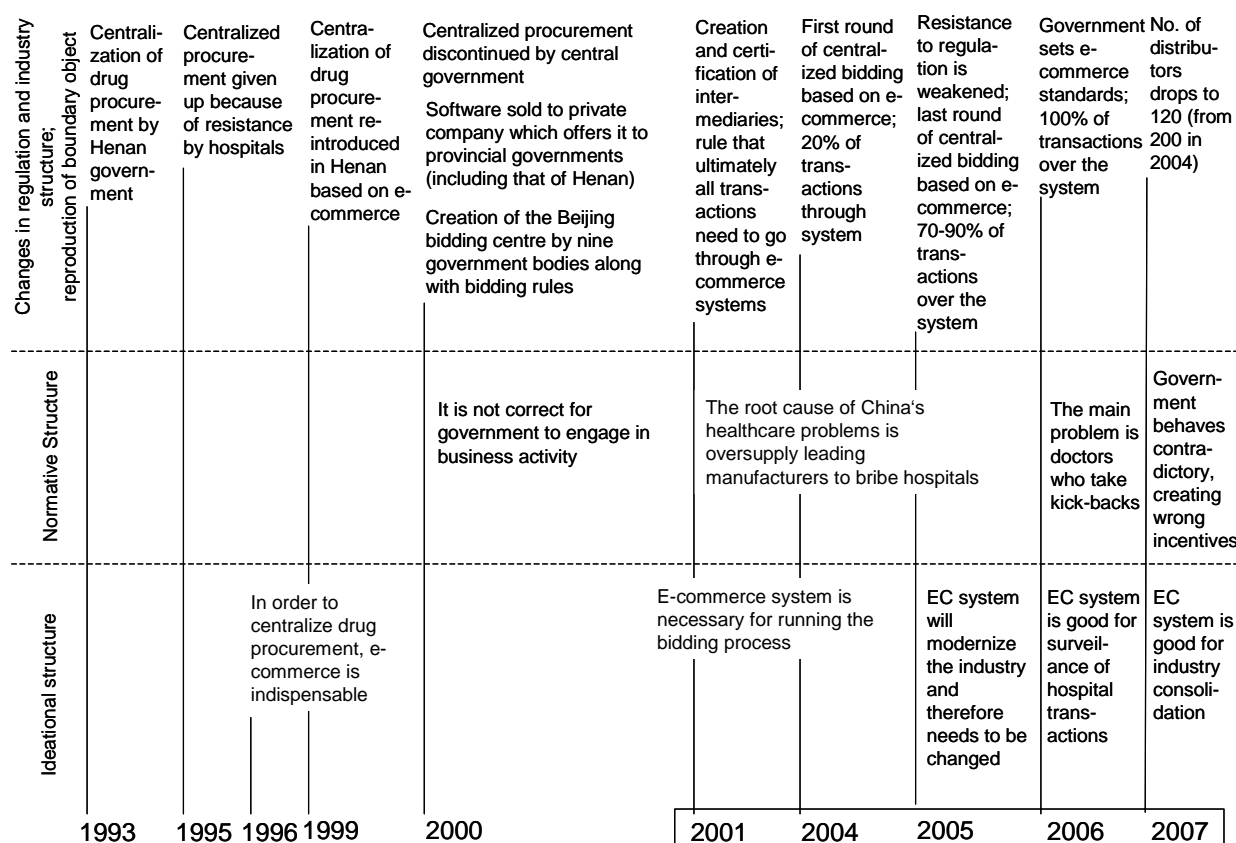


Figure 5: The systems' evolution from 2001 - 2007 and its historical context (boxed years indicate the evolution of the systems' incarnation in Beijing)

The most prominent characteristic of the development in Beijing, as pointed out above, is the gradual drift of the e-commerce systems from a bidding platform towards a transaction platform. This drift is accompanied by changes in other material structures as well as changes

in normative and ideational structures, as viewed from the perspective of Haihong's boundary practice. Regarding material structure, regulation aimed at strengthening e-commerce is put in place while more and more transactions are conducted over the system. Regarding ideational structure, as the percentage of transactions conducted over the system grows strongly, the idea emerges that the system could become a comprehensive platform for modernizing the industry and thus its supply chain management functions would have to be substantially extended. And as the bidding process is suspended, the moral stance shifts towards identifying doctors -- not manufacturers -- as the main culprits while the system's main function (an ideational structure) shifts away from supporting the evaluation process towards facilitating hospital purchasing activity.

These structural shifts across the three dimensions display a high degree of "horizontal compatibility", i.e. they reinforce each other across dimensions at any one time -- given our admittedly very rough time roster of annual intervals -- (note that, in Figure 5, horizontal relationships among structural dimensions appear as vertical relationships due to the row-wise arraying of structures). For example, initially the main idea driving system adoption is to support the evaluation of bids; legal rules subject manufacturers to a time-consuming and, in a way, humiliating procedure as they first are screened whether they qualify at all for participation in the bidding process. Also, manufacturers have to subsidize intermediaries although these are serving the hospitals. From a normative perspective, manufacturers receive most of the blame for the messy state of the China's healthcare sector as they engage in (immoral) bribing of hospitals.

As government suspends the bidding process (at the end of 2005), the idea legitimizing the system changes; now, the main rationale is that the system facilitates monitoring of hospital purchasing behaviour as hospitals have to place purchase orders over the system. At the same time, doctors are starting to receive most of the blame as they are characterized as corrupt (while hospitals are explicitly exempted from this blame since they have to fund their operations).

Finally, as it becomes apparent that the system is rather ineffective for monitoring hospital purchasing behaviour, the system is credited with having helped the drug market in moving "from chaos to order". This rationale coincides with a consolidation of industry structure, which we view as an aspect of material structure. Also, government itself emerges as a new culprit since it tends to provide contradictory incentives that leave industry participants little choice but to buy over-priced drugs.

This unfolding of structural drifts and the relations of these drifts across structural dimensions is suggestive of a mutual reinforcing relationship among structures. New ideas and accompanying discourses giving a rationale for the continued use of the e-commerce system provide meaning to changes in material structure which, in turn, provides evidence for the validity of these ideas. Both, in turn, are supported by drifting moral stances, although these drifts may appear but as slight shifts in emphasis. Yet, they reflect different material circumstances and ideational support while also being justified by these developments in material and ideational structure. As mentioned in the theory section we call these mutually reinforcing relationships "resonance".

Discussion

While the early development phases in the 1990s may seem to be explainable based on action and power, the later phases for which more detailed data are available present a less clear case for an action/power-based explanation. The initial on-and-off characteristic of the development process clearly looks like a power play between the provincial government, hospitals, and central government (see Figure 5). But even in these early phases, a pure power play story would fail to recognize the role played by new ideas and moral stances that were brought to bear on the development process. For example, without the idea that, in order to successfully establish centralized drug procurement e-commerce was necessary (probably much driven by the hype around the Internet at that time) provincial government probably could not have re-instated the centralized procurement practice. And even central government had to draw on the moral stance that business activity performed by governmental organizations was not a correct thing to do in order to successfully discontinue the practice again. While these ideational and normative structures could be viewed as “resources” that are mobilized in the power struggle, they are resources only in view of the (changes in) material structure with regard to which they are mobilized. Thus, their character as a resource depends on the way they interact -- we would say resonate -- with other structures that are already in place. Also, they needed to be reproduced at the time when they were being drawn upon in this power struggle; for example, in the 1990s there were ubiquitous discourses that reproduced the idea that e-commerce enabled new forms of organizing economic activities. The normative structure that governmental agencies should not be engaged in business activity was reproduced through multiple instances of sanctioning such behaviour, many of which supported by the high moral reputation that premier Zhu Rongji commanded, not only in China.

The evolution of the systems in Beijing would be difficult to explain based on a power concept. While power issues surfaced in this development, notably through the wholesaler (distributor) and pharmacy association organizing resistance to the e-commerce systems, government did not take these actions seriously. Rather, government tends to ignore the actions of trade associations. This, again, raises the question of how resources -- structures -- come to serve as power bases, or, rather, fail to serve as power bases.

We argue that the property of a structure as a resource that can be mobilized as a power base is established through mutual reinforcement mechanisms across the three dimensions of structure, i.e. through processes of materialization and legitimization. These processes provide stability to the system while, simultaneously, being the source of drifts. In contrast, appearance of individual instances of structure do not suffice to explain subsequent evolution of the system. For example, initial regulatory intentions were aimed at both, supporting the bidding process as well as the transaction process by the system. Thus, the systems' gradual drift from a bidding towards a transaction platform was not pre-determined by the regulatory context; neither was it pre-determined by the technology which was rather flexibly changed in the development process. Also, it is not possible to say that changes in material structure (regulation and technology) consistently preceded those in ideational and normative structure. Likewise, new ideas and norms did not always precede changes in material structure; rather, it appears as if structural developments along the three dimensions occurred more or less simultaneously or hand-in-hand with one another (cf. Child (2000) for a similar argument).

Our interview intervals provide far too rough a time roster to ultimately establish a possibly sequential unfolding of changes across structural dimensions. However, when subscribing to a

structural concept of changes, such changes must be thought of as occurring in a continuous fashion as reproduction processes are slightly altered over time; thus, it would be futile to nail down single events (of structural changes in the three dimensions) and then map out how different such events follow on one another and thus possibly constrained/enabled preceding and subsequent events. From a structural perspective, changes in structure would appear as a gradual strengthening and weakening of individual structures which correspond with structural shifts in the other dimensions, as observed here. For example, as the systems' transaction structure grows stronger, the norm weakens which blames manufacturers for the current misery of China's healthcare system and other culprits emerge (doctors, the government). Also, the rationale that e-commerce facilitates market-like processes gives way to rationales which emphasize supply chain management (a development in discourses which can be observed across the globe in the years after the collapse of the dot-com bubble). However, these developments do not seem to converge towards a stable state but continue to zig-zag between alternative states; for example, the idea that e-commerce facilitates the monitoring of hospital purchasing transactions has been given up quickly after it emerged (i.e. was not reproduced in discourses); rather, a new idea that points towards industry consolidation effects quickly replaced it. However, both ideas "resonated" with developments in material structure.

As the systems have not converged towards a stable state yet, the dynamics across structural dimensions are more clearly visible. While we have emphasized resonance between the several structural dimension, it would be equally possible to frame the systems' evolution in terms of "dissonance" in which changes in one structural dimension contradict continued reproduction of structures in one or both of the other dimensions. For example, the idea that the systems facilitate monitoring of hospital purchasing behaviour sits uneasily with the disorganized structure of records concerning past transactions stored in the several databases (the boundary structures) and which would render any effort to document hospital purchasing behaviour extremely tedious. Similarly, the systems are at odds with the moral stance that hospitals "have the right" to act commercially. Such contradictory relationships occur because of drift in reproduction processes within particular structural dimensions and provide the dynamic motor of the systems' evolution.

As we only partially captured reproduction processes (those which concern reproduction of material structure through shifting patterns of purchase order and bid placements) we cannot untangle the way that material, normative and ideational structures were interacting with one another to create this development path. However, the picture that emerges from our data suggests that this interaction does not follow a mutual-shaping paradigm. Instead, reproduction processes (which continuously mangle together all three structural dimensions) slightly shift over time, resulting in some structures being strengthened while others drift towards the periphery or completely stop being reproduced. We therefore conclude that a notion of mutual reinforcement of patterns across structural dimension which are mangled together in reproduction processes provides a better picture than the mutual shaping lens. From a philosophical perspective, this implies that we replace the idea of one-way causality -- certain actions cause the rise of certain structures which then cause further events -- by the idea of resonance. Resonance, in turn, implies both the vertical process of reproduction and the horizontal processes of legitimization and materialization. As individual instances of -- material, normative, or ideational structure -- are reproduced this reproduction process also contributes to the reproduction of structural instances in the other dimensions. While one-way causality implies a strict time sequence of events, with earlier events causing later events, resonance implies both, simultaneous reproduction across structural dimensions and ongoing reproduction of structure.

Conclusion

We have discussed the issues of symmetry and causality in socio-material explanations of technology use and evolution in the context of a theory of IOIS we have developed as part of an international comparative empirical study of pharmaceutical supply chain practices. We used a case study of the evolution of e-commerce in China's drug distribution industry to illustrate the constructs of our model and to contrast our form of explanation with existing approaches. We show how these IOIS practices change over time through the waxing and waning of resonance and dissonance between competing material affordances, moral positions and rational visions, while the mangling of these in the reproduction process ensures that episodes of change cannot be solely attributed to any one dimension alone.

The paper contributes to theory in the information systems discipline by presenting a theory of IOIS in which the on-going persistence of these large scale systems is treated as a practical and socio-material accomplishment of communities of practice. The information technology and system component is modelled in terms of boundary practices and structures. The approach is novel and contrasts with existing rational theories of "adoption" as a decision and technological determinist theories emphasising the technological manifestation of these systems at the expense of human interpretation and appropriation.

We have also made contributions to the social theory approach to information technology adoption and use. We draw on Structuration-style reproduction and embodiment of practices to propose a symmetrical treatment of three dimensions of structure -- material, normative and ideational -- and associated patterns of actions. Recognition that material structures (as opposed to physical entities) are the experienced durable complement of bodily actions is an important and novel step which allows a material/bodily-action duality to be treated on a par with social and ideation structure/ action dualities. This symmetrical treatment of structure/action reproduction leads us to propose that these action/structure dimensions are not reproduced in isolation but rather undergo an intimate mixing, or mangling, in the process, which in turn suggest a new kind of two-way causal accommodation between the various aspects of structure which we term "resonance". While these ideas were developed as a reaction to various "determinisms" in the study of information systems adoption, we believe they have wider applicability in the study of the use and evolution of use of technologies in general.

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