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TECHNOLOGY ADAPTATION: THE CASE OF LARGE-SCALE INFORMATION SYSTEMS

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Abstract

The deployment of large-scale information systems is a major trend in the corporate world today due to a number of driving forces such as the Internet, globalization, and the use of IT for distributed knowledge. However, the adaptation process of such new technologies is not yet well understood. With its theoretical basis on structuration theory and actor network theory (ANT), this study employs a case study methodology with organizations implementing ERP systems and investigates how the technological adaptation of large-scale IS, specifically ERP systems, differs from that of traditional (standalone) IS. Our findings are expected to have both theoretical and practical implications for the design as well as implementation of large-scale IS.

Keywords: Large-scale information systems, technology adaptation, structurational model of IT implementation.

RESEARCH OBJECTIVES AND QUESTIONS ADDRESSED

Today we are watching a "paradigm shift" both on the business side (e.g., BPR, e-commerce) and the technology side (e.g., ERP, E-commerce solutions, interorganizational systems) (Markus 2000). The deployment of large-scale information systems is a major trend in the corporate world today due to a number of driving forces such as the Internet, globalization, and the use of IT for distributed knowledge (Braa and Rolland 2000). As an example, ERP systems have been adopted by over 60% of Fortune 500 companies in the USA (Milford and Stewart 2000) and the market is expected to grow to $66 billion by 2003 (AMR Research 1999).

The deployment of a large scale IS requires huge resources and is risky (e.g., Robey et al. 2000). Large scale IS imply that work practices as well as different technologies become increasingly interconnected and integrated, and accordingly, these systems become more vulnerable to unintended side-effects (Braa and Rolland 2000). However, despite several critical reasons to understand the process of technological adaptation (see Tyre and Orlikowski 1994) the adaptation process of such technology is not yet well understood (e.g., Majchrzak et al. 2000).

Therefore, this study examines how the technological adaptation of large-scale IS, specifically ERP systems, differ from that of traditional (standalone) IS. Several different models (e.g., Ciborra 1996; DeSanctis and Poole 1994; Majchrzak et al. 2000; Orlikowski 2000) of technology adaptation have been suggested and their usefulness has been proven, but these models have been primarily applied to traditional IS and coordination technologies. None of them has been applied to large scale IS and control and integration technology. Our overall research question is: what is the process of technology adaptation of large scale IS, how does the process differ from that of traditional IS, and why do the differences occur? The findings are expected to have both theoretical and practical implications for the design as well as implementation of large-scale IS.

THEORETICAL FOUNDATIONS AND PRELIMINARY FRAMEWORK

In the literature, large-scale IS are often referred to as enterprise systems (Davenport 1998), global information or IT infrastructure, horizontal information systems (Braa and Rolland 2000), and infrastructure (e.g., Hanseth and Monteiro 1997; Star

and Ruhleder 1996). Several authors (e.g., Davenport 1998; Ives and Jarvenpaa 1991; Markus 2000) have recognized the importance of large-scale IS or information infrastructure in the context of information integration, globalization, and strategic alignment with business processes.

In the emergent perspective (Markus and Robey 1988) on technology adaptation, there are several different understandings (e.g., Ciborra 1996; DeSanctis and Poole 1994; Leonard-Barton 1988; Majchrzak et al. 2000; Ngwenyama 1998; Orlikowski 1996, 2000) of how the adaptation process unfolds. Even though these studies differ in terms of their position on the specifics of technology adaptation, they share the same assumptions. The implementation and use of new technology are not deterministic: technology has interpretative flexibility and users of the technology are engaged in its constitution during development or use (Orlikowski 1992). Users of a technology are a source of innovation (von Hippel 1998) and reinvention (e.g., Johnson and Rice 1984). The technology is emergent, improvised, and appropriated in diverse ways by diverse users. These models tend to assume that the process of technological adaptation is ongoing and continuous rather than discontinuous, radical, and, often, periodic developments.

Our question is whether these models can explain the process of technology adaptation of large-scale IS, for example integration and control technology, since they have been primarily applied to traditional IS and groupware applications. This question is raised based on many authors' claim that large-scale IS differ from traditional IS with respect to complexity, size, design, etc. For example,

- Enterprise systems often become hard to modify due to their complexity and size (Davenport 1998).
- Horizontal IS are different from traditional IS in how they handle typical support for different communities in the organization or between organizations (Braa and Rolland 2000; Hanseth and Braa 1998).
- Large-scale IS such as ERP systems are like an "infrastructure" (e.g., analogous to a city's roads and bridges) (Markus 2000).
- Infrastructure is "sunk" into, inside of, other structures, social arrangements, and technologies and does not grow de novo (Star and Ruhleder 1996).

Furthermore, some authors have implied that the process of adaptation of large scale IS may differ from that of coordination technologies and traditional IS. For example,

- The change process for a more rigid, more fixed function technology may be different from more open-ended, generic, and user-customizable technology (Orlikowski 1996).
- Technology adaptation may become discontinuous when the costs of change are very high, and when the technology is large and complex; but when the costs to not adapt are higher, and when the technology is more malleable, the adaptations may become ongoing, if not continuous (Majchrzak et al. 2000).
- The implementation of ERP is fundamentally different from traditional IS, and is also distinct from the system user (Volkoff 1999) and characterized by a long-term and complex process with high degree of interdependencies and a *mandatory* context for its users (Pozzebon 2000).
- Such integration is likely to reduce the degrees of freedom for *technology-in-use* and the variety of technologies-in-practice that they will enact may decrease (restriction in malleability) (Orlikowski 2000).

These authors seem to be assuming that large scale or integrated IS tend to be less flexible and restrict users' interpretive flexibility. Therefore, the process of technology adaptation of large scale IS differs from that of flexible or non-integrated technologies. In this similar vein, Orlikowski (1992) notes that information technology has an only "limited" interpretive flexibility. Pinch and Bijker (1987, p. 40) refer the notion of the interpretative flexibility of technology not just to the "flexibility in how people think of or interpret artifacts, but also [the] flexibility in how artifacts are designed." Therefore, technologies vary in their level of interpretative flexibility (Orlikowski 1992). Hughes (1994) argues that "a technological system can be both a cause and an effect: it can shape or be shaped by society. As they grow larger and more complex, systems tend to be more shaping of society and less shaped by it." Drawing from actor-network theory, large-scale IS are more than pure technology; rather it is a socio-technical network (e.g., Rolland 2000) and develops through extending and improving the installed base (Star and Ruhleder 1996). Thus they may be hard to change due to the inertia of the installed base (Monteiro 1998) and could constrain redesigns and modifications (Braa and Rolland 2000). A number of other empirical studies (e.g., Kling and Iacono 1989; Leonard-Barton 1988) illustrate similar points.

These studies seem to imply that (1) in cases of large-scale IS implementation, changes due to organizational factors predominate, while technical changes are relatively less likely to occur, (2) the characteristics of large-scale IS tend to make local adaptation of the technologies very hard, even though local adoption is necessary and is expected to actually occur during the implementation, (3) large-scale IS are often institutionalized before the system is deployed in the focal organization (Rolland 2000), (4) when

time passes, the use of technology becomes habitual or "routines" (Giddens 1984, p. 376) and adaptation drops off, and finally, (5) technology adaptation is likely to reach closure, while the technology itself gains momentum (Hughes 1994), stabilization (Pinch and Bijker 1987), or black-box (Latour 1987). Here, large-scale IS may be regarded as a non-human actor. This closure may be or need to be broken by powerful external forces (Hughes 1987) or discrepant events (Tyre and Orlikowski 1994) such as the introduction of new systems, adoption of new versions of the system or IT standard, mergers and acquisition, etc. These events may initiate another large-cycle adaptation (Leonard-Barton 1988). Importantly, large scale IS, like "technological momentum" (Hughes 1994), is not irresistible.

It seems likely that neither technological determinism nor strong social constructivism may be suitable to explain the process of large scale IS adaptation (e.g., Akrich 1992; Hughes 1994; Misa 1994; Orlikowski and Barley 2001). A model which can be located somewhere between the poles of technical determinism and social constructivism may be appropriate. Thus our model of understanding technology adaptation is being built on several other structuration models mentioned early and borrows several concepts from science and technology studies, particularly ANT, which is claimed to be more specific and concrete with respect to the functions of an IS (Monteiro and Hanseth 1995).

RESEARCH METHODOLOGY

Like other studies (e.g., Ngwenyama 1998; Tyre and Orlikowski 1994) on technology adaptation, this study utilizes a longitudinal process research methodology (e.g., Barley 1990; Van de Ven and Poole 1990) by embracing the structuration perspective. Particularly the study follows methodological guidelines proposed by Barley and Tolbert (1997) and Langley (1999) to investigate the process of structuration empirically. The appropriate level of analysis is critical for studying the structuration process of technology and organizational contexts. Unlike most studies (e.g., DeSanctis and Poole 1994; Orlikowski 1996, 2000) that have investigated the structuration process of technology adaptation through "micro-level" analysis, our study adopts mixed levels studies (Markus and Robey 1988). Privileging one level of analysis over another leads to overdominance of its own causal structures, tends to emphasize either local practices or macro-organizational changes (Orlikowski and Barley 2001), and may lead to either technological determinism or social determinism (Misa 1994). Instead, the process of structuration between technology and organizations is neither strictly micro nor macro in character (Rousseau 1985) and thus mixed levels studies are promising.

CURRENT STATUS OF THE PROJECT

Our field study is expected to begin this fall. This study will be done with organizations that either are implementing or have already implemented ERP systems.

EXPECTED CONTRIBUTIONS

Understanding the process of technology adaptation of large-scale IS by organizations is a timely and critical issue in IS research. We believe that our work can make several important contributions to IS research. It extends many of technology and organization interaction studies and helps to build more adequate theories of large-scale technological change in organizations. It can reveal the differences in the nature of large-scale IS (ERP systems) and may offer a useful strategy for large-scale IS implementation, particularly ERP, and design. With respect to research method, it extends the work of intensive study and process theories in IS research. Since the study adopts mixing levels of analysis, it provides the dynamic interplay between micro and macro phenomenon in the structuration process and extends the few previous works (e.g., Barley 1986; Burkhardt and Brass 1990) done in this line.

PRESENTATION AT ICIS

The presentation will provide our refined model of understanding the process of technology adaptation of large-scale IS. Our expectation is that we will have collected data from case studies of ERP implementation and be able to present some initial findings from the case studies.

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