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Unified Modeling Language (UML) IT adoption — A holistic model of organizational capabilities perspective

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ABSTRACT

This study develops an integrated research model to examine various factors affecting the IT adoption in the context of the Unified Modeling Language (UML). UML is one type of business process modeling techniques, which in turn is a key aspect of the business process reengineering. The proposed research model is based on IT adoption framework and organizational culture theory. The model identifies fourteen variables, covering seven broad categories (IT characteristics, organization technology, environment, organization structure, organization process, organization culture, and project culture) that could potentially impact UML adoption in organizations. This comprehensive conceptual model is further validated by survey data collected from 251 North American organizations across five different industries. Our results support the proposed conceptualization and shed new light on the key factors associated with firms' adoption of UML technologies. Theoretical and managerial implications of the findings are discussed.

1. Introduction

The significance of understanding Information Technology (IT) adoption is well documented [1]. Considerable scholarly research has focused on investigating the impact of one or several of these factors (e.g., IT characteristics, organization technology, environment, organization structure, organization process, and organization culture) in different environmental settings [32,57,58,76]. Extant research has recognized the importance of *technological*, *organizational*, and *environmental* factors (TOE framework) in influencing IT adoption [8,14,80,83]. In spite of prior research that has found strong empirical support for the TOE framework, much fruitful theoretical work remains to be conducted. For instance, previous studies have proposed that IT adoption is affected by organization structure [14,17,60], organization process [12,14,56,76] and organization culture as well as project culture [52,60,80,84].

In spite of extensive prior studies, there is a lack of *comprehensive* and *integrative* understanding, from the organizational culture perspective, on the IT adoption process, which is crucial for both practitioners and researchers in terms of generating deeper understanding of IT adoption. To fill this void, we extend the TOE framework in our research to incorporate organizational culture theory such as organization structure, organization process, organization culture, and project culture. Thus, practitioners may benefit from the holistic analysis of the determinants of IT adoption, and managers interested in introducing new technologies may be able to understand and act more effectively in terms of how to better facilitate IT adoption.

The objective of this paper is therefore to identify a holistic IT adoption model to investigate three research questions on how various organizational factors will impact the IT adoption process. The purpose of this study is threefold. First, it seeks to investigate whether the technological, organizational, and environmental antecedents tailored for a specific context affect IT adoption. Second, it aims to explore whether various organizational idiosyncratic factors (organization structure, organization process and organization culture) determine their IT adoption. Third, it attempts to show the superiority of the holistic IT adoption model as compared to a traditional TOE framework.

These research questions are examined in the context of Unified Modeling Language (UML) adoption using survey data collected in the United States across five industries. UML is a visual and graphical modeling language and has been increasingly used in the past decade in software engineering and e-commerce [1], enterprise modeling, business engineering, process analysis and system configuration [81]. The adoption of UML in organizational computing represents a major change in information systems development and implementation [27,72]. Despite the perceived benefits and its promotion by many industry leaders and the Object Management Group (OMG), the adoption of UML has progressed slowly [71]. High level of complexity of UML makes learning and adopting UML problematic, especially when IT people were lacking of the prerequisite skills [24]. In

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practice, IT professionals often draw diagrams with the symbols provided by the UML tool, but without the meanings those symbols are intended to provide. Dzidek et al. [27] argued that there is little reported evaluation of the adoption of UML. Moreover, to date, most of the studies on UML are technically oriented [6], and there is little empirical research on UML adoption reported. Using UML adoption as a vehicle to study technology adoption in organizations will shed light on better understanding the adoption of this important technology in an organizational setting.

Our results suggest that technology characteristics, organization technology, and organization environment strongly affect UML adoption. In addition, larger organizations and organizations with a higher level of process maturity and strong presence of process champion are more likely to adopt UML. However, we find that some of the dimensions of both organizational and project cultures positively affect UML adoption while other dimensions of cultures have no direct impact on UML adoption.

This study makes an important theoretical contribution to IT adoption literature by being the first to construct and test a comprehensive and integrated model integrating both organizational culture theory and the TOE framework. Move over, we argue that the proposed research framework for UML adoption is developed based on matching type of innovation for UML (hybrid innovation type) with the viable diffusion approach. Our findings also suggest that our holistic UML adoption model is superior to the traditional TOE framework in predictive power. In addition, this study also adds to the literature on UML adoption across varied company sizes and in different industries. Despite its numerous perceived benefits, UML has met with relatively slow acceptance [71]. This paper, therefore, provides important managerial implications for both developers and managers in better understanding the driving forces of adopting UML, and thus implementing such applications more efficiently.

The paper will proceed as follows. First, we review relevant literature. We then develop our hypotheses. After developing our hypotheses, we describe our survey methodology, our multi-sector sample (N = 251), and our regression analyses. We then present our results and discuss the implications of our findings for both researchers and practitioners. Finally, we restate and summarize our contributions.

2. Literature review

2.1. Business process reengineering and UML

When the computer was first applied to business in the 1960s, it was predicted that information technology would bring organizations great benefit. This prediction didn't happen until the 1990s largely due to the limited applications of computer information systems to merely simply and directly simulate business process instead of bringing in quantum improvement [67]. Business process re-engineering (BPR) concept was then proposed to face this challenge. It was defined as the fundamental re-thinking and radical redesign of business processes to achieve dramatic improvements in critical contemporary measures of performance such as quality, speed, costs and service. BPR is regarded as a revolution of enterprise management [32].

Many factors can affect the success of BPR and one of the key factors is business process modeling (BPM). BPM is a set of technologies and standards for the design, execution, administration, and monitoring of business processes and it also provides the ability to model and analyze specific business processes [30]. One of the major BPM tools is the UML, which is used to analyze and design the object-oriented systems. UML was created in 1997 by three modeling advocates and the Object Management Group (OMG) adopted UML as a standard modeling language for object-oriented applications [10–25]. Since then, UML has been seen as the dominant set of techniques and standardized general-purpose modeling language for modeling and building complex IT systems. It offers a variety of techniques for analyzing, designing, and implementing flexible and robust information system, which can be applied and integrated in all business processes, throughout the systems analysis and development life cycle, and across different implementation technologies and platforms. It includes a large set of graphical notation techniques to create abstract models for specific systems.

According to the research conducted by Chau and Tam [14], a technology innovation's perceived benefits and perceived barriers will affect the technology adoption. UML has some significant benefits in comparison to other modeling languages based on its distinctive characteristics [24]. The perceived benefits of UML are summarized in the Appendix A.

Batra [6] claimed that, since the introduction of the UML, there was a certain degree of agreement on a number of the important issues revolving around the building of information systems, and real progress toward creating truly better systems seemed equally possible.

Barriers to UML adoption stem from its nature of high complexity; it is not easy to understand and implement, and it is recognized that learning how to properly construct high-quality UML diagrams is a challenging task [70]. Indeed, even the OMG warns users about the complexity of implementing UML, especially for building large and complex information systems. Complexity is identified by Tornatzky and Klein [80] as one of the innovation characteristics of the attitude towards the use of IT innovation. Hence, UML's complexity issue will ultimately have an effect on company's adoption of UML.

Over the years, substantial research on innovation adoption has been conducted based on innovation diffusion theory; however, it has been recognized that innovation diffusion theory does not provide a complete explanation for technology diffusion in organizations [41]. According to Zmud [86], much of the inconclusiveness of prior research can be attributed to a failure to recognize the innovation attributes that can be perceived very differently according to the specific organizational context involved. Drawing upon literature from both organization innovation and technology adoption (see Table 1), we propose a comprehensive IT adoption research model to study UML adoption.

2.2. UML and type of innovations

A variety of innovations have been studied in IS research. We suggest that IS innovations can be classified as being *administrative*, *business process*, and/or *technical innovations*. *Administrative innovations* in IS facilitate the planning, control, and coordination of the organization, or serve the same purposes within some subunit of the organization [20,86]. Examples of administrative innovations in IS include the creation of the CIO position and database administrator (DBA) function within organizations, the departmentalization of the software maintenance function, and the choice to outsource the IS function of a firm [3,75]. These examples are clearly not innovations in the computer and data communications technology of the organization, and thus a meaningful distinction can be drawn between administrative innovations and others that may be classified as technical innovations.

Business process innovations are changes to the methods and procedures that a firm uses to produce a specific output such as a product or service [22]. Business processes may include operational processes such as manufacturing products and coding software, or may include supporting processes such as purchasing, accounting, and technical support [63]. Examples of business process innovations include the adoption of application prototyping methods [75] and the use of MRP and ERP systems to computerize business processes [86]. Though administrative innovation may occur concurrently with a process innovation, it is not mandatory and therefore can be independent.

Technical innovations are changes to the computer hardware, software systems, and data communications technology that the organization uses. The adoption of e-business represents one example of a technical innovation (e.g., [85]). Other similar examples of technical