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IT STANDARD IMPLEMENTATION AND BUSINESS PROCESS OUTCOMES - AN EMPIRICAL ANALYSIS OF XML IN THE PUBLISHING INDUSTRY

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Completed Research Paper

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Abstract

Despite huge incentives and investments in information technology (IT) standards, many firms still fail to fully benefit from their implementations. To explain such failures, we examine why some firms benefit more from IT standard implementation than others. Specifically, we look at the implementation of the eXtensible Markup Language (XML) from a technological diffusion perspective, and investigate under what contextual conditions the extent of XML implementation has the greatest effect on business process outcomes. Using empirical data from the publishing industry (N=188), we find that the extent of XML implementation impacts business process outcomes, and both business process radicalness of XML implementation and related XML knowledge play moderating roles. For information systems (IS) practice, this study helps managers direct their attention to the most promising factors and elaborates on their differential effects on business process outcomes. For IS research, it integrates innovation diffusion theory into our current knowledge of IT implementation and provides theoretical explanations for XML implementation successes and failures.

Keywords: XML, business process outcomes, IT standard implementation, innovation diffusion

Introduction

Despite significant investments in information technology (IT), a considerable number of firms have not been able to derive full benefits from their IT investments, largely due to their inability to effectively deploy IT in their value-chain activities and business strategies (Armstrong and Sambamurthy 1999; Boynton et al. 1994). IT and IT standard implementation are important because they enable a firm's competitive strategies by lowering production costs, achieving operational flexibility, enhancing supplier or customer linkages, and enhancing or creating new products and services (Porter and Millar 1985). While some implementations of IT systems have led to significant reduction in inventory and in administrative costs, and millions of dollars in logistics savings at firms such as Dow Corning, IBM, and Texas Instruments (e.g. Hammer and Stanton 1999; Ross 1999), others have led to failures at firms such as AMR Corporation, Dow Chemical, and Hershey Foods (Scott and Vessey 2002). Similarly, the implementation of IT standards (such as XML or EDI) have resulted in considerable intra- and inter-firm process improvements at companies such as Campbell, John Wiley & Sons, Mercedes Benz, and Douglas Holding (e.g. McClure 2009; Marshall et al. 2009; Banker et al. 2006). However, there have also been several reports about failed attempts to implement IT standards or great obstacles to benefit from them (Zhu and Fu 2009; Jun and Cai 2003).

Such conflicting results have prompted numerous empirical examinations of the factors that lead to differential performance outcomes of IT-innovation implementation across firms (e.g. Karimi et al. 2009). In this respect, one of the more persistent criticisms of prior research examining the determinants of innovation-based performance outcomes has been the absence of strong and consistent findings across a wide range of IT (e.g. Prescott and Conger 1995). One plausible explanation for this is that researchers, in pursuing the worthy goal of establishing a more general theory of IT innovation diffusion, may have been working at a theoretical level too far abstracted from particular IT innovations and contexts. In this regard, previous studies have oftentimes adopted aggregate levels of analysis correlating IT investments (e.g. measured with financial indicators such as computer capital or IS staff) with firm performance or overall industry output factors, potentially obfuscating the impacts of specific IT systems and standards. This makes it difficult to isolate the impact of individual technologies and standards on business processes (Devaraj and Kohli 2003). An alternative approach – the one advocated here – is to develop more nuanced theories focusing on the distinctive performance effects of particular kinds of technologies and standards on business processes. Although there has already been a number of empirical studies investigating the performance effects of specific IT systems such as ERP (e.g. Karimi et al. 2007) or inter-organizational IT standards such as EDI (Iacovou et al. 1995), existing research still lacks empirical studies on the business process outcomes of the implementation of multi-purpose standard families such as *XML*.

The eXtensible Markup Language (XML) is a multi-purpose and platform-independent IT standard for creating custom markup languages that has been adopted in many industries and functions since its introduction in 1998. Markup languages are artificial languages that use a set of tags or annotations to describe how text is to be structured, laid out, and formatted. In contrast to EDI, XML offers a wider application range for the support of intra- and inter-firm business processes (Wareham et al. 2005). Because it is classified as an extensible language, it gives a maximum degree of freedom to its users to define their own data with contextual and specific meanings for any given industry, application, or transaction. Its primary purpose is to facilitate the sharing of structured data across different IS, particularly via the Internet, and it is used both to encode documents and to serialize data. Many derivative standards have evolved from XML, covering a broad range of application fields such as data storage and handling (e.g. XPATH, XLINK, XQUERY), metadata mark-up and interchange (e.g. RDF, XMI), data exchange (e.g. ebXML, RSS, ICE, GPX), output format transformation (e.g. XSLT, XPATH, SVG, WML), and data and functional integration (e.g. XML-RPC, SOAP). Since its introduction, XML has reached considerable penetration rates in various application fields and industries (e.g. ACORD in the insurance industry, ONIX in the publishing industry, RosettaNet in the consumer electronics industry) due to its ease-of-use, application versatility, and adaptability (Wareham et al. 2005). It is not only useful for facilitating exchange relationships between organizations, where it has already started to substitute the EDI standard (e.g. Nurmilaakso 2008), but it also has considerable application potentials within the boundaries of firms to standardize, automate, and integrate process steps to increase process efficiency, effectiveness and flexibility (e.g. Ou et al. 2004). According to Broadbent et al. (1999), XML can thus be characterized as a fundamental technology with a high level of reach and range. Despite its high application potential, however, XML still can be considered an innovation even several years after its introduction, as the use of XML is not routine in many firms yet (McClure 2009).

Although XML's relevance in facilitating business operations have been shown in several practitioner-oriented outlets (e.g. McClure 2009), previous empirical IS research has primarily focused on the formation (i.e. standard-making vs. standard-taking) and assimilation of XML (e.g. Bala and Venkatesh 2007; Nickerson and zur Muehlen 2006). Only few empirical studies have so far examined the performance effects of IT standard implementation and mainly focused on *inter-organizational* exchange relationships and *on outcomes on the firm or industry level* (e.g. Malhotra et al. 2007; Wigand et al. 2005; Markus et al. 2006; Premkumar and Ramamurthy 1994; Brousseau 1994). While this work has contributed significantly to our understanding of the value of IT standard implementation, it can be further extended in important ways by focusing on XML as an IT standard family covering a *wider range of intra- and inter-firm application areas* than IT standards examined in previous studies (e.g. EDI) and by investigating the effects of IT standard implementation focusing on *business process outcomes*. In this way, we avoid potential confounding and obfuscation that may result when IT impacts are measured and reported as firm performance or industry output variables. Moreover, this not only facilitates to investigate whether extending the scope of IT standard implementation increases business process outcomes. It also allows including contextual factors into the analysis that intervene on the process level providing for a deeper and richer understanding of IT standard implementation success. Given this research gap, the goal of our study is to analyze (1) whether greater scope of XML implementation leads to better business process outcomes and (2) what factors reinforce or attenuate the performance effects of XML assimilation on the process level (Fichman 2004a).

The remainder of this paper is organized as follows. The next section introduces the research framework of this study, followed by a section that develops the hypotheses to be tested. The research methodology is then described, and the results of the survey-based study are reported. A discussion of the findings, the implications for theory and practice, the limitations of the study and suggestions for future research are provided, followed by the conclusion.

Research Framework

Most frameworks for understanding IT (standard) implementation are ingrained in innovation diffusion theory (e.g. Armstrong and Sambamurthy 1999). From a technological diffusion perspective, IT (standard) implementation is defined as an organizational effort to diffuse an appropriate IT innovation within a user community (Cooper and Zmud 1990, p. 124). For an IT innovation to be successfully assimilated (implemented, used, and diffused), it first needs to be implemented (Fichman 2000). Researchers have argued that the extent of implementation is a better measure for quality of innovation (outcomes) than adoption, as not all innovations that are adopted actually get implemented (Fichman 2004a). A recent review of the technology strategy literature in Fichman (2004b) identified three broad-based technology-organizational factors that can significantly explain not only the increase in variance of potential payoffs but also the option value of an IT platform (e.g. IT standard) adoption. These factors are the (1) divisibility of technology (i.e. the extent to which a technology can be divided for sequential implementation), (2) radicalness of technology (i.e. the extent to which products or processes have the potential to be improved by the innovation), and (3) the extent to which a firm possesses innovative capabilities and endowments to absorb the technology. According to Fichman (2004b), as these technology-organizational innovation factors can interact in complex ways, they must be viewed holistically to find out which combinations of factors are more important in explaining the outcomes and under what contextual conditions the performance effects are greatest.

In this study, we examine XML implementation from a technological diffusion perspective drawing on Fichman (2004b) to find out when and under what contextual conditions the extent of XML implementation has the greatest effect on business process outcomes. The research model, presented in Figure 1, suggests that the extent of XML implementation can have the greatest effect on business process outcomes when organizations have accumulated a comprehensive stock of XML-related knowledge and when the business process radicalness of XML implementation is high due to a firm's increased business process complexity and information intensity. In the following sections, we introduce these three key factors of IT innovation diffusion, and show how they specifically relate to XML implementation. In the next section, we then hypothesize how these three factors' interactions affect business process outcomes.

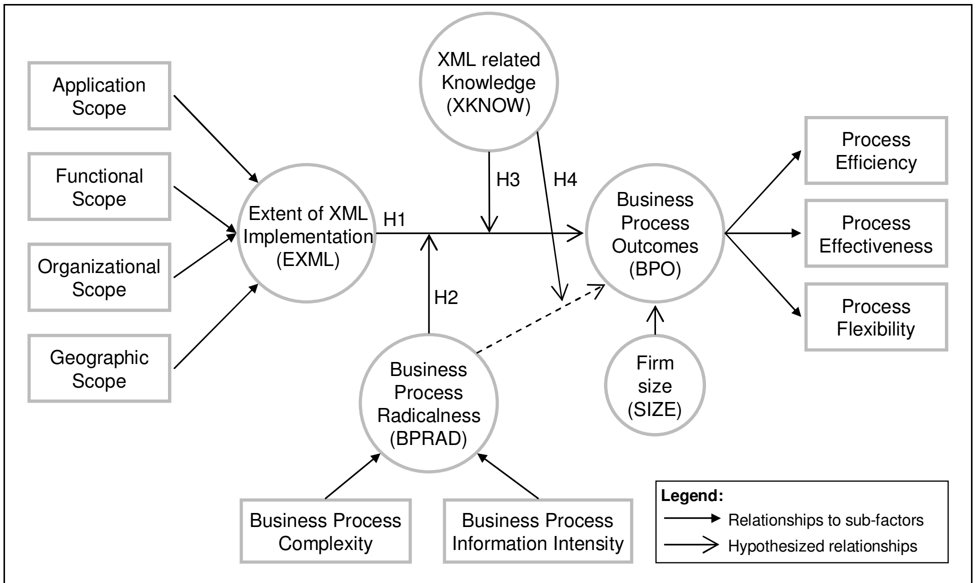

Figure 1. Research Model

Extent of XML Implementation

The quantity or scope of IT innovation has been conceptualized as the extent to which an organization adopts innovations often, adopts them early, and/or adopts them thoroughly (Fichman 2001). XML implementation is divisible to the extent that it can be divided up for sequential or incremental implementation by application areas, functions, departments, the entire company, locations, or regions (Karimi et al. 2009; Murray 2002). Because divisibility of XML (standards) allows for incremental implementation, it serves to enhance managerial flexibility and expected potential returns. Extent of XML implementation defines the types of benefits that can be derived from XML standards, and specifies the degree to which XML standards will change process integration in and across the business units of an enterprise (Benlian and Hess 2009). The extent of XML implementation is defined here as XML application scope (i.e. scope of application areas), functional scope (i.e. scope of supported functions such as procurement, production, marketing etc.), organizational scope (i.e. system reach in a company), and geographical scope (Keen 1991; Broadbent et al. 1999).

XML application scope refers to the range of application areas where XML is implemented and used (e.g. Lu et al. 2006; Murray 2002). Because XML is a simple, very flexible text format derived from SGML (ISO 8879), its basic components (i.e. (1) definition of document structure and metadata with DTDs or XML Schemas, (2) output format specifications with style sheets (e.g. CSS, XSL-FO), and (3) XML file as specific container of data specified in (1)) can easily be adapted and refined to other application areas (Blansit 2009; Lie and Saarela 1999). Five main uses of XML have been identified in previous studies (see Table 1[1]) that include (1) data storage and handling (e.g. in XML databases), (2) functional integration (e.g. in web services), (3) format transformation (in enterprise content management systems), (4) data/metadata exchange (e.g. in ERP/SCM systems), and (5) metadata/annotation management (e.g. authoring systems or ontology browsers).

These uses of XML can be relevant in different functions of the organization. Greater XML functional scope is achieved through the implementation of multiple or cross-functional XML modules (e.g. a DTD for several business functions). It provides data and process integration across business functions and more benefits than a single function implementation (Mendling and Nüttgens 2006). It can facilitate the exchange of data between applications for monitoring and managing business activities across the extended enterprise (e.g. by implementing business rules for the handover of information between two process steps) (Bala and Venkatesh 2007). Moreover, it enables end-to-end automation of business processes, thereby allowing firms to react more quickly to changes in business

[1] For a more detailed description and explanation of XML derivative standards, the interested reader is referred to http://en.wikipedia.org/wiki/List_of_XML_markup_languages

conditions. XML organizational scope is defined as the organizational locations that the XML implementation can reach, such as departments, divisions, entire company, multiple companies, and so on. It specifies the degree to which the system will change managerial autonomy, task coordination, and process integration in the business units of the enterprise. XML geographic scope refers to the regional, national, and global reach of the XML implementation. By integrating their XML standards with those of their trading partners, firms primarily hope to reduce cost, and improve business processes, data integrity, and customer service (Malhotra et al. 2007).

Table 1. Application scope of XML

Application areas of XML	Examples for derivative standards	Examples for supported IT systems	Selected literature for different XML uses
Data storage and handling	▪ XLINK, XPATH, XQUERY	▪ XML databases	Lu et al. 2006; Cox 2006
Functional integration	▪ SOA(P), UDDI, WSDL, XML-RPC	▪ Web services	Phaithoonbuathong et al. 2010; Ou et al. 2004
Format transformation	▪ XSL(T), XBRL	▪ Enterprise content management	Ou et al. 2004; Lie and Saarela 1999;
Data/metadata exchange	▪ ebXML, RosettaNet, WDDX, XMI	▪ ERP, CRM or SCM systems	Klein and Rai 2009; Wareham et al. 2005; Van der Aalst and Kumar 2003; Bala and Venkatesh 2007
Metadata/ontology management	▪ RDF, OWL, RuleML	▪ Authoring systems or ontology browsers	Orman 2009; Decker et al. 2000; Dongwon et al. 2005

Business Process Radicalness of XML Implementation

Radicalness is defined from the perspective of process innovation and refers to the extent (low or high) of potential improvements in organizational processes or products enabled by a technology innovation (Fichman 2004b; Dewar and Dutton 1986). IT innovations can be used to improve business processes by implementing systems and standards that support or integrate business functions and by integrating data and processes along the various links in the value chain, either for internal operations or for the external marketplace (Broadbent et al. 1999). In particular, XML standards can be used for (1) process innovations within the information system (IS) function to enhance the efficiency or effectiveness of the IS function (type I), (2) enhancing the administrative work processes from new IT products and services (type II), and (3) integrating IT in core value chain activities and business strategies that directly affect a firm's financial performance (type III) (Geerts and White 2004). XML implementation enables firms to integrate their business processes by business process standardization, innovation, and improvements (Attaran 2004). It can help firms integrate vast amounts of information and can reduce the need to navigate many different systems to acquire and disseminate information (Chen et al. 2006). While a business process is essentially composed of discrete and detailed activities performed on, or in response to, incoming information, the complexity (i.e. non-routineness, difficulty, uncertainty, and interdependence) and information intensity associated with those activities are the most important aspects of any business process (Picot et al. 2007). We discuss next why higher levels of business process complexity and information intensity result in radicalness of XML implementation.

Business Process Complexity

Business processes are activities underlying value-generating activities for transforming inputs to outputs in the value chain (Melville et al. 2004). Reducing business process complexity is a key business reason to adopt XML standards in both small and large companies with simple or complex structures (Chen 2003; Yen et al. 2002). The implementation of XML standards can reduce business process complexity by (1) solving maintenance problems associated with aging legacy systems and obsolete standards, (2) presenting "one face to the customer" through data integration and consistent interface designs across multiple output channels (e.g. B2B/E-Commerce or mobile channel) (3) reducing the variance in business process execution through standardization, and (4) reducing complexity of intricate transactions that involve multiple system platforms across a single business unit, multiple sites, and multiple business units (Aggarwal et al. 2006; Attaran 2004; Tarn et al. 2003; Lim and Wen 2002). Therefore, the higher a firm's business process complexity, the higher the radicalness of its XML implementation as a result of its potential to enable fundamental changes in the firm's business processes and their outcomes.

Business Process Information Intensity

Information intensity is the amount of information processing required to effectively manage a firm's products, services, and value-chain activities (Porter and Millar 1985). Porter and Millar (1985) suggest that products or services with high information intensity are those that (1) mainly provide information, (2) involve substantial information processing, (3) require especially high costs for buyer training, (4) have many alternative uses, and (5) are sold to buyers with high information intensity in their own business. Higher information intensity results in data integration difficulties and creates greater strategic opportunities for innovative applications of IT. In this regard, business process information intensity is a key technical reason for the adoption of XML standards by firms to reduce their data integration problems and to eliminate poor productivity and performance problems associated with older or legacy standards (Nurmilaakso 2008; Lu et al. 2001; Chen 2003). XML implementation can reduce data integration problems by (1) eliminating redundant data entry and concomitant errors; (2) reducing difficulty in data analysis by using consistent transformation rules (e.g. XBRL); and (3) managing, integrating, repurposing and sharing data associated with products, services, and value-chain activities across the firm (e.g. Chang and Shaw 2009; Nurmilaakso 2009; Gosain et al. 2003; Lim and Wen 2002). The higher a firm's business process information intensity, the greater the necessity to integrate a vast amount of information and reduce data integration problems. This results in business process radicalness because such implementation will not only enable improvements in the way how the vast amount of information is handled but it will also have a (radical) effect on the firm's business processes and their outcomes.

XML-Related Knowledge

According to Nelson and Winter (1982), organizations may be viewed, at any given moment, as possessing some bundle of knowledge and skills related to their current operational and managerial processes (Nelson and Winter 1982). In order to successfully assimilate and implement a new IT-related innovation, an organization must somehow reach a state where its bundle of knowledge and skills encompasses those needed to use the new technology effectively. Thus, an organization may be seen as having to travel some metaphorical distance to get from the current bundle to the needed bundle (Pennings and Harianto 1992). When complex technologies are first introduced, this distance is likely to be considerable for most organizations. In the case of XML, for example, successful assimilation requires learning on a number of fronts, including grasping the abstract principles on which the IT standard is based; understanding the nature of the benefits attributable to it; grasping specific technical features of different commercially available instances (i.e. derivatives) of the IT standard; discerning the kinds of problems to which it is best applied; acquiring individual skills and knowledge needed to produce a sound technical product on particular development projects; and designing appropriate organizational changes in terms of the team structure, hiring, training, and incentives.

Organizations should be more likely to innovate and reap the benefits of innovations when they can better afford any given level of costs associated with the journey from their current bundle to the needed bundle of skills. They should also be more prone to innovate and exploit innovations when they can cover the distance between their current bundle to the needed bundle with less effort and lower risk of failure. Cohen and Levinthal (1990) develop the idea that a firm's ability to appreciate an innovation, to assimilate it, and apply it to new ends – what they term its "absorptive capacity" – is largely a result of the firm's preexisting knowledge in areas related to the focal innovation (Cohen and Levinthal 1990). This prior related knowledge makes it easier for individuals to acquire, retain and apply new technologies because it gives individuals rich, well-organized mental schemas into which new knowledge can be placed, and allows the associative connections needed for insights related to the new knowledge. In addition to promoting absorptive capacity, related knowledge also effectively diminishes the distance a firm must travel to get from its current bundle of skills to the needed bundle, because some of the burden of knowledge acquisition is eliminated. In other words, knowledge related to the focal innovation (i.e. to XML in the context of our study) can be viewed as lubricant providing organizations with advantages to exploit the innovation's improvement potentials.

Business Process Outcomes

Rather than looking at the level of a firm's output measures for determining business value, the process-based perspective favors a process-oriented assessment of IT business value. From the perspective of resource-based theory, business processes provide a context within which one can examine IT business value (Porter and Millar 1985). This perspective is based on the argument that the first-order effects of IT investment occur at the operational level by pointing to process efficiency, effectiveness, and flexibility as various formulations of outcomes (Barua et al. 1995; Mooney et al. 1996). IT (standards) can improve individual processes by enabling business process integration across physical and organizational boundaries (Basu and Blanning 2003). In addition to operational benefits, IT benefits are classified at higher tactical and strategic levels, and at infrastructure and organizational levels (Weill and Broadbent 1998). As discussed by Shang and Seddon (2002), although these dimensions have been outlined separately, they nevertheless interact: operational benefits may come with increased managerial effectiveness; strategic benefits rely on process efficiency; infrastructure benefits result in business flexibility, reduced cost, and increased capability; and organizational benefits can be realized in parallel with managerial benefits. At the operational level, IT in general and IT standards in particular create business value by having three separate, but related, effects on business processes: (1) automational effects, which refer to the efficiency perspective of value derived from the role of IT as a capital asset being substituted for labor and from its role in cost reduction; (2) informational effects, which are the results of IT capacity to store, process, and disseminate information; and (3) transformational effects, which refer to IT's ability to facilitate and support process innovation and transformation (Mooney et al. 1996). From a business process manager's perspective, the effects of these business process outcomes will be reduced cost and cycle time, and improved productivity, quality, and customer service benefits (Shang and Seddon 2002). Automational effects result in process efficiency by increasing throughput, reducing labor costs, and increasing reliability (Banker and Kauffman 1988). Informational effects result in process effectiveness by increasing resource utilization, reducing waste, and improving quality (Porter and Millar 1985). Transformational effects result in process flexibility by enabling product and service innovation, reducing cycle times, and improving customer relationships (Mukhopadhyay et al. 1995).

Hypotheses Development

Business process improvements have been major motivations for XML implementation in the past (Nurmilaakso 2009; Bala and Venkatesh 2007). Prior research on the benefits of XML standards suggests that because XML automates business processes and enables (ad-hoc) process changes at the operational level, its implementation has the potential to result in cost and cycle time reduction, as well as productivity, quality, and customer services improvements (Nurmilaakso and Kotinurmi 2004; Lim and Wen 2002). Further evidence on the potential of XML to influence business process outcomes can be seen in its capability to support concepts such as single sourcing or flexible repurposing of information and content (McClure 2009). While single sourcing allows companies to store highly structured information at one place (i.e. in a central repository) and thus providing data consistency, availability, and automated information integration, flexible repurposing of information enables companies to flexibly utilize information in different areas (e.g. across different customer touch-points) with low to zero transformation costs and with high information quality (Bala and Venkatesh 2007). XML standardizes the communication and collaboration processes between internal and/or external parties by specifying the rules, protocols and data needed for the execution of sequential process steps. XML can thus be considered to support information processing through enhanced communication and increased efficiency of information sharing (Van der Aalst and Kumar 2003). Furthermore, XML standards can be viewed as boundary spanning objects or interfaces that have the potential to enable *adaptive* partnerships and virtual organizations and provide for a more seamless and effective cooperation among internal and external entities. Likewise, they may enable increased flexibility due to its capability to adapt to change by enhancing the accessibility and availability of knowledge (Orman 2009).

Given the potential benefits of XML, its divisibility affects decisions regarding the extent of XML implementation and whether it should be a big bang deployment, a phased roll-out, or incrementally implemented (Nord and Tucker 1987). Fichman (2004b) suggested that increases in IT-based innovation divisibility extend the potential for incremental implementation, which in turn increases the expected value of potential payoffs. These subsequently lead to increases in the option value of positioning investments in IT platforms. Applying these arguments to XML, extending the use of XML in different application areas, business functions, departments and geographies will be likely to increase the option value and thus business process outcomes of XML. Therefore, we assume that there is a positive relationship between extent of XML implementation and a firm's business process outcomes.

H1: *Extent of XML implementation has a positive association with business process outcomes.*

Radicalness of IT innovations is suggested to affect IT adoption, implementation, and implementation outcomes (Fichman 2004b). Incremental implementation of innovations is associated with better implementation of organizational innovations and software packages (Fichman and Moses 1999). On the other side, rapid, big bang-style implementations are especially prone to disaster because of the potential for (un-)intended consequences on the structure of business. Although radical changes can still be enacted through a sequence of incremental implementations, radical innovations impose greater implementation challenges. However, they also enable greater opportunities (Dewar and Dutton 1986). Thus, increases in radicalness are expected to increase the variance of potential returns and to increase the option value of positioning investments in IT standards (Fichman 2004b).

When processes are complex and require a significant amount of information processing, the potential for improvements through the extent of XML implementation increases. In other words, XML implementation increasingly unfolds its effects on business process outcomes, when business processes are infused with more information (i.e. either because of information-rich products or processes) and are more complex (e.g. due to high uncertainty and a high number of involved parties) because XML builds on the automation and standardization of information handling and thus on scale (Benlian and Hess 2009). Therefore, we expect that business process radicalness influences the association between the extent of XML implementation and business process outcomes such that the higher the business process radicalness, the higher will be its association. Hence, the following hypothesis is proposed:

H2: *Greater extent of XML implementation in conjunction with greater business process radicalness is positively associated with higher business process outcomes.*

As described above, related knowledge is the extent of abstract knowledge, know-how, and skills possessed by the organization in areas related to the focal innovation. Dewar and Dutton (1986) found in an empirical study that extensive knowledge depth is crucial for the adoption of incremental as well as radical innovations. Similarly, related knowledge facilitates assimilation by making it easier for organizations to acquire new knowledge (Cohen and Levinthal 1990), and by decreasing the total quantity of knowledge that must be acquired (Pennings and Harianto 1992). As with most IT standards, XML imposes a substantial burden of organizational learning on would-be adopters. To ensure successful implementation outcomes, adopters must have knowledge of fundamental structural principles (e.g. separation of structure, style and content) and how to apply them; the nature of potential benefits resulting from XML (e.g. modularity, reuse, productivity) and the circumstances under which these benefits are most likely to be obtained; how to use the derivative standards of XML and technologies likely to be used in conjunction with XML (e.g. in XML editors); and how to redesign team staffing, structure, procedures, and incentives in light of the radical differences between XML and conventional data/document handling mechanisms. Therefore, we hypothesize that

H3: *Greater extent of XML implementation in conjunction with greater XML-related knowledge is positively associated with higher business process outcomes.*

Prior studies suggested that the effects of radicalness on the expected value of returns from innovation are unclear, because technologies that enable more radical improvements typically require more changes in organizational processes and have wide-ranging intended or unintended consequences that can increase the variance of potential returns (Fichman 2004b). Innovation-related capabilities/endowments (such as related XML-knowledge) become important for radical innovations because such innovations impose greater implementation challenges (Dewar and Dutton 1986). Fichman (2004b) suggests that the interaction between radicalness and innovation-related endowments seems likely. We expect that the "nature" of the relationship between business process radicalness and business process outcomes varies as a function of XML-related knowledge. The existence of appropriate XML-related knowledge moderates the effect of business process radicalness on business process outcomes such that the higher the firm's XML-related knowledge, the higher will be its effect. Thus, we propose:

H4: *Greater extent of business process radicalness in conjunction with greater XML-related knowledge is positively associated with higher business process outcomes.*

In the context of XML implementation, there are theoretical reasons for suggesting that both innovation antecedents (i.e. XML-related knowledge and business process radicalness) have moderating effects on BPO. It is true that the existence of high XML-related knowledge can ultimately result in better outcomes at the project level. At the business process level, however, it is hard to justify their direct effects in isolation without simultaneously considering the main effect of XML implementation on outcomes. After all, business process outcomes result as a consequence of the XML implementation. Without proper integration of the resources to build capabilities (via XML implementation), unused resources (such as knowledge) by themselves cannot result in outcomes at the business process level. Also, the direct effects of business process radicalness on outcomes are unclear because radical innovations can have wide-ranging intended or unintended consequences that can lead to increases in the variance of potential returns or increase in the expected value of potential payoffs (Dewar and Dutton 1986).

Finally, prior research suggests that firm size can play an important role in implementing radical innovations (Tornatzky and Fleischer 1990). Larger firms, with their larger operating budgets, technology base, and resources, are generally able to implement more extensive XML-based applications. On the other hand, large firms tend to be less nimble and more inert than smaller firms because they need more communication, coordination, and support to effect radical innovations (Nord and Tucker 1987). To help us provide a better explanation for the moderating effects of XML-related knowledge and business process radicalness on the relationship between extent of XML implementation and business process outcomes, we controlled for the confounding effects of firm size.

Research Methodology

Data Collection

To investigate our research hypotheses, a survey instrument was created to collect empirical data during September and October 2008. The survey questionnaire (see Table 1 in the Appendix) was mailed to the senior-most IS executive in each firm (e.g. chief information officer [CIO], vice president in charge of IS), along with a letter outlining the purpose of the research, soliciting their participation in the survey, and a postage-paid return envelope for mailing back completed responses. To foster participation and reduce self-reporting bias, each participant was given the opportunity to receive a report regarding how his/her firm position compares to firms of similar size and firms with similar patterns of XML implementation. The survey was directed at a random sample of 1,000 publishing firms from the database of the Association of German Publishers and Booksellers, which represents the interests of about 5,850 publishing companies, bookshops and antiquarian booksellers, intermediate book traders and publishing representatives. We decided to focus our analysis on publishing companies for two reasons: (1) XML implementation seemed to be particularly prevalent among these firms because the publishing industry has played a pioneering role in the adoption and implementation of XML/SGML standards, and (2) we wanted to minimize potential confounding effects due to industry variations. The survey underwent both a pretest and pilot phase. Content and face validity of the questionnaire was ensured by asking 10 IS managers of publishing firms to fill out the survey and then provide feedback on usability, language ambiguity, and expected completion time.

In the context of this study, it was important to identify respondents within organizations who were intimately involved with, and most knowledgeable about XML (usage). With this in mind, we introduced our survey with a clear definition of XML and its derivatives and indicated that the survey should be filled out by the senior-most IS manager having a good overview of the organization's perception of XML. Additionally, a formal check was administered as part of the questionnaire (Kumar et al. 1993). Specifically, two items were used to assess an informant's knowledge about and familiarity with XML. The mean score for the respondents' knowledge about XML (and its derivatives) was 5.89 and for the familiarity with XML usage 5.45 on a 7-item scale (where 1 refers to the lowest score and 7 the highest score), indicating that respondents were appropriate.

Table 2. Sample descriptives (*N=188*)

Category	Percent	Category	Percent
Number of employees		*Annual revenue (Euro million)*	
< 49	40.4	< 5	35.1
50 – 99	35.1	5 – 10	27.2
100 – 199	18.6	10 – 25	24.1
> 200	5.9	> 25	13.6
Number of years since XML rollout		*Respondent title*	
< 2	27.7	CIO/CTO/VP of IS/IT	33.0
2 – 5	21.8	CEO, CFO and COO	19.7
5 – 10	42.6	IS (middle) managers	30.3
> 10	7.9	Other managers and n/a	17.0

A total of 1,000 firms were contacted, of which 92 firms declined participation. After two follow-up mailings, a total of 188 usable responses were obtained, for a respectable response rate of 19 percent. Descriptive statistics are reported in Table 2. All firms in our sample reported that they had adopted and used XML standards at least in one application area. Almost half (49.5 percent) of the firms have been using XML standards up to 4 years since it was rolled out, 42.6 percent between 5 and 10 years, and 7.4 percent reported using XML 10 years or longer.

Non-response bias was assessed by verifying that (1) the publishing firms' revenues, size, and XML usage characteristics of our sample were similar to those in the broader population of German publishing firms and (2) by ensuring that early and late respondents were not significantly different (Armstrong and Overton 1977). Early respondents were those who responded within the first two weeks (slightly over 50 percent). We compared the sample based on key characteristics related to our study (i.e. revenues, number of employees, XML usage). All t-tests between the means of the early and late respondents showed no significant differences ($p>0.05$), and the characteristics were similar to the industry characteristics reported by comparable studies of German publishing firms (e.g. Benlian and Hess 2007; Benlian et al. 2005).

Because the data were obtained from one key respondent from every organization, we also conducted Harman's one-factor test (Podsakoff and Organ 1986). We performed an exploratory factor analysis on all the variables, but no single factor was observed and no single factor accounted for a majority of the covariance in the variables. Furthermore, a correlational marker technique was used, in which the highest variable from the factor analysis was entered as an additional independent variable (Richardson et al. 2009). This variable did not create a significant change in the variance explained in the dependent variables. Both tests suggest that common-method bias does not significantly impact our analyses and results. The data was thus deemed suitable for testing our hypothesized research model.

Measurement of constructs and instrument validation

The four constructs of interest to this study were extent of XML implementation (EXML), XML-related knowledge (XKNOW), business process radicalness (BPRAD), and business process outcomes (BPO). For each construct, we adopted validated measurement items from previous research studies, with minor changes on wording (see Table 1 in the Appendix). More specifically, EXML and XKNOW were measured as formative first-order constructs with indicators adapted from Karimi et al. (2007) and Fichman and Kemerer (1997). BPRAD was measured as a formative second-order construct based on reflective first-order constructs (i.e. Business Process Complexity and Business Information Intensity) adapted from Karimi et al. (2007). BPO, a first-order construct, were measured using the weighted average of the measurement items assessing process efficiency (PEFFI), effectiveness (PEFFE), and flexibility (PFLEX) adapted from Gattiker and Goodhue (2005) and Karimi et al. (2007). This study also controlled for firm size by computing the natural logarithmic transformation of the number of employees (Tanriverdi 2006). The constructs were all measured using seven-point Likert scales anchored with "strongly disagree" and "strongly agree", except for EXML which was measured by a summative scale adapted with minor changes on wording and XKNOW that was measured by percentage scales (between 0 and 100%).

We assessed the psychometric properties of the measurement model results, presented in Table 3, by examining individual item loadings, internal consistency, convergent validity, and discriminant validity. The loadings of the measurement items on their respective factors were above the threshold value of 0.70 and all were significant ($p<0.05$). Furthermore, measurement items did not have cross loadings above 0.4 on the unintended constructs (Hair et al. 2006) suggesting discriminant validity (the results of an exploratory, principal components factor analysis are omitted here for brevity). The internal consistency of all reflective constructs clearly exceeded the threshold of 0.70, suggesting acceptable reliability. Convergent validity is considered adequate when the average variance extracted (AVE) is 0.50 or more, and this condition was satisfied in all cases. Although the internal and external validity of the scales are typically assessed, there is a significant difference in the interpretation of the measurement model for formative constructs (Petter et al. 2007). Measures of internal consistency and unidimensionality cannot be used to judge the quality of the measurement model involving emergent constructs (Diamantopoulos and Winklhofer 2001). Accordingly, the general practice is to examine item weights. As seen in Table 3, the weights for the formative constructs were all statistically significant.

Table 3. Assessment of Measurement Model: Loadings, Weights and Reliability

Constructs	*Number of indicators*	*Range of Loadings (for reflective measures) / Weights (for formative measures)*[1]	*Composite Reliability*	*AVE*
BPO[2]	3	0.696 – 0.877 (loadings)	0.960	0.651
EXML[3]	4	0.231 – 0.354 (weights)	n/a	n/a
XKNOW[3]	5	0.202 – 0.274 (weights)	n/a	n/a
BPII[4]	4	0.904 – 0.928 (loadings)	0.953	0.835
BPC[4]	4	0.879 – 0.920 (loadings)	0.943	0.805

[1] All loadings/weights are significant at least at the p<0.05 level; [2] Summative scale representing each of the three dimensions of PEFFI, PEFFE, and PFLEX; [3] First-order construct with formative indicators; [4] First-order construct with reflective indicators; n/a = not applicable

To estimate the formative second-order model of BPRAD, we modeled the coefficients of each first-order factor to the second-order factor using a principal components factor analysis, following the procedure in Diamantopoulos and Winklhofer (2001). The assessment of BPRAD as second-order factor involved examining the correlations among the first-order factors. Tanaka and Huba (1984) argue for the possible validity of a second-order factor, if the first-order factors are highly correlated (Tanaka and Huba 1984). Figure 2 shows that the first-order factors are correlated and significantly different from zero, suggesting a second-order factor structure and validating their expected relationships. Because the correlation between BPC and BPII is not negative, a high value on one factor does not preclude a high value on another. Moreover, the correlation among the first-order constructs are below the suggested cutoff value of 0.90 (Bagozzi et al. 1991), demonstrating that the content captured by the first-order factors are distinct from one another and indicative of discriminant validity. The coefficients (β-values) of the first-order enabling factors to the second-order factors are statistically significant, providing justification for the existence of the hypothesized formative second-order model (Chin et al. 2003; Edwards 2001).

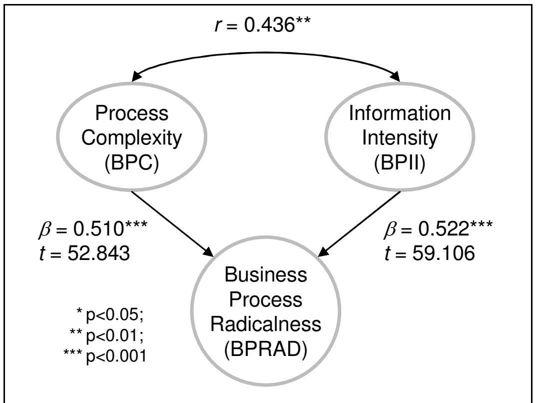

Figure 2. Second-Order Construct Results

Following the mediation tests using PLS, we also tested whether the second-order construct of BPRAD fully mediated the impact of the first-order facets (i.e. BPC and BPII) on business process outcomes. This step ensures that the second-order construct is a more parsimonious representation of the first-order constructs and fully captures their predictive power on the dependent variable it is theorized to predict. BPRAD was significant when both first-order factors were controlled, suggesting it fully mediated the link between first-order constructs and BPO. This supports the conceptualization of BPRAD as second-order construct. Although PLS is reasonably robust against multicollinearity and skewed responses (Cassel et al. 2000), nonetheless, we performed the relevant assessment. We did not observe a high level of association between the exogenous constructs. Further, an examination of the variance inflation factors did not provide evidence of multicollinearity (Hair et al. 2006). Table 4 shows the descriptive statistics and the correlation matrix of the principal constructs.

Table 4. Correlation Matrix

Latent construct	*Construct mean (STD)*	*1*	*2*	*3*	*4*
1. Extent of XML implementation (EXML)	2.81 (1.08)	1.000			
2. Business process radicalness (BPRAD)	3.83 (1.36)	0.365**	1.000		
3. XML-related knowledge (XKNOW)	44.54 (27.50)	0.431***	0.301**	1.000	
4. Business process outcomes (BPO)	3.77 (1.23)	0.585***	0.381**	0.476***	1.000

*p<0.05; **p<0.01; ***p<0.001

Although self-reported measures for BPO were used in this study, we triangulated these measures using standard financial ratios drawn from the database of the Association of German Publishers and Booksellers. BPO was correlated with the average change in return on sales in the last three years. Similarly, BPO was correlated with average sales growth during the same three year period. The analyses indicated strong correlations of self-reported BPO measures with changes in return on sales (0.367; p<0.01) and with average sales growth (0.323; p<0.01).

Data Analysis and Results

SmartPLS, version 2.0 (Ringle et al. 2005), was used to test the hypothesized relationships among the study variables shown in Figure 1. The choice was motivated by several considerations. Partial least squares (PLS) can be used to estimate models that use both reflective and formative indicators, is more appropriate for analyzing moderating effects, allows for modeling latent constructs under conditions of non-normality, and is appropriate for small to medium sample sizes (Chin 1998).

Table 5. Structural Model Results

Hypothesized paths	*Path coefficients (t-value)*	*Hypothesis supported*
Main effect:		
EXML → BPO	0.391 (4.347)***	Yes
Interactions:		
EXML x BPRAD[1]	0.268 (2.764)**	Yes
EXML x XKNOW[1]	0.271 (2.983)**	Yes
BPRAD x XKNOW[1]	0.182 (2.231)*	Yes
Control variable:		
SIZE → BPO	0.281 (3.070)**	Yes

*p<0.05; **p<0.01; ***p<0.001

[1] Following the two-stage approach suggested by Chin et al. (2003), we used the formative indicators of the constructs in conjunction with PLS to create underlying construct scores for the predictor and moderator variables, then taking those single composite construct scores to create a single interaction term.

Overall, our hypothesized research model was supported. First, as seen by the structural model results presented in Table 5, the coefficients are in the appropriate direction, all are statistically significant, and provide support for the four hypotheses. Second, the predictive power of the model is good. The model explains a considerable portion of the variance in BPO (R^2 = 0.542), and we confirmed that the variance explained due to the moderated effects was significant beyond the main effect (Carte and Russell 2003; Chin et al. 2003; Ping Jr 1995). A bootstrapping resampling procedure was performed to obtain estimates of standard errors for testing the statistical significance of path coefficients using t-tests. The results are also listed in Table 5. Consistent with H1, the main effect, EXML, had a positive and significant effect on BPO (β_{EXML}=0.391; t=4.347; p<0.001). We used firm size to control for organizational size effects. The results show that it was significantly related to BPO (β_{SIZE}=0.281; t=3.070; p<0.01).

We next examined moderating effects, which may serve to establish contingency conditions, and recognized that formative moderators need to be treated differently from reflective constructs (Chin et al. 2003; Cenfetelli and

Bassellier 2009). Typically, the interaction effect is tested before the direct effects when using a parametric technique (e.g. LISREL) (Schumacker 2002). That is, if the interaction effects are not statistically significant, then the two direct effects (XKNOW → BPO and BPRAD → BPO) would be tested and interpreted. However, PLS, a nonparametric technique, is not constrained by these requirements. As shown in Table 5, BPRAD had a significant moderating effect (β=0.268; t=2.764; p<0.01) on the relationship between EXML and BPO (H2 supported). Also, a significant moderating effect of XKNOW for its influence on the relationship between EXML and BPO was found (β=0.271; t=2.983; p<0.01), showing support for H3. As well, XKNOW significantly moderated the relationship between BPRAD and BPO (β=0.182; t=2.231; p< 0.05), supporting H4. The standardized path estimate from each interaction term construct to BPO indicates how a change in the level of the moderator construct (i.e. XKNOW and BPRAD) would change the influence of EXML (and BPRAD) on the dependent construct (BPO). For example, XKNOW can potentially strengthen or weaken the effect of EXML on BPO.

To further assess the association of EXML and the moderators' influence on BPO, in Table 6 we provide a summary of alternative model results. Model 1 contains only the main effect of EXML and the control variable (SIZE), which were significant and explained 34.5 percent of the variance in BPO. Building on this, Model 2 added the interaction effect of EXML by BPRAD. Again, all constructs are significant and together they increase the explained variance in BPO to about 43.6 percent. Model 3 shows the relationship of the main effect (EXML) and two of the interaction effects (EXML × BPRAD, EXML × XKNOW) to BPO. The constructs are significant and explain about 47.3 percent of the variance in BPO. The final Model 4 (our research model) indicates that EXML is significantly associated with BPO and the three moderators significantly delineate how the association between EXML and BPO changes according to the different levels of XML-related knowledge and radicalness.

Table 6. Alternative Model Results

Model	***Standardized coefficients***	***t-value***	R^2
(1) BPO = $f(\beta_{EXML}, \beta_{SIZE})$			0.345
EXML	0.532	5.893***	
SIZE	0.321	3.343**	
(2) BPO = $f(\beta_{EXML}, \beta_{EXML*BPRAD}, \beta_{SIZE})$			0.436
EXML	0.496	5.323***	
EXML x BPRAD	0.284	3.724***	
SIZE	0.310	3.206**	
(3) BPO = $f(\beta_{EXML}, \beta_{EXML*BPRAD}, \beta_{EXML*XKNOW}, \beta_{SIZE})$			0.473
EXML	0.442	4.745***	
EXML x BPRAD	0.276	3.323**	
EXML x XKNOW	0.286	3.207**	
SIZE	0.292	3.137**	
(4) BPO = $f(\beta_{EXML}, \beta_{EXML*BPRAD}, \beta_{EXML*XKNOW}, \beta_{BPRAD*XKNOW}, \beta_{SIZE})$			0.542
EXML	0.391	4.347***	
EXML x BPRAD	0.268	2.764**	
EXML x XKNOW	0.271	2.983**	
BPRAD x XKNOW	0.182	2.231*	
SIZE	0.281	3.070**	

*p<0.05; **p<0.01; ***p<0.001

The test for the moderated relationship was conducted by using ΔR^2 to draw conclusions about the moderator effect size. The difference in R^2 can be used to estimate the effect size. The effect size (f^2) can be calculated as a gauge to determine whether the three interaction effects had a small (0.02), medium (0.15), or large effect strength (0.35) on BPO (Cohen 1988). The model containing only the main effect EXML and SIZE (Model 1) was compared to the research model (Model 4) containing EXML, SIZE, and the three interactions. As seen in Table 6, the inclusion of the interaction effects increases the R^2 value from 0.345 to 0.542. The interactions in sum had a large effect size (f^2 = (0.542 – 0.345)/(1 – 0.345) = 0.301). Thus, the relationship between EXML and BPO is moderated by XML-related knowledge, business process radicalness, and the interaction between XML-related knowledge and business process radicalness. Finally, we calculated the effect size of EXML's coefficient (Model 4) and found that the strength of the relationship between EXML and BPO was large (f^2=0.28).

Discussion

The goals of our study were to determine under what conditions and by what mechanisms the extent of XML implementation has the greatest effect on business process outcomes. We assessed the association of extent of XML implementation, XML-related knowledge, and business process radicalness with business process outcomes. Our results are consistent with the research model hypothesized. The findings suggest that although the extent of XML implementation is significantly and substantially associated with business process outcomes, XML-related knowledge and radicalness can have significant moderating effects. This suggests that the association is stronger when firms have better XML-related knowledge and when the underlying processes are more complex and information-intense. Further, XML-related knowledge significantly moderates the association of business process radicalness with business process outcomes. This confirms prior research on the importance of aspects of a company's knowledge resources for radical innovations (Attewell 1992). It suggests that radical innovations may result in better business process outcomes when they are extensively implemented based on sound knowledge of the focal innovation.

This study makes several contributions to IS research and practice. It builds upon innovation diffusion theory as it relates to IT (standard) implementation literature. Although this theory has proved helpful in understanding the organizational and technological attributes that facilitate innovation diffusion over time in a variety of settings, this is the first empirical study that has applied this theory to a XML implementation setting and has examined its ability to predict business process outcomes. The research model helps to identify why there will be a particularly high variance in potential outcomes and further validates when or under what conditions IT investments in XML implementation projects create real options on subsequent implementation and use of XML standards. Because business process radicalness and XML-related knowledge lead to increasing variance in potential outcomes, these factors should also be predictive of early XML adoption. Evaluation of these factors can also help managers direct their attention to most promising factors and provide insights into how to manage their complex interactions. Our findings also strongly suggest that future research on IT value should address the role of IT implementation at the process level in its theoretical development and empirical investigation. While linking IT to firm-level financial performance variables is definitely valuable, the latter are likely to aggregate the impact over several processes and make it difficult to understand process-level impacts. Research investigating process-level impacts of IT implementation and business process outcome variables that are linked to such implementation are likely to be particularly useful.

From a practical perspective, this study explains why some firms adopting XML standards will have higher expected returns from XML implementation than others. Ultimately, the results can help managers in their decision to terminate or redirect troubled XML implementation projects. The first-order factor structure for XML-related knowledge and the second-order structure of business process radicalness categorize several critical success factors in XML implementation and IT innovation literature. They provide parsimonious descriptions for complex interactions among factors that go beyond their independent effects and suggest that a combination of these factors may be necessary to affect business process outcomes. They suggest that the association between the extent of XML implementation and business process outcomes is influenced by increased XML-related knowledge, and increased XML-related knowledge can increase managerial flexibility by incremental implementation, and can serve to increase business process outcomes. They also suggest that business process radicalness reinforces the association between the extent of XML implementation and business process outcomes. These results, therefore, suggest that the combination of organizational, technological, and implementation factors significantly enhances outcomes and that managers should be more concerned with synergy among these factors because that is where the real benefits can be found.

Limitations and Future Research

Our approach involves several limitations. First, our findings must be interpreted in light of the limitations of cross-sectional research. Because our data are not longitudinal, we are unable to conclusively confirm the direction of causality. While we feel that the balance of logic in our study supports the idea that business process outcomes are significantly affected by the extent of XML implementation and enhanced by contingency factors such as XML-related knowledge and business process radicalness, longitudinal research would help researchers to better understand the temporal relationships between our constructs. Second, our findings cannot be applied to companies that consider but have not yet adopted XML because our results are based on companies that already had implemented and used XML in the past. Future research studies may include those companies in their investigations that intend to but have not yet implemented XML and may examine BPO differences between XML adopters and non-adopters. Third, we collected data from a single respondent within the organization. Given the nature of the survey items that ask about XML implementation practices and related organizational aspects as well as business process performance, the majority of respondents are IS senior executives and IS managers with comprehensive understanding of the organization-wide XML use. The respondent characteristics suggest good data quality, minimizing the potential problem of single respondent bias. The tests conducted on our data also indicate that common method bias may not significantly affect our results. Nonetheless, there still exist concerns with analyses based on self-reported data collected from a single source. Fourth, this study relied on a sample of senior IS executives in publishing firms. The executives' perceptions of implementation practices and outcomes are, taken as a whole, grounded in industry-specific assumptions, which brings into question some boundaries on the study's generalizability. Consequently, in the assessment of the study's external validity, one needs to consider that the study involved senior IS executives within a publishing setting. This limits generalizations to other industries. Generalizability is best addressed through replication in different contexts to identify the boundary conditions for the theoretical model. Fifth, we examined only XML-related knowledge as specific capability/endowment to better absorb IT-based innovations. Future research should include other innovation-related capabilities/endowments (such as leveraging project management, consultant or training resources) to examine which type of capabilities are key to strengthen the relationship between XML implementation and business process outcomes. Sixth, our data analysis is limited to the extent that all relationships were assumed to be linear. Future studies may investigate whether specific constructs in our research model (e.g. EXML or BPRAD) rather have a non-linear effect on BPO (e.g. similar to an inverted U-shaped curve). Finally, and more broadly, given the wide range of potential antecedents that can lead to higher efficiency, effectiveness, and flexibility, coupled with the fact that none of the studies conducted to date have provided theoretical and empirical examination of the factors that lead to differential outcomes of XML implementation across firms, this is an important issue for future research to consider.

Conclusion

This study commenced with the premise that the extent of XML implementation is a key determinant of business process outcomes. We examined XML implementation from organizational innovation and technology assimilation perspectives and evaluated the role of two moderating variables in determining business process outcomes. We found broad-based support for our research model. This study thus advances our understanding of the combined role and multiplicative effects of characteristics of technology (extent of XML implementation) and organizational factors (XML-related knowledge, business process radicalness of XML implementation) on business process outcomes. Lessons learned from this study are useful for other organizations in their efforts to successfully implement XML standards. The results of this study point to critical factors in XML implementation that require more attention to ensure implementation success. They will benefit organizations seeking to achieve higher business benefits from XML and specialized IT consultants seeking to inject XML-related knowledge into the organization during implementation projects. Finally, they will help researchers seeking to understand some of the drivers and barriers to successful XML implementation and subsequent exploitation of this multi-purpose standard.

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Appendix

Table 1. Measurement scales

Constructs	***Indicators***		***Source***
Business Process Outcomes (BPO)	*Process Efficiency (PEFFI)*		Gattiker and Goodhue 2005; Karimi et al. 2007
	PEFFI1	XML implementation has improved our efficiency of operations.	
	PEFFI2	XML implementation has lowered our cost of operations.	
	PEFFI3	XML implementation has reduced the amount of rework needed for data entry errors.	
	Process Effectiveness (PEFFE)		
	PEFFE1	Data processed through XML add value to our operations.	
	PEFFE2	XML implementation has improved timely access to corporate data.	
	PEFFE3	XML provides a high level of enterprise-wide data integration.	
	PEFFE4	XML implementation helps us make better sales forecasts than before.	
	PEFFE5	The functionalities of XML adequately meet the requirements of our jobs.	
	PEFFE6	XML implementation has improved our quality of operations.	
	Process Flexibility (PFLEX)		
	PFLEX1	XML implementation has given us more ways to customize our processes.	
	PFLEX2	XML implementation has made our company more agile.	
	PFLEX3	XML implementation has made us more adaptive to changing business environment.	
	PFLEX4	XML implementation has improved the flexibility of our operations.	

Extent of XML Implement-tation (EXML)	EXML1	Application scope of implementation of XML standards (select all that apply): Data storage/handling (e.g. XPATH, XLINK, XQUERY) ǀ Functional integration (e.g. SOAP, UDDI, WSDL, XML-RPC) ǀ Format transformation (e.g. XSL(T), XBRL, CSS) ǀ Data/metadata exchange (e.g. WDDX, ONIX, ebXML) ǀ Metadata/Ontology management (e.g. RDF, OWL) ǀ Other (please specify): ____________	Karimi et al. 2007; Zmud and Massetti 1996; Keen 1991
	EXML2	Functional scope of implementation of XML (select all that apply): Logistics/Inventory ǀ Production ǀ Sales/Distribution ǀ Marketing ǀ Planning/Scheduling ǀ Accounting/Finance ǀ Human Resources Control ǀ Other (please specify): ____________	
	EXML3	Organizational scope of implementation of XML: Department ǀ Division ǀ Entire company ǀ Multiple companies ǀ Other: ___________	
	EXML4	Geographical extent of implementation: Single site ǀ Multiple sites ǀ National ǀ Worldwide	
Business Process Radicalness (BPRAD)	*Business Process Information Intensity (BPII)*		Karimi et al. 2007
	BPII1	Our production/service operations require a significant amount of information processing.	
	BPII2	There are many steps in our value chain that require frequent use of information.	
	BPII3	Information used in our production/services operations needs frequent updating.	
	BPII4	Information constitutes a large component of our product/service to customers.	
	Business Process Complexity (BPC)		
	BPC1	The business processes we deal with often cut across multiple functional areas.	
	BPC2	We frequently deal with ad hoc, non-routine business processes.	
	BPC3	We generally have a high degree of uncertainty in our business processes.	
	BPC4	A majority of our business processes are quite complex.	
XML-related Knowledge (XKNOW)	XKNOW1	Percentage of development staff with experience in data storage/handling using XML (e.g. XPATH, XLINK, XQUERY)	Fichman and Kemerer 1997; Benlian and Hess 2009; Murray 2002
	XKNOW2	Percentage of development staff with experience in functional integration using XML (e.g. SOAP, UDDI, WSDL, XML-RPC)	
	XKNOW3	Percentage of development staff with experience in output format transformation using XML (e.g. XSL(T), XBRL, CSS)	
	XKNOW4	Percentage of development staff with experience in data/metadata exchange using XML (e.g. WDDX, ONIX, ebXML)	
	XKNOW5	Percentage of development staff with experience in meta data/ontology management using XML (e.g. RDF, OWL)	