July 2009

# DO PROCESS STANDARDIZATION AND AUTOMATION MEDIATE OR MODERATE THE PERFORMANCE EFFECTS OF XML? AN EMPIRICAL ANALYSIS IN THE PUBLISHING SECTOR

Alexander Benlian
*University of Munich*, abenlian@gmail.com

Thomas Hess
*University of Munich*, thess@bwl.lmu.de

# DO PROCESS STANDARDIZATION AND AUTOMATION MEDIATE OR MODERATE THE PERFORMANCE EFFECTS OF XML? AN EMPIRICAL ANALYSIS IN THE PUBLISHING SECTOR

Alexander Benlian & Thomas Hess, University of Munich, Institute for Information Systems and New Media, Ludwigstr. 28, 80539, Munich, Germany, {benlian|thess}@bwl.lmu.de

## Abstract

*We draw on process theory to examine how information technology standards affect firm performance via and in conjunction with process variables. In contrast to past IT performance studies that have been rather silent on the simultaneous investigation of indirect and enabling effects of process variables, this study takes an integrative approach by comparing moderating and mediating effects of process standardization and process automation. The model is empirically tested by investigating the (perceived) performance impact of the IT standard XML using data collected from 201 publishing firms in Germany. While process variables showed strong and significant mediating effects in the relationship between IT and perceived cost effectiveness, we could not detect significant moderating effects of process variables. Furthermore, process standardization consistently outperformed process automation in terms of effect magnitude and strength of impact on perceived cost effectiveness. The implications of these findings and the limitations of the study are discussed in an effort to contribute to a methodological extension of the business value of IT debate at the organizational level of analysis.*

*Keywords: XML, IT performance, standardization, automation, publishing industry, industrialization.*

## 1 INTRODUCTION

The performance effects of information technology (IT) remains the subject of considerable interest and intense debate among managers and researchers in the IS community. While modern organizations continue to invest heavily in technology standards and computing technologies, research studies and practitioner surveys report contradictory findings on the effect of these expenditures on organizational productivity. Two major dichotomies which keep recurring underlie this delicate debate. First of all, the discussion on the productivity of IT provoked a division of the research community into two positions: One position supporting the notion that IT has no systematic impact on productivity (the so-called 'productivity paradox'), and the other demonstrating significant interrelationships between IT and organizational performance. Although the hotly debated "productivity paradox" has largely been put to rest by a number of recent studies (McAfee & Brynjolfsson, 2008), the significance of IT has been called into question again with the "IT doesn't matter" debate, reducing IT to a commodity or even to a big switch (Carr, 2003). A second dichotomy can be seen in the disagreement in the research community on the effect immediacy of IT. While some researchers argued that IT performance effects should be investigated directly (e.g., IT spending and organizational or industry performance), others claimed that the full potential of IT can only be recognized via the effects of intermediate and context-related variables such as IT capabilities and process change (Mooney et al., 1996).

Rather than examine IT investments and their impact on bottom line metrics, this research study examines XML usage and its impact on perceived cost effectiveness. By drawing on IT decision makers as key informants, the study attempts to provide a yardstick of whether higher levels of IT usage result in a perception of increased cost effectiveness or not. Further, rather than using IT as a generic entity, XML will be used as general-purpose technology standard, which is neither too abstract

(such as in the economic IT performance studies) nor constrained to a single application context (e.g., only for supply chain management or e-business). Since its first appearance ten years ago, XML has succeeded to gain a foothold in many industries and application areas for its ease-of-use and application versatility. While XML has mainly been examined in IS literature on its contribution to change market structures or to enable and improve interorganizational exchange relationships, no single research study has focused on how XML has affected firm performance both within and across the boundaries of a company.

As noted in earlier studies, investments in IT without recalibration of underlying process structures can lead to sub-optimization of larger inter-functional processes (Davenport, 1993). This state of affairs can lead to incremental gains in productivity that fall well below managerial expectations. In order to optimize the effect of IT usage, it is therefore recommended that the intervening effects of process variables have to be understood and actively managed (Grover et al., 1998). Through structural equation modelling, we compare two fundamentally different types of intervention in the IT-cost effectiveness relationship based on process standardization and automation. The first of the intervening effects, *moderation*, suggests that the interaction of process change variables and XML usage is as important as either of its components in predicting increases in cost effectiveness. The second effect, *mediation*, suggests that XML usage influences cost effectiveness not only directly but also indirectly through process variables. Through analysis of these relationships it is hoped that further understanding of the nature and magnitude of these interactions can be gleaned, thereby providing a clearer frame of reference for IT decisions and associated changes in process structure.

Therefore, the major research questions addressed in this study are: (1) is there a significant relationship between XML usage and cost effectiveness as perceived by IS executives? (2) Which of the two process (change) variables, process standardization or automation, has a stronger impact on cost effectiveness? and (3) How do mediating and moderating effects of process variables compare relative to each other? Collectively, through these questions we hope to get a differentiated perspective on XML's impact on a firm's perceived cost effectiveness.

The structure of the paper is as follows. First, the paper reviews the IT performance literature and argues that a significant research gap exists in the comparison of moderated vs. mediated performance effects of IT in general and XML specifically. Then, based on process theory, we motivate our research models and deduct research hypotheses. After outlining our research methodology, which is based on an empirical study of 201 publishing firms in Germany, major descriptive and explanatory findings of this research study are presented. The paper concludes with a discussion on the study's contributions, shortcomings and promising future research avenues.

# 2 LITERATURE REVIEW AND THEORETICAL FOUNDATION

## 2.1 The Business Value of IT and XML

In the last two decades a large number of studies have investigated the relationship between IT investment and firm performance, yet the findings are equivocal. The question of whether IT has any performance effects at all was raised by several studies that could not reject the hypotheses that investments in IT add nothing to total output (Barua & Mukhopadhyay, 2000; Loveman, 1994). In response to what was, in the eyes of the IS community, alarming evidence of a productivity paradox, researchers conducted a considerable amount of follow-up studies, which thus far have unraveled the 'business value of IT' puzzle only to some extent. While still grappling with inconsistent findings, the discussion on IT performance effects has also shifted toward addressing methodological issues, such as conducting studies at the firm level to understand how IT payoffs may be complemented by intermediate and moderating factors. Following these suggestions, a number of studies have analyzed direct and indirect performance effects of IT. For instance, Byrd et al. introduced IS success variables into their research framework to analyze how they intermediate the relationship between upstream IS variables and firm performance (Byrd & Davidson, 2006). Santhanam et al. assessed the relationship

between IT capability, comprising IT infrastructure, human IT resources, IT-enabled intangibles, and firm performance (Santhanam & Hartono, 2003). However, what has been widely neglected within this body of research is a simultaneous, comparative analysis of direct and indirect IT effects within a single study.

Besides the lack of a comparative analysis of direct and indirect IT performance implications, previous studies have concentrated their investigations either on quite abstract notions of IT (investments) (Brynjolfsson & Hitt, 1996) or on very context-specific application systems or fields, such as e-commerce (Zhu & Kraemer, 2002). In doing so, they have tended to disregard multi-purpose technologies and IT standards of greater reach and application versatility. In the rare cases where research studies have examined the performance effects of technologies of greater application potential (Rai et al., 2006), they only investigated single-application contexts. In order to address these research gaps, we chose to study the performance effects of XML (eXtensible Markup Language), since it is an established technology standard with a high number of application fields. Due to its level of maturity and reach, it lends itself to examine direct and indirect performance effects.

The Extensible Markup Language (XML), which started as a simplified subset of the Standard Generalized Markup Language (SGML) in 1998[1], is a multi-purpose specification for creating custom markup languages which are an artificial languages that use a set of tags or annotations to text that describe how text is to be structured, laid out, and formatted. It is classified as an extensible language because it gives a maximum of degrees of freedom to its users to define their own elements. Its primary purpose is to facilitate the sharing of structured data across different information systems, particularly via the Internet, and it is used both to encode documents and to serialize data. A lot of derivative standards have evolved from XML, covering a broad range of application fields such as metadata mark-up and interchange (e.g., RDF, Dublin Core, XMI) and data exchange (e.g., RSS, ICE, GPX), document and data management or transformation (e.g., XSLT, XPATH, SVG, WML), or data and functional integration (e.g., SMIL, XML-RPC, SOAP). Since its introduction, XML has reached high penetration rates in various application fields and industries due to its ease-of-use, application versatility, and adaptability. It not only covers application fields between organizations (e.g., e-business, supply chain management), where it already started to substitute EDI standards, but has also extensive application potential within the boundaries of firms (such as content reutilization or document management). According to Broadbent et al., XML can thus be characterized as fundamental technology with a high level of application reach and range (Broadbent & Weill, 1999). Existing academic and practitioner-oriented literature on XML have mainly reported operational performance effects of XML so far. These are due to reduction of production, printing, distribution and communication costs, since XML – as a standard – provides higher levels of data integration, content re-use and structuredness of communication (Goodhue et al., 1992; Lu et al., 2006).

Although a huge number of research studies exist on how XML can be applied in various technical application scenarios, the IS literature is rather silent on its linkage to IT and organizational performance. Khazanchi, for example, explored factors affecting the readiness (i.e., the appropriateness) of small and medium-sized enterprises to adopt EDI/XML for interorganizational data integration and also examined the direct relationship to organizational performance (Khazanchi, 2005). He found small but statistically significant positive changes to several benefit indicators due to the implementation of EDI. Lu et al. provided a systematic survey of the current development and challenges of processing XML data in relational and native XML databases, and a useful benchmark for IT practitioners who need to assess data processing effectiveness (Lu et al., 2006). They found that relational database systems outperform native XML databases in processing XML data and thus could contribute more effectively to support operational processes. Wigand et al. examined the direct impact of vertical information systems standardization in the form of XML/EDI adoption on different variables of the US mortgage market structure (such as industry consolidation and vertical disintegration) (Wigand et al., 2005). With a case study approach, they could discover an increase in industry consolidation and outsourcing through the availability of an industry-wide EDI/XML

[1] XML 1.0 became a W3C Recommendation on February 10, 1998.

standard. Finally, Aggarwal et al. analyzed the relationship between open vs. proprietary XML schema standardization and financial markets' performance indicators (i.e., cumulative standardized abnormal return) in an event study (Aggarwal et al., 2006). They found that financial markets respond positively to announcements of proprietary, but not to those of open XML schema standardization.

In summary, besides the rather low number of studies in this field, it is interesting to note that the majority of studies focus on interorganizational application fields and direct performance effects of XML. Previous literature offers only scant insights into the direct and indirect effects of XML on firm performance, in particular within the boundaries of companies. Given the parsimony in this research area, the authors believe that after 10 years of XML diffusion, the time is ripe to fill this research gap. Besides this research goal, we attempt to take an alternate non-economic view of IT performance by applying three major changes to previous studies. First, for the independent variable, we gauge actual XML utilization by assessing the extent of usage intensity in the organization and not by economic data (such as IT capital investments). Recent studies on system usage have proven that perceptual data can capture valuable additional insights (Burton-Jones & Gallivan, 2007). Second, rather than consider just a direct link between XML usage and cost effectiveness, we put an emphasis on intervening effects of process variables which are not only understudied in the context of XML, but in IS research in general. And third, our research study contributes to current IT performance literature by drawing on a process theoretical perspective to explain the mediating and moderating effects of IT. While classical IT performance studies mainly used the resource-based view (Tanriverdi, 2006), contingency theory (Oh & Pinsonneault, 2007), or the strategic alignment model (Chan & Reich, 2007) to assess the link between IT and performance, process theory is still a widely neglected theoretical lens that has not been well explored in IT performance research.

### 2.2 Process theoretical foundation for moderated and mediated performance effects of IT

A process theory synthesis of IT and business value was initially proposed by Soh and Markus (Soh & Markus, 1995), who suggested that IT use and know-how are intermediate outcomes and require further research. Their process theory model suggests that investments in IT projects, applications, and skill base represent creation of IT assets in an organization. Successful deployment of IT assets leads to IT impacts such as redesigned processes, improved decision making, and improved coordination. Consistent with these findings are the results of Setzekorn et al. who found that IT infrastructure, rather than directly impacting aggregate firm performance, may instead support critical processes that improve firm performance (Setzekorn et al., 2002). The process view of IT payoff is also echoed in the framework of Mooney et al. proposing that firms derive business value from intermediate operational and management processes (Mooney et al., 1996). As IT continues to permeate the organization, the authors argue that it has a greater impact on the processes and eventually on the organization. Complementing these process theoretical models, Barua et al. presented a theory of business value complementarity which is based on the notion that the value of having more of one factor increases by having more of another complementary factor (Barua et al., 1996). The authors suggest that organizational payoff is maximized when several factors relating to IT, organizational structure, business processes, and incentives are changed in a coordinated manner in the right directions by the right magnitude to move toward an ideal design configuration. Applying the process theory to the notion that IT exerts indirect effects on firm performance via process variables, we argue that IT is more or less complementary with organizational characteristics and processes, and that the adoption of IT and business process optimization cannot succeed if done in isolation. Applied to the study at hand, the same set of XML standards may generate high productivity in one company but not in another, because the former company may have characteristics (either pre-existing or redesigned) that are complementary with the nature of the technology. Thus, the achievement of significant cost improvements is attainable only in combination with the adaptation of business process characteristics.

The authors' concern in this research study is to investigate the industrializing effects of XML usage and thus to focus on the automational and informational effects of XML in operational processes (Mooney et al., 1996). Similar to the process characteristics discussed in the industrial organization

and mass production literature (Kelley, 1994), automational and informational effects of IT are manifested in process phenomena such as automation and standardization (Hickson et al., 1969): (1) Process standardization refers to the extent a process instance adheres to common rules on how process steps should optimally look like and thus aims to avoid a high level of process variance between the execution of different process instances. In other words, standardization of structure or process is the degree to which activities have been routinized and harmonized (Hickson & Macdonald, 1964). (2) Process automation refers to the notion that single or all steps in a process can be executed by machines or information systems replacing the support of labor (Dewan & Chung-ki, 1997). In particular in highly structured and routinized workflow areas where productivity effects are highest, process automation is suggested. Building on this notion of IT exerting industrialization effects on the process level, it can be suggested that XML affects firm performance via the automation and standardization of production, distribution and administrative processes.

Prior studies that have addressed different forms of intervention in the IT-cost effectiveness relationship have examined either moderating or mediating effects. Only in rare instances (Grover et al., 1998), both intervening effects have been compared and analyzed at the same time. A *moderating* variable affects the direction and/or strength of the relation between an independent and dependent variable (Venkatraman, 1989): the strength and direction of the association between IT usage and performance improvement is influenced by the level of process standardization and process automation and thus on the complementarity between IT and process variables (Barua et al., 1996). Translated to the study at hand, the relationship between XML usage and (perceived) cost effectiveness will be facilitated by process variables that are complementary to XML usage (see Figure 1: 1a and 1b). The moderating effect of process standardization and automation is supported through the significance of the interaction between XML usage and the process variables. Based on these notions of moderating effects of process standardization and automation, we thus formulate:

**H1a:** *The relationship between XML usage and perceived cost effectiveness improvement will be moderated by the extent of the association of process standardization with XML usage.*

**H1b:** *The relationship between XML usage and perceived cost effectiveness improvement will be moderated by the extent of the association of process automation with XML usage.*

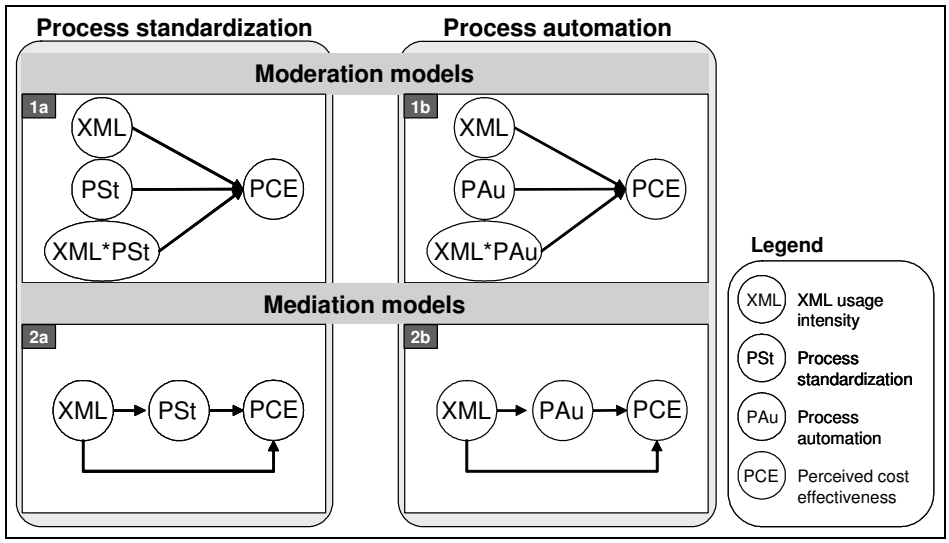


*Figure 1. Moderated and mediated IT performance research models*

A variable is said to function as a *mediator* when it accounts for a significant amount of the causality between a predictor and criterion variable (Venkatraman, 1989). A mediating model of process standardization and automation with respect to XML usage and perceived cost effectiveness is illustrated in Figure 1 (2a and 2b). As shown, the model assumes a three-variable system with two causal paths influencing the outcome variable. Process standardization and automation partially

mediate the association between XML usage and perceived cost effectiveness and are based on the assumption of causality, not complementarity. According to this assumption, process standardization and automation are consequents and not complements to XML usage. In this mediation model, XML is conceived of as an enabler or supporter of process change, which in turn results in a change in (perceived) cost effectiveness (Grover et al., 1998). Based on this nature of intervening effect between IT and performance variables, we derive the following hypotheses:

**H2a:** *The relationship between XML usage and perceived cost effectiveness improvement will be mediated by the level of process standardization.*

**H2b:** *The relationship between XML usage and perceived cost effectiveness improvement will be mediated by the level of process automation.*

# 3 RESEARCH METHODOLOGY

## 3.1 Data collection

To investigate the research hypotheses, an online survey instrument was created to collect data for the model comparison. In parallel, a written questionnaire and e-mails were sent to a random selection of 1.000 publishing firms of the German Publishers and & Booksellers Association during the period of June through August 2008 promoting either digital or paper-based survey participation. The contact data was provided through the directory of the association which is published annually. The publishing industry was chosen because it can be considered as having a pioneering role in the adoption of XML and the longest experience with XML usage which is mostly due to the fact that application opportunities for XML in publishing are plenty. The survey underwent both a pre-test and pilot phase. Content validity of the questionnaire was ensured by asking 10 IT managers of publishing firms to provide feedback on usability, language ambiguity, and expected completion time after filling in the survey. Eligible respondents were those executives or managers best qualified to speak about the firm's overall computing activities. After 15 responses were discarded because of missing data and incomplete information, our final data set contained 201 respondents resulting in a response rate of 20 percent. The distribution of size reflects the structural characteristics of the underlying population of German publishing companies. We tested non-response bias and no statistically significant differences were found (Armstrong & Overton, 1977). Chi-square tests comparing early and late respondents on organization size, performance data, and XML usage also revealed no significant response bias.

The survey was targeted at senior managers in the IT/IS department of the publishing companies, as they are likely to be the most informed about the strategic issues pertaining to the performance implications of IT systems and standards. The assessment of informant competency revealed that all in all, more than 50% of informants were at chief information/technology officer or higher levels (i.e., vice president, of information services or chief executive officer), 32 percent were IT managers, 10 percent were business operations managers or COOs, and around 5 percent had other job titles such as chief financial officer, head of marketing, and so forth. Average organizational tenure of the informants was 8.5 years. They had been involved in (corporate) IT strategy issues for 6.4 years on average. Thus, informants were highly qualified to answer the questions.

## 3.2 Measurement models

Table 1 provides our conceptual definitions of the constructs and a summary of the sources from which the items for the scales were derived or adapted. All items were measured on a Likert scale from 1=low to 5=high. We chose formative constructs for perceived cost effectiveness and XML usage intensity in order to be able to analyze the relative importance of single indicators. Besides the

variables in our research framework, we controlled other potential compounding effects on cost effectiveness (i.e., firm size, other IT investments, IT maturity, IT sophistication).

| Constructs | Indicators | Mean (Std. dev.) | Source |
|---|---|---|---|
| Perceived cost effectiveness (PCE) (formative) | Our development and material costs (i.e., editorial, design, proofing, paper, binding etc.) have decreased since the introduction of XML | 2.55 (1.08) | (Greco, 2005) |
| | Our author royalty costs have decreased since introducing XML | 2.35 (1.03) | |
| | Our marketing and selling costs have decreased since the introduction of XML | 2.74 (1.15) | |
| | Our logistics and distribution costs (incl. freight) have decreased since the introduction of XML | 2.11 (0.98) | |
| | Our overhead costs (e.g., for controlling, administration etc.) have decreased since the introduction of XML | 2.75 (0.99) | |
| Process Standardization (PSt) (reflective) | The extent to which processes (in procurement, production and distribution) have been harmonized through rules, procedures, and workflow documentation since the introduction of XML | 3.79 (1.02) | (Banker et al., 2006) |
| | The extent to which content procurement, production or distribution have been standardized through templates and formats since the introduction of XML | 3.82 (1.00) | |
| | The extent to which deviations from standardized process procedures have been reduced since the introduction of XML | 3.85 (1.03) | |
| Process Automation (PAu) (reflective) | The extent to which single process steps in the procurement, production or distribution of content have been automated since introducingXML while simultaneously reducing manual activities | 3.39 (1.18) | (Stohr & Zhao, 2004) |
| | The extent to which the usage of IT systems to support the accomplishment of different activities (i.e., procurement production, distribution) has been increased since introducing XML | 3.27 (1.09) | |
| | The extent to which manual tasks have been substituted by automated (IT) systems in procurement, production, or distribution processes since the introduction of XML | 3.50 (1.04) | |
| XML usage intensity (XML) (formative) | Intensity of using XML as standard for document management | 2.23 (0.69) | (Benlian et al., 2005) |
| | Intensity of using XML as standard for functional integration | 2.09 (0.67) | |
| | Intensity of using XML as standard for format transformation | 2.30 (0.73) | |
| | Intensity of using XML as standard for data exchange | 2.14 (0.71) | |
| | Intensity of using XML as standard for metadata markup | 2.27 (0.74) | |

*Table 1. Measurement models of variables*

# 4 STATISTICAL ANALYSIS AND RESULTS

## 4.1 Analytical methods

We tested the research models shown in Figure 1 by using PLS-based structural equation modeling (Chin, 1998). In contrast to parameter-oriented and covariance-based structural equation modeling, the component-based PLS method is prediction oriented (Chin, 1998) and the preferred option when formative constructs come into play (Gefen et al., 2000). It seeks to predict the variations in the dependent variables of the model, which we want to achieve for the process and performance oriented variables of our study. More specifically, PLS uses an iterative algorithm of ordinary least square regressions that seeks to minimize the residual variances of the dependent latent variables and all the reflective indicators. Since PLS does not account for the covariances of all indicators, but only for

those variances that have been specified in the model, it is closer to the actual data than the covariance-based procedure. To provide an aggregate view on the assessment of PLS-based models, the structural model is evaluated by looking at the percentage of the variance explained ($R^2$) of all dependent latent variables. By examining the size and stability of the coefficients associated to the paths between latent variables by using the t-statistics obtained from bootstrapping resampling, proposed hypotheses are analyzed for their significance. Moderating and mediating effects were analyzed based on the structural equation modeling approach to testing for mediation and moderation (James et al., 2006) and validated with the Baron and Kenny approach (Baron & Kenny, 1986).

### 4.2 Assessment of measurement models

Content validity was established through the adoption of constructs that had been used in former studies and through pilot tests with IS practitioners of different industries. In particular, the formative constructs were carefully reviewed to make sure that they performed as expected in the research model and that they were well supported by past studies.

The reflective measurement models were validated using the standard procedures of current literature (Chin, 1998). Items of scales in a related domain were pooled and factor-analyzed to assess their convergent and discriminant validity. While convergent validity was determined both at the individual indicator level and at the specified construct level, discriminant validity was assessed by analyzing the average variance extracted and inter-construct correlations. All standardized factor loadings are significant (at least at the $p<0.05$ level), thus suggesting convergent validity (Bagozzi et al., 1991). To evaluate construct reliability, we calculated composite reliability and Cronbach's alpha for each construct. All constructs have a composite reliability and Cronbach's alpha significantly above the cutoff value of ~0.70. All reflective constructs also met the threshold value for the average variance extracted (AVE>0.50). For discriminant validity of latent variables, the square roots of AVEs exceeded the inter-construct correlations between the independent constructs (see Tables 2 and 3).

| Constructs | Number of indicators | Range of Standardized Factor Loadings* | Composite Reliability ($\rho_c$) | Average variance extracted (AVE) | Cronbach's Alpha |
|---|---|---|---|---|---|
| Standardization | 3 | 0.91 – 0.93 | 0.94 | 0.85 | 0.91 |
| Automation | 3 | 0.87 – 0.92 | 0.93 | 0.82 | 0.89 |

* All factor loadings are significant at least at the $p<0.05$ level

*Table 2. Assessment of reflective measurement models: Factor Loadings and Reliability*

| Latent Constructs | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. Perceived cost effectiveness | n/a | | | |
| 2. Process automation | 0.48 | **0.91** | | |
| 3. Process standardization | 0.54 | 0.34 | **0.92** | |
| 4. XML usage intensity | 0.58 | 0.47 | 0.53 | n/a |

*Note*: The diagonal elements (in bold) represent the square roots of AVE by latent constructs from their indicators. For convergent and discriminant validity, diagonal elements should be at least 0.707 (i.e., AVE>0.50) and larger than off-diagonal elements in the same row and column.

*Table 3. Correlation Matrix and Average Variance Extracted of Principal Constructs*

Validating the formative measures of this study, principal component analysis was used to examine the path weights, expressing the strength with which each indicator forms a given construct

(Sambamurthy & Chin, 1994). To ensure that multicollinearity is not present, we calculated the VIF (variance inflation factor) statistic. If the VIF statistic for formative measures is greater than 3.3, the researcher should adjust the formative construct. While VIF-values indicated that there is no problem with multicollinearity, two weights of cost effectiveness and two weights of XML usage intensity were non-significant. In accordance with Bollen & Lennox (1991), we retained these indicators, since dropping those items would mean to skip a significant part of the nomological domain of the constructs and to harm content validity (Bollen & Lennox, 1991).

## 4.3 Assessment of structural models

### *4.3.1 Process standardization and automation as moderator variables*

Figure 2 (left side) illustrates the path coefficients and the $R^2$ values of the structural models including the moderating effects of process standardization and automation.

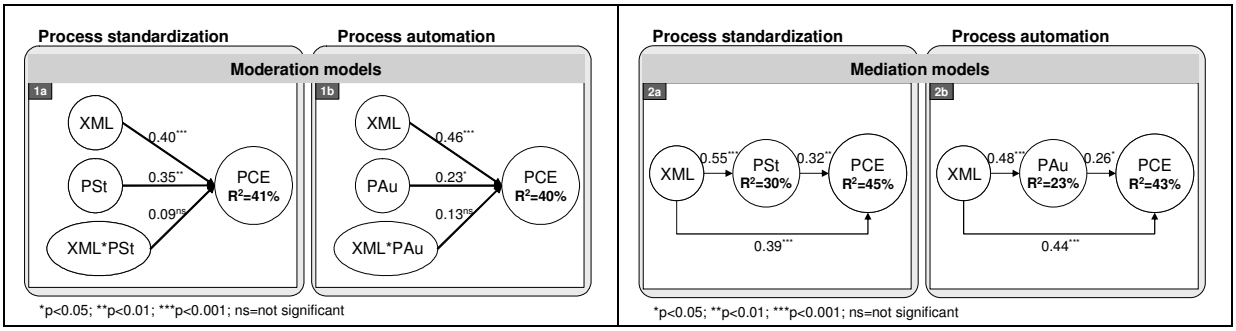


*Figure 2. Results on moderated and mediated IT performance models*

While 41% of the variance in perceived cost effectiveness is explained in the process standardization model, 40% is explained in the process automation model. All four paths leading from XML usage and process variables to cost effectiveness improvement are significant. However, both interaction effects (i.e., XML*PSt and XML*PAu) are weak and not significant. Analyzing the effect magnitude $f^2$ of the interaction effects, which is an indicator for the change in $R^2$ when one latent exogenous variable at a time is excluded from the analysis (Cohen, 1988), confirms that the interaction effects do not add any explanatory power to the research model (see Table 4).

| | XML*PSt | XML*PAu |
|---|---|---|
| $f^2$ ($R^2$delta) related to cost effectiveness | 0.03* | 0.02* |

*no/weak effect strength, **moderate effect strength, ***substantial effect strength
$f^2$-values of 0.02, 0.15, and 0.35 indicate whether an exogenous latent variable has a weak, moderate, or substantial effect on the endogenous latent variable it is associated with (Chin, 1998).

*Table 4. Effect magnitudes of interaction effects in moderator models*

### *4.3.2 Process standardization and automation as mediator variables*

Figure 2 (right side) shows the path coefficients and the $R^2$ values of the structural models including the mediating effects of process standardization and automation. 45% of the variance of cost effectiveness is explained by the direct and indirect effects of XML usage in the process standardization model, 43% is explained in the process automation model. All six paths coefficients are significant. Unlike in the moderator models, both process variables have a moderate effect as mediator variables on cost effectiveness improvement (see Table 5).

| | PSt | PAu |
|---|---|---|
| $f^2$ ($R^2$delta) related to operating performance | 0.16** | 0.12** |

*no/weak effect strength, **moderate effect strength, ***substantial effect strength

*Table 5. Effect magnitudes of mediator variables*

Assessing the proportion of the overall effect of XML usage on cost effectiveness that is accounted for by the mediator variables, which is called 'Variance Accounted For' (VAF) (Shrout & Bolger, 2002), provides additional useful insights. While process standardization accounts for almost a third of the overall effect of XML usage on cost effectiveness, process automation mediates just around a fifth of the total effect. Table 6 illustrates what percentage of the overall effect of the IT variable XML usage intensity on the different performance variables is transmitted via the mediator variables.

| | Path coefficients (Standard errors) | VAF (z-value) |
|---|---|---|
| | Perceived cost effectiveness (PCE) | |
| XML | 0.39 (n.r.) | n.r. |
| PSt | 0.32 (0.13) | 31% (60.4) |
| PAu | 0.26 (0.11) | 22% (68.8) |

*Reading example:* The path coefficient between Pau and PCE is 0.26, the standard error is 0.11. Pau explains 22% of the relationship between XML and OPE. With z=68.8, the intermediating effect is highly significant;
n.r. = not relevant for the calculation of VAF- or z-values

*Table 6. Evaluation of Mediating Effects of Process Standardization and Automation*

# 5 DISCUSSION

## 5.1 Major findings and contributions

To pick up the first research question formulated at the beginning of this research paper, the results of this study suggest that XML usage does lead to perceived improvement in cost effectiveness. In all sub-models of this research design, XML usage significantly affected perceived cost effectiveness. The results thus show that organizations that are able to use and deploy XML more intensely across diverse application settings will be more able to benefit from the use of XML. This result is in line with models like Venkatraman's IT-enabled business transformation model (Venkatraman, 1994) where organizations must go through a lower stage of IT usage before it can proceed to a new, higher state of IT usage and sophistication. These models also suggest that the sophistication of IT at one stage determines a higher level of IT sophistication at the next stage of development. Our study thus confirms that companies must go through these lower stages of sophistication to successfully move to the next level.

The focus of most research studies within the business value of IT stream has been the determination of a relationship between IT investment and productivity; the drive has been to establish the association rather than comprehend the nature of the association. In this study, we attempted to make a contribution to the complex relationship between IT and firm performance by comparing the mediation and moderation role of process variables in organizational IT value. To address our second and third research question, we found that process automation, and even more process standardization, are significant mediators between XML usage and perceived cost effectiveness. The introduction of XML requires changes in the process structure in order to fully unfold its potential and have an impact on operating performance. Improving the adherence to standardized and automated workflows through XML thus substantially supports reaping IT performance effects. In contrast to substantial mediating effects in our research models, moderating effects through process variables could not be found. The

effect of XML on cost effectiveness is thus not facilitated by process standardization and automation. To put in other words, the fit between IT and process variables is not the primary determinant of cost performance. Change in process variables are rather the consequent of the diffusion and usage of IT and not a facilitating condition nor a supporting complement. Unlike previous work, this study has attempted to deepen our understanding of the relationship between IT and operating performance through perceptual assessments of XML usage, perceived cost effectiveness improvement, and process standardization and automation. Doing so adds richness to previous quite abstract economic analyses that precedes this study, as well as insights into the implications of a technology standard with high application versatility and reach. This approach enables us to separate the confounding influence of other factors such as strategy and market vagaries taking us closer to the phenomenon itself.

Besides theoretical and methodological contributions, practical recommendations can be drawn from the research findings. The adoption and application of XML specifically, but also IT in general must be a conscious decision, which is quite a commonsense recommendation, but still widely neglected in many companies where IT/XML is acquired and used inconsistently. By providing empirical evidence that XML usage intensity accounts for a considerable share of perceived cost effectiveness, this study highlights that IS managers have to do more than just invest in the latest technologies. Not only IS/IT executives, but also top management (i.e., in particular the COO) must show dedication and commitment to foster a culture where IT (projects) receives necessary attention and resources. Furthermore, in case that cost effectiveness is a major objective, they should ensure that XML/IT adoption and usage is followed by supporting and 'industrialized' process structures that significantly mediate the IT-performance relationship.

### 5.2 Limitations and Future Research

As with any research, this study does have some limitations. First, the research model was tested using cross-sectional data. Since the data represents a snapshot in time, the imputation of cause-effect relationships between the constructs in the model must be made with caution. Although we established the associations between the independent and dependent constructs statistically, we argued for the sequential relationships between the constructs based on theory. Thus, although the only firm way of testing causal relationships among constructs is through longitudinal studies, we reasoned our model through appropriate theoretical arguments. Second and perhaps the most significant limitation is the tendency of IS executives to overrate the level of cost effectiveness realized from IT investments. While perceptual data of participating public firms was triangulated with objective operating cost data from annual reports (showing indeed high correlation coefficients), IS executives do have a vested interest in the relationship between IT investment and cost performance. The results of this study should therefore be interpreted with this bias in mind.

Third, the empirical analysis was conducted based on one type of IT standard (XML) in the context of one exemplary industry, namely the publishing industry. The external validity of the results may thus be limited. We therefore recommend replicating the research model suggested here in other industries and for other types of IT standards (e.g., SOA). Fourth, the potential for common method variance may exist because measurements of all of the constructs in this study were collected at the same point in time and via the same instrument (Straub & Limayen, 1995). To test common method bias, we applied Harmon's one-factor test to data from the current experiment (Podsakoff et al., 2003). 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, suggesting that common method bias is not a concern in the present study.

Finally, we used a key informant method for data collection. This method, while having its advantages, also suffers from the limitations that the data reflects the opinion of one person. Although our data represents the perceptions of rather senior IS executives who, most likely, are able to assess how the adoption of technologies affect the bottom-line of their business, we recommend that future studies consider research designs that allow data collection from multiple respondents within an organization.

## References


Aggarwal, N., Qizhi, D. and Walden, E. A. (2006) *Do Markets Prefer Open or Proprietary Standards for XML Standardization? An Event Study,* International Journal of Electronic Commerce, 11 (1), pp. 117-136.

Armstrong, J. S. and Overton, T. S. (1977) *Estimating nonresponse bias in mail surveys,* Journal of Marketing Research, 14 (3), pp. 396-402.

Bagozzi, R. P., Y., Y. and Phillips, L. W. (1991) *Assessing construct validity in organizational research,* Administrative Science Quarterly, 36 (3), pp. 421-458.

Banker, R. D., Bardhan, I. R., Hsihui, C. and Shu, L. (2006) *Plant information systems, manufacturing capabilities, and plant performance,* MIS Quarterly, 30 (2), pp. 315-337.

Baron, R. M. and Kenny, D. A. (1986) *The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations,* Journal of Personality & Social Psychology, 51 (6), pp. 1173-1182.

Barua, A., Lee, C. H. S. and Whinston, A. B. (1996) *The Calculus of Reengineering,* Information Systems Research, 7 (4), pp. 409-428.

Barua, A. and Mukhopadhyay, T. (2000) *Information technology and business performance: Past, present, and future,* In Framing the domain of IT research: Projecting the future through the past(Ed, Zmud, R. W.) Pinnaflex Educational Resources, Cincinnati, OH, pp. 65-84.

Benlian, A., Reitz, M., Wilde, T. and Hess, T. (2005) *Diffusion, application fields and cost effectiveness of XML in publishing firms - An empirical assessment*, Proceedings of the 7th International Conference Wirtschaftsinformatik, Bamberg, Germany, pp. 211-230.

Bollen, K. and Lennox, R. (1991) *Conventional Wisdom on Measurement: A Structural Equation Perspective,* Psychological Bulletin, 110 (2), pp. 305-314.

Broadbent, M. and Weill, P. (1999) *The implications of information technology infrastructure for business process redesign,* MIS Quarterly, 23 (2), pp. 159-182.

Brynjolfsson, E. and Hitt, L. (1996) *Paradox Lost? Firm-level Evidence on the Returns to Information Systems Spending,* Management Science, 42 (4), pp. 541-558.

Burton-Jones, A. and Gallivan, M. J. (2007) *Toward a deeper understanding of system usage in organizations: A multilevel perspective,* MIS Quarterly, 31 (4), pp. 657-679.

Byrd, T. A. and Davidson, N. W. (2006) *An empirical examination of a process-oriented IT business success model,* Information Technology & Management, 7 (2), pp. 55-69.

Carr, N. G. (2003) *IT doesn't matter,* Harvard Business Review, 81 (5), pp. 41-49.

Chan, Y. E. and Reich, B. H. (2007) *IT alignment: what have we learned?,* Journal of Information Technology, 22 (4), pp. 297-315.

Chin, W. W. (1998) *The partial least squares approach for structural equation modelling,* In Modern Methods for Business Research(Ed, Marcoulides, G. A.) Lawrence Erlbaum Associates, Hillsdale, NJ, pp. 295-336.

Cohen, J. (1988) *Statistical power analysis for the behavioral sciences,* Lawrence Erlbaum Associates, Hillsdale.

Davenport, T. H. (1993) *Process innovation: Reengineering work through information technology,* Harvard Business School Press, Boston, MA.

Dewan, S. and Chung-ki, M. (1997) *The Substitution of Information Technology for Other Factors of Production: A Firm Level Analysis,* Management Science, 43 (12), pp. 1660-1675.

Gefen, D., Straub, D. and Boudreau, M.-C. (2000) *Structural Equation Modeling and Regression: Guidelines for research practice,* Communications of AIS, 4 (7), pp. 1-78.

Goodhue, D. L., Wybo, M. D. and Kirsch, L. J. (1992) *The impact of data integration on the costs and benefits of information systems,* MIS Quarterly, 16 (3), pp. 293-311.

Greco, A. N. (2005) *The book publishing industry,* Lawrence Erlbaum.

Grover, V., Teng, J., Segars, A. H. and Fiedler, K. (1998) *The influence of information technology diffusion and business process change on perceived productivity: The IS executive's perspective,* Information & Management, 34 (3), pp. 141-159.

Hickson, D. J. and Macdonald, K. M. (1964) *A scheme for the empirical study of organizational behaviour,* International Journal of Production Research, 3 (1), pp. 29.

Hickson, D. J., Pugh, D. S. and Pheysey, D. C. (1969) *Operations technology and organizational structure: An empirical reappraisal,* Administrative Science Quarterly, 14 (3), pp. 378-397.
James, L. R., Mulaik, S. A. and Brett, J. M. (2006) *A tale of two methods,* Organizational Research Methods, 9 (2), pp. 233-244.
Kelley, M. R. (1994) *Productivity and Information Technology: The Elusive Connection,* Management Science, 40 (11), pp. 1406-1425.
Khazanchi, D. (2005) *Information Technology (IT) appropriateness: The contingency theory of "fit" and its implementation in small and medium enterprises,* Journal of Computer Information Systems, 45 (3), pp. 88-95.
Loveman, G. W. (1994) *An Assessment of the Productivity Impact of Information Technologies,* In Information Technology and the Corporation of the 1990s: Research Studies(Eds, Allen, T. J. and Morton, S.) MIT Press, Cambridge, MA, pp. 84-110.
Lu, E. J.-L., Wu, B.-C. and Chuang, P.-Y. (2006) *An empirical study of XML data management in business information systems,* Journal of Systems & Software, 79 (7), pp. 984-1000.
McAfee, A. and Brynjolfsson, E. (2008) *Investing in the IT That Makes a Competitive Difference,* Harvard Business Review, 86 (7/8), pp. 98-107.
Mooney, J. G., Gurbaxani, V. and Kraemer, K. L. (1996) *A process oriented framework for assessing the business value of Information Technology,* Database, 27 (2), pp. 68-81.
Oh, W. and Pinsonneault, A. (2007) *On the assessment of the strategic value of information technologies: Conceptual and analytical approaches,* MIS Quarterly, 31 (2), pp. 239-265.
Podsakoff, P. M., Mackenzie, S. B., Lee, J. and Podsakoff, N. P. (2003) *Common method biases in behavioral research: A critical review of the literature and recommended remedies,* Journal of Applied Psychology, 88 (5), pp. 879-903.
Rai, A., Patnayakuni, R. and Seth, N. (2006) *Firm performance impacts of digitally enabled supply chain integration capabilities,* MIS Quarterly, 30 (2), pp. 225-246.
Sambamurthy, V. and Chin, W. W. (1994) *The effects of group attitudes towards alternative GDSS designs on the decision-making performance of computer-supported groups,* Decision Sciences, 25 (2), pp. 215-242.
Santhanam, R. and Hartono, E. (2003) *Issues in linking information technology capability to firm performance,* MIS Quarterly, 27 (1), pp. 125-153.
Setzekorn, K., Rai, A. and Melcher, A. (2002) *Manufacturing IT Infrastructure and Supply Chain Coordination Strategy's Impact on Strategic Performance*, 8th Americas Conference on Information Systems (AMCIS 2002), Dallas, Texas, pp. 2354-2364.
Shrout, P. and Bolger, N. (2002) *Mediation in Experimental and Nonexperimental Studies: New Procedures and Recommendations,* Psychology Methods, 7 (4), pp. 422-445.
Soh, C. and Markus, M. L. (1995) *How IT creates business value: A process theory synthesis*, Proceedings of the sixteenth Conference on Information Systems, Amsterdam, pp. 29-41.
Stohr, E. A. and Zhao, J. L. (2004) *Workflow Automation: Overview and Research Issues,* Information Systems Frontiers, 3 (3), pp. 281-296.
Straub, D. and Limayen, M. (1995) *Measuring System Usage: Implications for IS Theory Testing*, Management Science, Vol. 41 INFORMS: Institute for Operations Research, pp. 1328-1343.
Tanriverdi, H. (2006) *Performance effects of Information Technology synergies in multibusiness firms,* MIS Quarterly, 30 (1), pp. 57-77.
Venkatraman, N. (1989) *The concept of fit in strategy research: toward verbal and statistical correspondence,* Academy of Management Review, 4 (3), pp. 423-444.
Venkatraman, N. (1994) *IT-Enabled Business Transformation: From Automation to Business Scope Redefinition,* Sloan Management Review, 35 (2), pp. 73-87.
Wigand, R. T., Steinfield, C. W. and Markus, M. L. (2005) *Information Technology Standards Choices and Industry Structure Outcomes: The Case of the U.S. Home Mortgage Industry,* Journal of Management Information Systems, 22 (2), pp. 165-191.
Zhu, K. and Kraemer, K. L. (2002) *e-Commerce Metrics for Net-Enhanced Organizations: Assessing the Value of e-Commerce to Firm Performance in the Manufacturing Sector,* Information Systems Research, 13 (3), pp. 275-295.