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Abstract

The factors that influence an organization's decision to begin using a certain type of technology have come under much study. Several theoretical models, referred to as technology diffusion models, have been developed to better understand the role of these factors in the adoption, diffusion and infusion of certain types of technology. This paper provides background and positioning regarding a recent technological development in B2B e-commerce known as XML-based interorganizational systems (IOS). A Co-Adoption Model of XML-Based IOS is introduced and defined. The theoretical model is developed to empirically evaluate the influential factors leading toward adoption and internal diffusion (volume, diversity, and breadth) of the target technology. The factors under study include compatibility, relative advantage, environmental and three control variables (seller versus buyer, technology conversion type, and location in supply chain). A field study covering twelve implementations of the target technology is conducted with the RosettaNet consortium. An empirical analysis of the field study results to the theoretical model is completed and nine hypotheses are tested. From the compatibility construct, the XML-based IOS solution earned greater compatibility levels in four of the five common task needs as compared to the EDI solution. Findings also indicate substantial improvements in all direct financial and operational measures (ROI, transaction cost, payback, cycle time and throughput). In fact, transaction cost savings ranged from 16% to 87%. The indirect benefit findings are the most significant. The most common indirect benefits include 'reduced negotiation time of technical standards' and 'improved resource allocation time'. While the most important indirect benefits include 'compliance with business partner mandates' and 'product cost advantages'. Significant indirect benefits were also derived from a supply-chain focused interorganizational architecture standards setting consortium (such as RosettaNet) that are over and above direct transaction cost savings. Examples of the benefits from such a consortium include designing (and promoting) modularity in IOS architecture, enabling a blanket PO process, and reduced tensions between business partners. From the environmental construct, partner power was heavily in favor towards buyer organizations. The expectations of market trend variable provided valuable insight as well. Respondents placed a higher expectation of market trends on the RosettaNet consortium (overall) as compared to the specific RosettaNet IOS technology they utilized. Thus supply chain partners felt greater confidence with the existence of the consortium, than they did with the technological standards output from that consortium. Based on preliminary findings, environmental factors and indirect benefits jointly resulted in the participating organizations' decision to adopt RosettaNet-based solutions. However, the relative advantage direct measurement variables (transaction cost savings, ROI, operational improvements) is the key construct in sustaining interest in the target technology and likely leading towards greater levels of internal diffusion. Several recommendations for future research and managerial implications are provided.

Keywords: Innovation diffusion, interorganizational systems, XML, supply chain interoperability, inter-organizational architecture

Introduction

The factors that influence an organization's decision to begin using a certain type of technology have come under much study. Several theoretical models, referred to as technology diffusion models, have been developed to better understand the role of these

factors in the adoption, diffusion and infusion of technology innovations. The benefits of this line of research are pervasive and the opportunities are clear.

- Managers can gain insight as to why a technological innovation may diffuse quickly, or may stagnate (Fichman and Kemerer 1999, Cho and Kim 2002).
- Researchers can gain insight into factors causing greater assimilation depths or wider adoption breadths (Cho and Kim 2002, Fichman and Kemerer 1999, Fichman 2001, Hart and Saunders 1998).
- Managers may find the opportunity to influence or predict these factors (Davis, et al 1989, Lucas and Spitler 1999, Rai and Bajwa 1997).
- Researchers may detect common influential factors across several technology types and generalize their models to a broader scope (Fichman 1992, Cooper and Zmud 1990)

This paper introduces an innovation diffusion model regarding a recent technological innovation of XML-based inter-organizational systems (IOS). Based on a review of prior innovation diffusion and IOS literature, a theoretical framework is proposed to empirically assess the influential factors leading toward adoption and internal diffusion of the target technology. The factors under study include compatibility, relative advantage, environmental and three control variables (seller versus buyer, technology conversion type, and location in supply chain). A case study utilizing RosettaNet's XML-based IOS is presented examining twelve instances of the target technology. The results are empirically compared to the theoretical model and the findings stated. Managerial implications are summarized and recommendations for future research are presented.

The driving research questions include. How can XML-based standards setting organizations promote the adoption and diffusion within and between their participating organizations? What are the significant factors influencing the adoption and diffusion of XML-based IOS standards in organizations? How do these influencing factors change between seller organizations versus buying organizations? How do these influencing factors change between roles in a supply chain?

The contributions from this research are significant. For instance, this is one of the first known studies to model adoption and internal diffusion of XML-based technologies in an interorganizational setting. Second, this study assesses how the content and influence of these factors change between sellers versus buyers and between participants along a supply chain. Third, an emphasis is placed on measurement variables that are quantitatively measured and objectively based. The relative advantage construct, for instance, includes the direct financial impact from the target technology's implementation (ROI, transaction costs, and payback), as well as the operational performance impact (cycle time and through-put). Fourth, the significant indirect benefits accrued by participating organizations' are discussed at length.

For nomenclature purposes, the terms 'target technology', 'technology innovation' and XML-based IOS are used interchangeably through out the paper. For purposes of this study, these terms are intended to connote similar meanings. The term RN IOS (abbreviated for RosettaNet interorganizational system) refers to a type of XML-based IOS as developed by the RosettaNet consortium. Also, the term *co-adoption* is intended to imply the mutual adoption of the same technology innovation between two different organizations. This is similar to the notion of *electronic dyads* as defined by Choudhury, "electronic dyads are bilateral IOSs, where a buyer (seller) establishes individual logical link(s) with a selected seller (buyer)…. each line[between a buyer and a seller] represents an electronic dyad." (Choudhury 1997, page 3).

Technological Innovation Background

Many claims have been made that business-to-business (B2B) e-commerce growth over the Internet is constrained by HTML's inherent limitations - minimal content structuring capability, application coupling with back-end systems, and limited options to customize electronic business documents. Development for eXtensible Markup Language (XML) started in 1996 and was formerly recommended by the World Wide Web Consortium (W3C) in 1998. By allowing programmers and system developers the flexibility to define (and invent) electronic business documents, field attributes, and data tags; XML provides an avenue to overcome many of HTML's obstacles and substantially improves the ability to conduct B2B e-commerce via the Internet (Varon 2001, Sliwa and King 2000, Berinato 2001, Jones 2000, and others).

The very benefits that XML offers, however, have introduced a host of new challenges. To fully leverage the B2B e-commerce benefits that XML offers (and the Internet for that matter), industry groups and supply chain partners must agree on common sets of electronic business documents, field definitions, data attributes and communication protocols. This has spawned a host of new horizontal and vertical industry organizations with the purpose to develop XML-based standards for their respective industries. Output from such organizations have included XBRL for Extensible Business Reporting Language, HR-XML for Human Resource based XML, MathML for XML use in advanced Mathematical equations, and many others. In fact, as of August 2001, *XML.org Registry* had 105 different registered submissions for XML-based standards spanning 25 vertical and 7 horizontal industries. Similarly, *XML in Industry* had 450 different submissions for XML based standards spanning 54 vertical and 9 horizontal industries.

An example of one such XML-based standards setting organization is RosettaNet. Founded in 1998, RosettaNet is a non-profit consortium formed to develop XML-based standards for the Information Technology, Electronic Components, Semiconductor Manufacturing and Solution Provider industries. Like RosettaNet, many of these newly formed XML standard setting organizations have not limited there standards to consistent field attributes and definitions, but rather expanding standards to include business dictionaries, networking protocols, and technical dictionaries organized around shared business processes between partner organizations. RosettaNet, for example, has developed standards for more than 75 of these shared business processes ranging from '*request engineering change'* to '*cancel a purchase order'* to *'notify of authorization to build'*. The content of each is complete with messaging service standards, business dictionaries, technical dictionaries, and business process choreography. These XML-based shared business process standards form point to point connections, via the Internet, that enable execution of the relevant business processes within and between different organizations on a global basis. They are, in effect, modularized XML-based interorganizational information systems. On an individual basis, the scope of these packaged standards is small (traditionally limited to a single business function). But, collectively, taken on a business process by business process and a industry by industry basis, these standard setting organizations are developing the foundation to facilitate and enable future B2B e-commerce growth over the Internet.

The scope and purpose of these standards setting organizations are beginning to vary greatly. Some, for instance, limit their scope to setting standards for simple XML-based business document attributes and common data definitions in their representative industries. Others, like RosettaNet, are developing XML-based shared business process standards that are tantamount to a modularized XML-based IOS. The scope of this study is focused on the latter, and not the former.

Co-Adoption Model of XML-Based IOS

Based on a review of IOS and innovation diffusion literature the following are factors under consideration for influencing the adoption and internal diffusion of this technological innovation. The factors can be classified into four constructs- compatibility, relative advantage, environmental and control variables (see Figure 1).

Compatibility

Technology compatibility is referred to as how the new technology is consistent with existing tasks, needs, prior experiences and processes of the adopters (Cho and Kim 2002, Cooper and Zmud 1992, Agarwal 1999). Cooper and Zmud (1992) provide a framework for assessing compatibility of a new technology by evaluating assumption gaps between the new technology characteristics versus the task characteristic needs of the organization. This framework should prove to be useful for the current study for two reasons. First, the scope includes three shared business processes – *purchase order (PO) generation, PO change / cancel,* and shipments from made-to-stock items (a.k.a. *ship from stock and debit*). Similar technological innovations are applied to these business processes that necessitate different task characteristics. Second, the alternative technical solutions include XML-based IOS, web-based POs, electronic data interchange (EDI) and manual-based process solutions. This will provide a useful framework for evaluating the alternative technical solutions to the share business process types. Since our focus is towards IOS between organizations with shared business processes, we hypothesize that XML-based IOS will have greater compatibility with shared business process task needs than other technical solutions.

H1: XML-based IOS will have greater compatibility with shared business process task needs, than other technical solutions (e.g. EDI or semi-automated based).

Relative Advantage

Davis defines perceived usefulness (PU) as meaning, "the prospective user's subjective probability that using a specific application system will increase his or her job performance within an organizational context" (Davis, et al 1989, page 985). This definition is altered in two respects for the current study. First, usefulness is measured from an organizational perspective, as opposed to the individual 'user' level. This is consistent with several studies in innovation diffusion (Iacovou 1995, Agarwal 1997, Cho and Kim 2002 and others). Second, by considering financial performance (direct and indirect) improvements and operational performance enhancements enabled by the technological innovation, the 'subjectivity probability' component in Davis' definition is significantly reduced. Although most IT adoption and innovation diffusion studies include financial benefits and / or operational performance enhancements to be within the scope of PU (Iacovou 1995, Cho 2002, and others), few have used objective (unbiased) measures for PU (Venkatesh and Davis 1996). This second notion is also consistent with research objectives of the present study. These objectives include (1) an introduction of an XML-based IOS diffusion model and (2) empirically compare this model to case studies (currently omitting statistical corroboration of the model). This affords a prime opportunity to quantify and report PU measures experienced by the participating organizations. Thus, a revised definition of relative advantage for the present study (which is closer to the definition presented by Agarwal 1997) is; the extent to which a potential adopting organization views the innovation as offering financial and operational benefits over previous ways of performing the same tasks (page 562). The financial indicators to be used include ROI, transaction costs savings, investment and payback. The operational performance indicators includes throughput (capability per unit of time) and cycle time.

The first two hypotheses for *Relative Advantage* are described below. They are intended to assess measurement variable differences between sellers and buyers in a supply chain.

> *H2: Buyer organizations will have greater direct financial benefits from the target technology than seller organizations.*

> *H3: Seller organizations will have greater operational performance improvements and greater indirect benefits than buyer organizations.*

The second two hypotheses for *Relative Advantage* are intended to assess measurement variable differences between technology conversion types.

> *H4: Organizations with semi-automated technologies (as their prior technology) will have greater direct financial and operational performance improvements, than organizations with other technology conversion types.*

> *H5: Organizations with EDI-based technologies (as their prior technology) will have lower direct financial and operational performance improvements, than organizations with other technology conversion types.*

Environmental

The two environmental factors under consideration include *partner power* and *expectations of market trends*. The first, *partner power*, is measured as the percentage of sales (or purchases) that a business partner is dependent on from their customer (or supplier). This use of the power variable is consistent with the industry under study, availability of substitute suppliers, low manufacturing capacity utilization rates and relatively low switching costs. This is consistent with Hart and Saunder's notion of supplier dependence in dyadic relationships (see page 90) and similar to Iacovou's findings regarding external pressure in EDI adoption. The second, *expectations of market trends*, is an infrequently used variable in study of innovation diffusion (Fichman 1993, Cho and Kim 2002). For the present study, the definition for this variable is consistent with Cho's, "Expectation for market trend is the degree of expectation that the target technology will be pervasively adopted in the industry in the future" (Cho and Kim 2002, page 130). The reason for including this variable is rather complex to explain, but simple in nature. RosettaNet is a non-for profit XML-based standard setting organization funded from contributions by partner organizations. Thus, partner organizations have a serious and 'vested' interest in developing and setting the most appropriate standards that need to be utilized within their industry. Indeed, a particular technical solution that has been implemented that is found not to be a high expectation of future market trends would be a significant finding.

> *H6: Outsourcing partners* will have lower *partner power* than other roles in the supply chain.

Control Variables (Levels of Analysis)

Three control variables used in this study and include *buyers versus sellers*, *location in supply chain*, and *technology conversion type*. Since the present study does not develop a statistical deterministic model, the control variables are used for levels of analysis to perform on the data collected from the field study.

Innovation Measures

The innovation measures (dependent variables) included in this study focus on the notion of adoption and internal diffusion. For purposes of the present study, Cooper and Zmud's product definition of adoption will be utilized, "A decision is reached to invest resources necessary to accommodate the implementation effort." (Cooper and Zmud, page 124). Fichman defines internal diffusion as, "The extent of use of an innovation across people, projects, tasks, or organizational units" (Fichman 2001, page 454). In the area of IOS (and more specifically EDI) Massetti and Zmud provide three additional dimensions to internal diffusion that will be useful in the present study – volume, diversity and breadth (Massetti and Zmud 1996). *Volume* refers to the ratio of business documents transmitted via the technology innovation channel, over the total number of business documents exchanged (regardless of the technology). *Diversity* refers to the count (or total instances) of the target technology that the organization has implemented. *Breadth* refers to the count of different trading partners with whom the respondent has co-adopted the target technology. The use of these definitions is consistent with other EDI studies (Hart and Saunders 2002, Massetti and Zmud 1996). For analysis and discussion purposes, *diversity* and *breadth* are measured at the organizational level (as opposed to an individual business process level). Similarly, *adoption* will be measured at the RosettaNet-based standards level (as opposed to a specific type RN IOS).

H7: Partner power and *internal diffusion* are positively related.

H8: Expectations of Market Trends and *lack of compatibility* (between the business process task needs and the *old* technology) will be *positively related* towards *greater internal diffusion*.

H9: Indirect benefits enabled by the target technology will have a greater significant influence towards *internal diffusion*, than the *direct financial benefits*.

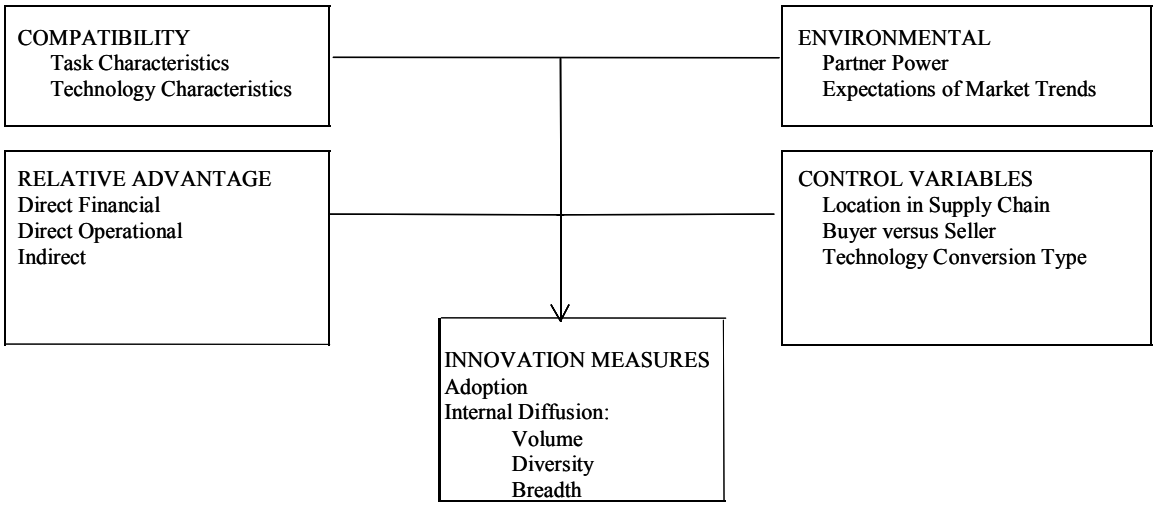

Figure 1. Co-Adoption Model of XML-Based Interorganizational Systems

Research Framework

The field study is organized into four cases (see Figure 2). Each case represents a shared business process between two separate organizations (companies) 'paired' on each end of the IOS (with the exception of Case #2 which includes three *closely related* shared business processes grouped into a single case). Thus, the current scope of the field study includes six instances of RN IOS (for a total of 12 different installations) between eight organizations. All of who participate in the same industry and are members in the RosettaNet consortium. Each paired set of organizations mutually agreed to co-adopt (and have already implemented) the shared business processes utilizing the target technology (RN IOS). With respect to each case, the participating organizations are tagged with control variable attributes. Thus, every case has a buyer and a seller organization. Similarly, with respect to each case, each organization participates in a different role in the same supply chain and each organization has a type of technology they used (e.g. semi-automated, EDI, manual) prior to implementing the target technology.

		SHARED BUSINESS PROCESS				
PRIOR TECHNOLOGY	ROLE IN SUPPLY CHAIN W.R.T. BUSINESS PROCESS	SELL SIDE	SHARED BUSINESS PROCESS DESCRIPTION	BUY SIDE	ROLE IN SUPPLY CHAIN W.R.T. BUSINESS PROCESS	PRIOR TECHNOLOGY
CASE #1						
SEMI-AUTOMATED (FAX / E-MAIL)	MANUFACTURER	Company A-1	*Ship From Stock & Debit*	Company B-1	DISTRIBUTOR	SEMI-AUTOMATED (FAX / E-MAIL)
CASE #2						
EDI	OUTSOURCING PARTNER	Company C-2	*PO Generate, Change & Cancel*	Company D-2	MANUFACTURER	EDI
CASE #3						
MANUAL	OUTSOURCING PARTNER	Company E-3	*PO Generate*	Company F-3	MANUFACTURER	SEMI-AUTOMATED
CASE #4						
SEMI-AUTOMATED (FLAT FILE)	OUTSOURCING PARTNER	Company G-4	*Notify of Advance Shipment*	Company H-4	MANUFACTURER	SEMI-AUTOMATED (FLAT FILE)

Figure 2. Case Study Research Framework

Representatives from RosettaNet selected the participating organizations in the field study. The selection process was primarily based on three criteria: (1) Both organizations in the dyadic relationship were willing to participate (2) The technology was already implemented and (3) The participating organization could identify a lead point of contact to participate in the study. As a result of these criteria, three organizations were dropped and two organizations were added from the board's initial recommendations. Data was collected between June 2001 through July 2002. A kick-off meeting, initial interviews and data collection surveys were conducted with all participating organizations. Survey copies can be obtained from the authors. Some organizations required interim interviews and additional working sessions to assist with completing the surveys (primarily related to the transaction costs and operational impact sections of the survey). Survey instrument explanations and descriptions are provided in the Findings section.

Results and Discussion

Based on the consolidated responses from the field study, an empirical comparison was made to the Co-Adoption Model of XML-based Interorganizational Systems. As previously indicated, the sample size and lack of randomness in participant selections currently prevents statistical corroboration of the model. The intent of this comparison, rather, is to evaluate the proposed constructs and measurement variables utilized in the model, test the hypotheses, provide an organized approach to analyzing the field study data and gain insight into the research questions. Indeed, a future goal of this research is construction of a statistically corroborated model.

Compatibility

Respondents were requested to identify and rank (beginning with one as the most important) specific task needs associated with shared business processes. Next, respondents were requested to rate (on a 5-point Likert scale with Strongly Disagree as 1 and Strongly Agree as 5) the ability of the various technical solutions with meeting those shared business process task needs. See Table 1 for a summary of compatibility findings. Responses were grouped into three shared business process types (*PO Generate, PO Change / Cancel, Ship from Stock and Debit*). Five task needs were found to be common among all shared business process types (these are indicated as 'Common'). The common task needs included (in order from most important to least): data accuracy & integrity, timeliness, effective communications, collaboration levels, and transaction volumes. Several other task needs were found to be unique to the shared business process type (indicated as 'Distinct' in the table).

Although the findings associated with compatibility ratings are similar to what we predicated, they are nonetheless interesting. Overall, the RN IOS technology was found to be more compatible than EDI and semi-automated solutions with meeting the task needs for all three shared business process types (thus supporting hypothesis 1). From an RN IOS versus semi-automated perspective, the RN IOS solution earned more than twice the compatibility rating than the semi-automated technology. This is no surprise since the semi-automated solutions include informal process steps with a hybrid of e-mails, faxes and phone calls. In fact, the largest to smallest compatibility ratings of RN IOS over the semi-automated solutions are improved data accuracy & integrity, collaboration levels, timeliness, effective communications, and transaction volumes. Similar results were found in comparing EDI versus semi-automated solutions.

Table 1. Compatibility Rating of Technical Solutions versus Business Process Task Needs

	SHIP FROM STOCK AND DEBIT (5D-1)				REQUEST PO (3A-4)				CHANGE PO AND CANCEL PO (3A-8, 9)				OVERALL ROSETTANET		
		RATING				RATING				RATING					
BUSINESS PROCESS TASK NEEDS	RANK	Semi-Auto	RN IOS	EDI	RANK	Semi-Auto	RN IOS	EDI	RANK	Semi-Auto	RN IOS	EDI	RANK	LARGEST BENEFIT OF RN VS SEMI-AUTO	LARGEST BENEFIT OF RN VS EDI
COMMON															
Ability to manage transaction volumes	5	3.0	4.0	5.0	5	2.5	4.8	4.5	2	2.5	4.5	4.5	5	2.0	0.0
Enhanced timeliness	3	2.0	5.0	4.0	2	2.5	4.8	4.0	2	2.0	4.5	4.0	2	2.4	0.7
Effective communication	2	2.0	5.0	4.0	3	2.8	5.0	4.3	3	3.0	5.0	4.0	3	2.3	0.9
Improved data accuracy and integrity	1	2.0	5.0	3.0	1	2.0	5.0	4.0	1	1.5	5.0	4.0	1	3.1	1.1
Collaboration levels with S.C. Partners	4	2.0	5.0	3.0	4	2.0	4.5	3.3	2	2.0	5.0	3.0	4	2.7	1.6
DISTINCT															
Ability to utilize standards on a global-basis						2.0	5.0	3.0		2.0	5.0	3.0			
Enhanced consistency with other business processes						4.0	4.0	4.0		4.0	4.0	4.0			
Ability to be automated (reduced people touch-points)						4.0	4.0	3.0		4.0	4.0	3.0			
Integration with Back-end systems						1.0	5.0	5.0		1.0	5.0	5.0			
Ease of Implementation of New SC Partner						1.0	5.0	2.0		1.0	5.0	2.0			

From an RN IOS versus EDI perspective, the RN IOS solution earned greater compatibility levels in four of the five common task needs. In order of largest to smallest, the respondents considered the RN IOS solution to have higher compatibility levels than EDI with the following business process task needs (collaboration levels, data accuracy & integrity, effective communications, timeliness). The survey respondents considered RN IOS and EDI to have the same compatibility rating with respect to their ability handle large transaction volumes.

Relative Advantage

The relative advantage construct is broken into direct financial impact, operational performance impact, and indirect impact of the new target technology. The direct financial impact was the most challenging part of the data collection effort. This required respondents to calculate transaction costs prior to implementation and after implementation of the target technology. The direct cost components included technical standards negotiation time (between the two participants), hardware, software, and implementation related expenses. These direct cost components were consolidated, amortized and divided by the average volume of business document exchanges (associated with the shared business process) to determine the ongoing transaction cost for both before and after implementation. The initial up-front investments associated with implementing the new technology were isolated in order to calculate the ROI and payback financial indicators. The direct operational impact of the new technology was simpler to assess. Respondents were requested to identify the new technology's impact on cycle time and throughput (processing capability per unit of time). Assessing the indirect impact of the target technology was similar in structure to the compatibility segment of the survey. Respondents were requested to identify, rank and rate the indirect impact of the new RN IOS technology.

See Table 2 for summarized findings associated with the direct financial and operational measurement variables in the relative advantage construct. Five respondents provided quantifiable survey responses and three provided relative assessments ('moderate' to 'slight'). Overall, the direct financial benefit of the new technology is significant. Transaction cost savings enabled by the new technology range from 16% to 87%. Contrary to hypothesis 2, sellers have accrued more direct transaction cost savings than buyers on nearly a 2:1 ratio. This finding is peculiar when considering the type of shared business processes under study (*PO processing* and *ship from stock & debit*). One would intuitively believe, from a transaction cost perspective, buyers would incur the majority of costs associated with these shared business process types and thus reap the greatest transaction cost saving benefits. This is not the situation with the respondents in this study and hypothesis 2 is not supported.

The direct operational impact from the new technology is significant as well. Overall, throughput (processing capability per unit of time) improvements range from *no change* to *19-fold* improvements. Three respondents (organizations C-2, D-2 and F-3) provided throughput improvement estimates based on system capacity testing. Actual throughput improvements may be larger. Cycle-time reductions range from *slight* to *99%*. The drivers causing these operational improvements will vary primarily depending on the shared business process type and the type of technology that the organization converted from. For instance, Case #1's business process type is *ship from stock and debit* that utilized semi-automated procedures prior to implementing the target technology. The ubiquitous data access, automated centralized approval-progression procedures and automated tolerance checks enabled by the RN IOS has reduced the size of the debit memo re-work queue thus enabling the 650% through-put increase by the seller and 67% through-put increase by the buyer. This also accounts for the cycle-time improvements for Case #1. Case #2's business process type is PO processing (*generate, change & cancel*) that utilized EDI prior to implementing the new technology. The real-time processing, consistent data structures and reliable data packets enabled by the RN IOS have contributed to the significant increases in throughput capability and reductions in cycle time experienced on both ends of the IOS. Case #3's business process type is *PO generate* that utilized a semi-automated solution (SAP fax and e-mails) from the buyer to the seller prior to the implementation of the target technology. The operational performance improvements are enabled by traditional benefits experienced with automating a semi-manual shared business process (real-time communications, data accuracy, and data communication integrity.). Case #4's business process type is *notify of advance shipments* that utilized a semi-automated solution (flat file) for data communications prior to the target technology's implementation. The slight to moderate operational performance improvements were a result of the increase data communications reliability, timeliness, and accuracy enabled by the new RN IOS.

Table 2. Direct Financial and Operational Impact Measurement Variables for Relative Advantage

				DIRECT FINANCIAL IMPACT			OPERATIONAL IMPACT	
					RETURNS			
ORG	TECH CONVERSION TYPE	RN SOLUTION	BUY / SELL SIDE	TRANS COST	ROI (1 YEAR)	PAYBACK (YEARS)	THRU-PUT CAPABILITY	CYCLE-TIME
CASE #1								
A-1	SEMI-AUTO	SHIP FROM STOCK & DEBIT	SELL SIDE	-87% savings	High	1.9	650% increase	91% reduction
B-1	SEMI-AUTO	SHIP FROM STOCK & DEBIT	BUY SIDE	-40% savings	High	1.8	67% increase	40% reduction
CASE #2								
C-2	EDI	PO GENERATE, CHANGE, CANCEL	SELL SIDE	-32% savings	Moderate	10.4	PO CREATE(no change) PO CHANGE(tested at 19x incr)	PO CREATE (no change) PO CHANGE (tested at 86% reduction)
D-2	EDI	PO GENERATE, CHANGE, CANCEL	BUY SIDE	-16% savings	Moderate	14.8	PO CREATE (tested at 2x incr.) PO CHANGE (tested at 2x incr.)	PO CREATE (98% reduction) PO CHANGE (98% reduction)
CASE #3								
E-3	MANUAL	PO GENERATE	SELL SIDE	-20% savings	Moderate	9.8	100% increase	99% reduction
F-3	SEMI-AUTO	PO GENERATE	BUY SIDE	Moderate savings	Moderate	Moderate	Tested at 2x increase	99% reduction
CASE #4								
G-4	SEMI-AUTO	NOTIFY OF ADVANCE SHIPMENT	SELL SIDE	Slight savings	Slight	Slight	Slight	Slight
H-4	SEMI-AUTO	NOTIFY OF ADVANCE SHIPMENT	BUY SIDE	Slight savings	Slight	Slight	Moderate	Moderate

Assessing the indirect impact of the target technology was similar in structure to the compatibility segment of the survey. Respondents were requested to identify, rank and rate the indirect impact of the new XML-based IOS technology. The rating, however, was limited to rating the ability of RN IOS towards meeting and achieving the identified XML-based IOS indirect benefits. See Table 3 (Panels 1 & 2) for a summary of the indirect benefits.

Overall, the indirect benefits are one of the most significant findings from the field study. The most common indirect benefits include *reduced negotiation time of technical standards* and *improved resource allocation time*. While the most important indirect benefits included *product cost advantages* and *compliance with business partner mandates*. Table 3 (Panel 1) organizes indirect benefits between those *Common to Buyer* organizations, those *Common to Seller* organizations and *Distinct* (unique from an individual respondent). The RN-IOS solution scored an overall rating of 3.68 (out of 5.0 as the highest and best rating) for demonstrating the ability to successfully provide the indirect benefits of XML-based IOS. Buyer organizations felt RN-IOS technology was able to provide greater indirect benefits than Seller organizations (an overall rating of 3.92 by buyers versus 3.61 by sellers).

Table 3 (Panel 1). Indirect Benefits of RN IOS (Buyers versus Sellers)

	BUYERS		SELLERS		RN OVERALL	
	RANK	RATE	RANK	RATE	RANK	RATE
COMMON						
Reduced negotiation time of technical standards	3.7	4.7	2.0	5.0	3.0	4.8
Improved resource allocation time	2.3	4.3	2.0	3.5	2.2	4.0
Product cost savings	2.0	3.3			2.0	3.3
Improved employee morale			5.5	3.0	5.5	3.0
Compliance with supplier or customer mandates			2.0	4.0	2.0	4.0
DISTINCT						
Improved employee morale	2.5	4.5			2.5	4.5
Compliance with supplier or customer mandates	5.0	3.0			5.0	3.0
Improved manufacturing lead time	5.0	3.0			5.0	3.0
(F) Improved response times	4.0	4.0			4.0	4.0
Increased accuracy	2.0	4.5			2.0	4.5
Product cost advantages			4.0	4.0	4.0	4.0
Enables & improves the 'Blanket' PO process			7.0	3.0	7.0	3.0
Compliance with Industry-based technical standards			4.0	4.0	4.0	4.0
Nightly batch vs Real-time processing			8.0	3.0	8.0	3.0
Other Features & Functionality (Enhanced accuracy)			5.0	3.0	5.0	3.0
OVERALL		3.92		3.61		3.68

Table 3 (Panel 2). Indirect Benefits of RN IOS (By Shared Business Process Type)

	SHIP FROM STOCK AND DEBIT (5D-1)		REQUEST PO (3A-4)		CHANGE PO AND CANCEL PO (3A-8, 9)	
	RANK	RATE	RANK	RATE	RANK	RATE
COMMON						
Reduced negotiation time of technical standards	4.0	5.0	3.0	4.8	2.0	5.0
Product cost savings	2.0	5.0	2.0	3.0		
Improved resource allocation time	1.0	4.0	1.0	4.0	1.0	3.5
Improved employee morale	3.0	4.0	5.0	3.7	3.0	4.0
Compliance with supplier or customer mandates	5.0	3.0				
Increased Accuracy & Integrity			4.0	4.0	3.0	3.5
DISTINCT						
Compliance with supplier or customer mandates			2.5	4.0	3.0	4.0
Product cost advantages						
Enables & Improves the 'Blanket' PO Proces			7.0	3.0	7.0	3.0
Compliance with Industry-based technical standards			4.0	4.0	4.0	4.0
Nightly batch vs Real-time processing			8.0	3.0	8.0	3.0
Manufacturing Lead Times			5.0	3.0	5.0	3.0
Improved Response times			4.0	4.0	4.0	4.0
OVERALL		4.20		3.67		3.70

All respondents included comments regarding the substantial timesavings associated with having an independent (non-profit) supply-chain focused organization dedicated towards establishing consistent standards for XML-based IOS solutions. Although this causes an overlap between the direct and indirect benefits (since the costs associated with these timesavings are reflected in

the direct transaction cost impact), respondents indicated there are benefits derived from this over and above transaction cost savings. Examples of these additional benefits include enabling and facilitating a *real* blanket PO process, designing (and encouraging) modularity in IOS architecture and design, reduced tensions between business partners regarding non-core issues, government tax-breaks for enabling interconnectivity between organizations, reduced internal IT development expenditures, and many more. The preponderance of these additional benefits provides insight into future research questions such as, What circumstances in a supply chain generates the need for an independent organization to develop IT interorganizational architecture?

Hypothesis #3 cannot be supported since the operational performance improvements, as well as the indirect benefits, are relatively balanced between both seller and buyer organizations. Hypothesis #4 is partially supported since there does appear to be a trend towards greater financial and operational performance improvements among organizations converting from semi-automated procedures in the old environment (although more specific data from organizations F-3, G-4 and H-4 is necessary to validate this hypothesis). Surprisingly, Hypothesis #5 can not be supported. It was originally hypothesized that EDI users would not experience as great of direct financial and operational benefits as compared to organizations that utilized manual or semi-automated technologies in their old environment. However, organizations in Case #2 (formerly EDI users) are earning comparable (or even greater) benefits from the new technology than the E-3 organization and potentially the Case #4 organizations (formerly manual and semi-automated users, respectively). Ironically, this is a solid endorsement of XML-based IOS solutions outperforming EDI solutions in interorganizational architecture.

Environmental

The two environmental measurement variables include – *partner power* and *expectations of market trends*. Table 4 provides a summary of findings for the environment measurement variables. The first, *partner power*, is measured as the percentage of sales (or purchases) that a business partner is dependent on from their customer (or supplier). Due to data confidentiality agreements, specific % values could not be published. Instead, relative qualitative values (high, moderate, and low) have been substituted. The second, *expectations of market trends,* are based on the respondents expectations for market dominance of XML-based IOS over other types of IOS technology from three perspectives: (1) RosettaNet technology overall (2) XML-based IOS technology in general and (3) The specific RN IOS applicable to each case's business process. The respondents were requested to assess the market dominance using a 5- point Likert scale with one as strongly disagree and five as strongly agree.

Table 4. Environmental Measurement Variables

ORG	PRIOR TECH	RN IOS	BUY / SELL SIDE	ROLE IN SUPPLY CHAIN W.R.T. BUSINESS PROCESS	PARTNER POWER	EXPECTATIONS OF MARKET TRENDS		
						RosettaNet Overall	XML-based IOS	This Specific RN IOS
CASE #1								
A-1	SEMI-AUTO	SHIP FROM STOCK & DEBIT	SELL SIDE	MANUFACTURER	MODERATE	4.00	5.00	4.00
B-1	SEMI-AUTO	SHIP FROM STOCK & DEBIT	BUY SIDE	DISTRIBUTOR	LOW	5.00	5.00	2.00
CASE #2								
C-2	EDI	PO GENERATE, CHANGE, CANCEL	SELL SIDE	OUTSOURCING PARTNER	HIGH	4.00	5.00	4.00
D-2	EDI	PO GENERATE, CHANGE, CANCEL	BUY SIDE	MANUFACTURER	LOW	5.00	5.00	3.00
CASE #3								
E-3	MANUAL	PO GENERATE	SELL SIDE	OUTSOURCING PARTNER	MODERATE	4.00	5.00	4.00
F-3	SEMI-AUTO	PO GENERATE	BUY SIDE	MANUFACTURER	LOW	3.00	4.00	3.00
CASE #4								
G-4	SEMI-AUTO	NOTIFY OF ADVANCE SHIPMENT	SELL SIDE	OUTSOURCING PARTNER	MODERATE	4.00	5.00	4.00
H-4	SEMI-AUTO	NOTIFY OF ADVANCE SHIPMENT	BUY SIDE	MANUFACTURER	LOW	5.00	5.00	4.00
SELL SIDE AVERAGE					MODERATE	4.00	5.00	4.00
BUY SIDE AVERAGE					LOW	4.50	4.75	3.00
TOTAL AVERAGE						4.25	4.88	3.50

From a partner power perspective, buyer organizations have the 'power' advantage in all four cases. Case #2 is the most extreme situation where the seller organization (C-2) has low power and the buyer organization (D-2) has high power in the dyadic

relationship. It's interesting to note that despite this power advantage by buyers, several seller organizations included survey comments indicating they were not coerced or mandated to adopt this technology. In Case #2 for example, the seller organization decided to adopt the RN IOS only after they implemented a new ERP system and their technical architecture was consistent with RN IOS standards. Thus the adoption decision was based on 'a good fit…when it was convenient for us', as opposed to coercion by the buyer organization. In addition, Hypothesis #6 can be supported since three of the four seller organizations are considered outsourcing partners.

From an expectations of market trends perspective, respondents indicated an extremely high expectation of market dominance for XML-based IOS technology (4.88), slightly less for RosettaNet (4.25) and slightly less, again, for the specific RN IOS installed for their shared business process (3.50). A rather straightforward analogy of this situation could be made with computers. In 1989, for example, there was little doubt concerning the prevalence of personal computers (in general), but that expectation diminished when one considered a specific PC manufacturer (Dell) or a specific computer model. Another noteworthy finding is associated with seller versus buyer organizations. Although they have the dominant power advantage, buyer organizations collectively found expectations of market dominance for XML-based IOS and the specific RN IOS, to be less than the seller organizations. A possible explanation of this, which would be consistent with Case #2's seller's adoption decision, could be seller organizations do not feel coerced to adopt RN IOS solutions and are independently choosing this technology.

Analysis in the environmental construct also provides a recommendation for future research. With the respondent's expectations higher for RosettaNet (in general) than for a specific RN IOS they are utilizing, what are the attributes associated with the standards setting organization that the respondents find so appealing and pervasive? At a minimum, future models should consider attributes associated with the IT interorganizational architecture standards setting organization.

Innovation Measures

All respondents in this study have adopted and implemented the target technology. Thus, the insightful innovation measures include the varying levels and extent of internal diffusion. Current and projected levels (over the next 12 and 24 months) of internal diffusion were collected (see Table 5 for a summary). Three measures of internal diffusion were collected: volume, diversity and breadth. Volume levels refer to the ratio of business documents transmitted via the technology innovation channel, over the total number of business documents exchanged (regardless of the technology). With the exception of respondent C-2, all current volume levels are low. However, with the exception of respondent F-3, significant volume growth rate increases are projected over the next 12 to 24 months ranging from 100% to 800% increases. This is indicative of the fairly recent development of this technological innovation and consistent with the expectations of future market trend findings. *Diversity* refers to the count (or total instances) of the target technology that the respondent has implemented. *Breadth* refers to the count of different trading partners with whom the respondent has co-adopted the target technology. All respondents are expecting significant diversity and breadth growth projections. During the next 24 months, respondents are expecting to triple the number of RN IOS implementations (diversity) to 857 and more than double the number of trading partners (breadth) to 347.

Table 5. Internal Diffusion Levels

			CURRENT		GROWTH RATE PROJECTIONS					
			VOLUME		VOLUME		DIVERSITY		BREADTH	
ORG	TECH CONVERSION TYPE	BUY / SELL SIDE	RATIO	T.P. COUNT	*NEXT 12 MONTHS*	*NEXT 24 MONTHS*	*NEXT 12 MONTHS*	*NEXT 24 MONTHS*	*NEXT 12 MONTHS*	*NEXT 24 MONTHS*
CASE #1										
A-1	SEMI-AUTO	SELL SIDE	LOW	1	200%	300%	150%	200%	50%	50%
B-1	SEMI-AUTO	BUY SIDE	LOW	2	250%	450%	29%	100%	50%	200%
CASE #2										
C-2	EDI	SELL SIDE	MED	1	400%	800%	100%	200%	300%	500%
D-2	EDI	BUY SIDE	LOW	41	149%	398%	165%	429%	114%	329%
CASE #3										
E-3	MANUAL	SELL SIDE	MED	2	150%	250%	67%	150%	40%	100%
F-3	SEMI-AUTO	BUY SIDE	LOW	3	0%	0%	167%	233%	67%	133%
CASE #4										
G-4	SEMI-AUTO	SELL SIDE	LOW	5	80%	100%	100%	200%	25%	88%
H-4	SEMI-AUTO	BUY SIDE	LOW	5	100%	300%	165%	429%	114%	329%
TOTALS		SELL SIDE	LOW	9	144%	233%	95%	185%	65%	135%
		BUY SIDE	LOW	51	139%	367%	137%	360%	96%	289%
		TOTAL		60	140%	347%	133%	342%	91%	261%

From a sell side versus buy side comparison, buyers are projecting greater diffusion in diversity and breadth of the technology over the next 12 and 24 months. From a volume perspective, sellers are projecting slightly greater growths over the next 12 months, but buyers are expecting significantly greater growths over the next 24 months. These results are consistent with the buyer power dominance and the probable need for sellers to *catch-up* with technology. Hypothesis #7 is partially supported from a buyer's perspective. That is, the 'moderate to high' buyer partner power is positively related to their larger internal diffusion. Hypothesis #7 is not supported from a seller's perspective. Again, this could be explained through buyer organizations (manufacturers and distributors) in this industry that are likely setting the technological trends with the sellers (outsourcing partners) quick to follow suite.

Hypothesis #8 is only partially supported as well. It is true, that positive *expectations of market trends* and low levels of *compatibility with the old technology* are correlated (in all cases) with increases in *internal diffusion*. However, the caution relates to the degree of these relationships. The Environmental results indicated that the *expectations of market trends* occurred for '*This specific RN IOS'* were only slightly positive (3.5 on a 5-point Likert scale). However, *internal diffusion* results indicate the greatest growth projections to occur in *volume*. Thus respondents are indicating the greatest levels of internal diffusion are expected to occur with the specific RN IOS they have implemented, even though they have only slightly positive confidence levels in the future market trend of that RN IOS. An explanation of this could be similar to the *environmental* discussion. Respondents rated *expectations of market trends* for the RosettaNet consortium (overall) higher than the specific RN IOS under study. Perhaps the supply chain partners have greater confidence (and a greater need) for the existence of a non-profit - independent - supply chain focused consortium to develop IT interorganizational architecture solutions, than the specific technical solutions that they release. This would be an interesting future research question. Thus, Hypothesis #8 is partially supported.

Hypothesis #9 can not be supported. Based on the collective findings, the most that can be concluded is as follows. Overall, *environmental* factors (*partner power* and *expectations of market trends*) and *indirect benefits* jointly resulted in the participating organizations' *adoption* of RosettaNet-based solutions decision. The *relative advantage* construct is determined to be the key construct that will sustain interest in the target technology, likely leading towards greater levels of internal diffusion. Indeed, a future research recommendation is to incorporate randomness and a large enough sample size in the survey to statistically corroborate these findings.

Conclusions and Limitations

This paper provided background and positioning regarding a recent technological development in B2B e-commerce known as XML-based interorganizational systems. A Co-Adoption Model of XML-Based IOS was introduced and defined. A field study covering twelve implementations of XML-based IOS was conducted with the RosettaNet consortium. An empirical analysis of the field study results to the theoretical model was completed and nine hypotheses were tested (see Table 6 for a summary of the hypothesis test results). Based on field study findings, the factors that influence the adoption and diffusion of XML-based IOS have become evident. From the *compatibility* construct, the XML-based IOS solution earned greater compatibility levels in four of the five common task needs as compared to the *EDI* solution. The XML-based IOS solution also earned more than twice the compatibility rating than *semi-automated* solutions. From the *relative advantage* construct, the *direct financial* and *operational improvements* enabled by the new technology were substantial. Transaction cost savings ranged from 16% to 87%. Most of these savings were generated through reductions in development, implementation and testing time of proprietary technical requirements that previously needed negotiations with each business partner. Throughput improvements ranged from no change (*worst case*) to *19-fold* improvements and cycle-time reductions ranged from no change (*worst case*) to 99% reductions. The *indirect benefits* were one of the most significant findings from the field study. The most common indirect benefits include *reduced negotiation time of technical standards* and *improved resource allocation time*. While the most important indirect benefits included *product cost advantages* and *compliance with business partner mandates*. Survey respondents indicated there are significant indirect benefits derived from the existence of an interorganizational architecture standards setting consortium for their supply chain (such as RosettaNet) that are over and above direct transaction cost savings. Examples include enabling and facilitating a blanket PO process, designing (and promoting) modularity in IOS architecture and reduced tensions between business partners regarding non-core issues. From the *environmental* construct, partner power was heavily in favor towards buyer organizations. However, several seller organizations indicated the coercion was minimal. The *expectations of market trends* proved to be a valuable finding. Although the respondents placed the greatest expectation of market trends on XML-based technology (in general), they placed a higher *expectation of market trend* on the existence of the RosettaNet consortium (overall) as compared to the specific RN IOS technology they had implemented.

A framework is forming for the managerial implications concerning promoting greater adoption and diffusion of the target technology by XML-based standards setting organizations. First, XML-based standards setting organizations need to continuously re-assess and add value to the supply chain. Based on the *indirect benefits* and *expectations of market trends* survey results,

supply chain business partners place a value on the *mere existence* of a standards setting organization that is greater than the sum of the individual XML-based IOS. Perhaps this concept can be referred to as the economics of supply chain interoperability. Second, XML-based standards setting organizations need to consider not only compatibility issues, but also the overall *organizational readiness* of supply chain business partners of adopting and further diffusing XML-based solutions. Organizational readiness considerations will include (among others) technical compatibility, management willingness and financial ability. Third, when promoting the benefits of XML-based IOS solutions, XML-based standards setting organizations should consider the innovation diffusion findings from this study. That is, it is the contention, albeit based on preliminary findings, that *environmental* factors and *indirect benefits* jointly resulted in the participating organizations' decision to *adopt* RosettaNet-based solutions. However, the *relative advantage direct* measurement variables (transaction cost savings, ROI, operational improvements) is the key construct in sustaining interest in the target technology and likely leading towards greater levels of internal diffusion.

Several limitations exist in this study. First, and foremost, the lack of statistical corroboration of the theoretical model. This limits the internal validity of the model and raises concerns regarding the hypotheses test results. Second, the respondents are all members of the RosettaNet consortium and participate in the same supply chain. This limits the generalizability of the model. Third, three of the buy side organizations are manufacturers, and three of the sell side organizations are outsourcing partners. Although the location in the supply chain does significantly vary for this group of respondents (both up-stream and down-stream), their particular role in the supply chain does not. This limited the ability to test hypotheses and draw conclusions regarding different roles in the same supply chain.

The results offer several opportunities for additional research. First, expanding the sample size and introducing a random selection process will make significant progress towards developing a deterministic model. Second, developing criteria for assessing an *organization's readiness* to adopt or diffuse the XML-based IOS technology would be valuable. Consistent with prior literature, possible criteria could include compatibility, management willingness, technical feasibility, or financial ability. Third, researching and evaluating the economics of supply chain interoperability is also a ripe area for additional research. What is the value of an independent (non-profit) interorganizational architecture standards setting organization to participant in the supply chain? What is the value of increased collaboration levels? What is the value of reduced negotiation time of technical standards with a new partner? Are the levels of modularity appropriate?

Table 6. Summary of Hypothesis Results

H1	XML-based IOS will have greater compatibility with shared business process task needs, than other technical solutions (e.g. EDI or semi-automated based).	Supported	Strong support of hypothesis
H2	Buyer organizations will have greater direct financial benefits from the target technology than seller organizations.	Not supported	Sellers did on a 2:1 ratio
H3	Seller organizations will have greater operational performance improvements and greater indirect benefits than buyer organizations.	Not supported	Relatively balanced between sellers & buyers
H4	Org's with semi-automated technologies (as their prior technology) will have greater direct financial and operational performance improvements, than org's with other technology conversion types.	Partial support	A trend exists, more data needed to validate
H5	Organizations with EDI-based technologies (as their prior technology) will have lower direct financial and operational performance improvements, than organizations with other technology conversion	Not supported	Some organizations formerly with EDI earned greater returns than other technolgy
H6	Outsourcing partners will have lower partner power than other roles in the supply chain.	Supported	3 of 4 sellers in this study are 'outsourcing partners'
H7	Partner power and internal diffusion are positively related.	Partial support	Supported for Buyers, not supported for Sellers
H8	Expectations of Market Trends and lack of compatibility (between the business process task needs and the old technology) will be positively related towards greater internal diffusion.	Partial support	Raises question of why respondents have greater confidence in RosettaNet 'the consortium' as opposed to a specific RN IOS.
H9	Indirect benefits enabled by the target technology will have a greater significant influence towards internal diffusion, than the direct financial benefits.	Not supported	Environmental factors and indirect benefits cause adoption; relative advantage will likely sustain interest and lead to greater internal diffusion.

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