Interorganizational System Standards Diffusion: The Role of Industry-based Standards Development Organizations

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ABSTRACT

Integrating cross-company business process standards in an interorganizational system (IOS) context is an emerging phenomenon on several business fronts. The practice is viewed as an enabler towards solidifying business to business connections, streamlining cross-company processes and providing a foundation for web-services. Although the practice is not new, most notably electronic data interchange (EDI) with X12 standards, recent technological innovations have enabled the emergence of IOS standards that are web-enabled, modular, scaleable, cost efficient, and structured around cross-company business process standards. Despite their inherent benefits, the adoption and diffusion of web-based IOS standards has been an extraordinary challenge throughout many industrial groups. This paper examines the diffusion of interorganizational system standards among members of industrial groups where an IOS standards development organization (SDO) exists. A conceptual innovation diffusion model is developed as a basis to understand the factors and determinants concerning the diffusion of IOS standards. The innovation - organizational - environmental (IOE) lens is employed in the research design and extended to include attributes associated with the SDO, cross-company business processes and the perceived network effects. The diffusion process is examined through a multi-stage technology assimilation scale. An empirical study is conducted based on cross-sectional surveys of 102 firms from 10 industrial groups encompassing 15 SDOs. The significant determinants of web-based IOS standards diffusion were found to be: installed base, top management support, feasibility, SDO participation level, direct network effects, mission and conduciveness towards interoperability. Comparisons between determinants of adoption versus deployment stages are provided. We also examine the role of industry-based voluntary-consensus standards development organizations, the IOS standards development process, and industrial group coordination of IOS standards.

KEYWORDS: Interorganizational system standards, Standards Development Organizations, IOS diffusion, industrial group interoperability

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INTRODUCTION

The integration of interorganizational business process standards with information technology is an emerging phenomenon across several business fronts. The practice solidifies business to business connections (including EDI) and provides a basis for streamlining cross-company business processes as the "next great frontier for reducing costs, enhancing quality, and speeding operations." (Hammer 2001, page 84). Strategically, the practice is an enabler towards outsourcing (Willet 2004), co-opetition, and pie expansion (Jap 1999). Fundamentally, the practice is viewed as laying the foundation for web-services (Hagel and Brown 2001, Koch 2003) and the building blocks toward the semantic web (Berners-Lee 2001).

Recent technological innovations that permit integration of interorganizational business process standards with information technology include eXtensible Markup Language (XML), Simple Object Access Protocols (SOAP), Web Services Description Language (WSDL) and other application programming interfaces (APIs). This grouping of related innovations, with the addition of Universal Description Discovery and Integration (UDDI), are considered key components of web-services (Hagel and Brown 2001, Koch 2003) and when utilized in an interorganizational system (IOS) context, have profound benefits for members of an industrial group. A fuller breadth of members will finally share in the interoperability capabilities with the rest of the industrial group (including industry action groups, smaller down-stream suppliers, research centers, and many others). Rather than piecemeals of interoperability in certain business segments (e.g. purchase orders or inventories), a broader scope of interoperability capabilities will be possible (engineering, R&D, manufacturing, and beyond). Rather than small portions of information exchanges within a business segment (e.g. goods manufactured), a richer depth of task-level interoperability capabilities will be enabled (production actual versus forecasts, work in progress, spoilage, etc.).

Despite the benefits of industry-wide interoperability, the diffusion of IOS standards among members of an industrial group is proving to be an extraordinary challenge. Although the W3C officially approved XML in 1998, the actual deployments of IOS solutions (utilizing the technology innovations identified above) are a mere fraction of the total end-to-end connections possible. The reasons are vast and growing in complexity. Intuitively, if a firm's trading partners fail to mutually co-adopt IOS standards few benefits will be gained. Some firms with a large electronic data interchange (EDI) installed base are reluctant to quickly embrace modern-day IOS solutions. They understand the benefits, but the cascading effect of updating back-end legacy systems (and the underlying business processes) for IOS standards that *may* or *may not* reach critical mass is a high-risk proposition. Other industrial groups, such as the marine industry, are intentionally timing the launch of IOS standards development efforts to reap lessons learned and best-practices from early adopter industries. Small to medium sized firms that serve customers from a variety of industrial groups are quick to adopt, but slow to deploy new IOS standards. Due to their size, they have the versatility to participate in a variety of IOS standards development initiatives, but are often forced to *hedge their bets* on which standards will take hold on a cross-industry (horizontal) basis. Many firms are in a wait-n-see mode, to see how others will move. Meanwhile, competitive pressures are mounting. Industry leading firms are beginning to include sunset clauses associated with EDI-based solutions into supplier contracts. Firms must demonstrate their web-services architecture is in place and avoid a *missing link* label towards enabling industry-wide interoperability.

What practices are used to develop and deploy IOS standards throughout an industrial group? What are the discriminating factors that will move fence-sitting firms towards implementing IOS standards? What are the antecedent conditions leading towards greater adoption and deployment of IOS standards? By examining a multi-stage diffusion process, this study seeks to address these research questions and identify the significant antecedent conditions towards IOS standards diffusion among members of an industrial group where an IOS standards development organization (SDO) exists. Fundamentally, this paper is intended to introduce the need for bridging the research gap between prior studies in IOS diffusion (based predominantly on EDI) versus web-based IOS standards.

The paper is organized as follows. First a brief background is provided regarding the hierarchy of information technology standards organizations, including identification of the IOS standards development process based on a synthesized review of fifteen SDOs. A conceptual model of IOS standards diffusion is then proposed. Theoretical support and definitions are provided for the measurement variables, diffusion measures and hypotheses comprehended in this study. The next section describes the research setting, methodology and design of the firm-level cross-sectional surveys. After presenting the results of the empirical study, the main research findings are discussed. Implications concerning industrial group coordination of IOS standards and recommendations for future lines of inquiry are provided throughout.

DEVELOPMENTS IN INTERORGANIZATIONAL SYSTEM (IOS) STANDARDS

The diffusion of interorganizational systems has been examined from several perspectives. From a technological perspective, researchers have examined the diffusion of proprietary IOS solutions (Grover 1993; Zaheer and Venkatraman 1994), customer-orientated IOS (COIS) (Cavaye 1996), web and e-commerce technologies (Chatterjee, Grewal, Sambamurthy 2002; Gosain 2001; Zhu, Kraemer and Xu 2002), EDI and EDI-like technologies (Saunders and Clark 1992; Reekers and Smithson 1994; Iacovou, Benbasat, and Dexter 1995; Massetti and Zmud 1996; Premkumar, Ramamurthy, and Nilakanta 1994; Premkumar and Ramamurthy 1995, 1997; Crook and Kumar 1998; Teo, Wei, and Benbasat 2003), telecommunication technologies (Grover and Goslar 1993; Sabherwal and Vijayasarathy 1994; Kettinger and Grover 1997) and open systems (Chau and Tam 1997).   Researchers have utilized a variety of theoretical frameworks to examine the diffusion of IOS innovations, including grounded theory (Crook and Kumar 1998), mimetic, coercive and normative pressures (Teo, Wei, and Benbasat 2003), power and trust (Hart and Saunders 1997), resource dependency (Reekers and Smithson 1994), the structuration theory of assimilation (Chatterjee, Grewal, Sambamurthy 2002), and the innovation-organizational-environmental framework (Saunders and Clark 1992; Grover and Goslar 1993; Chau and Tam 1997; Iacovou, Benbasat, and Dexter 1995; Premkumar and Ramamurthy 1995; Zhu, Kraemer and Xu 2002).

For purposes of this study, the *innovation-organizational-environmental* (IOE) framework was determined to be the most appropriate starting point.   With its origins based on Roger's *Diffusions of Innovations* (1995) the framework has the benefit of generalizeable in its use across a diverse set of disciplines (agriculture, natural sciences, education, and many others). The framework is particularly beneficial in exploratory research with *pre-hoc* studies (prior to widespread adoption of an innovation).   The framework provides a theoretical basis of potential determinants of diffusion, regardless of the type of innovation.   Thus setting the stage for context specific and longitudinal considerations with a more 'finely tuned' set of apriori antecedent conditions as the innovation reaches greater levels of diffusion.

Furthermore, the IOE framework has proven to be effective in prior technology diffusion studies. The *innovation-organizational-environmental* framework is one of the most widely used frameworks in prior IOS diffusion studies [1]. As with other disciplines in the study of innovation diffusion, IOS diffusion research seeks to examine the diffusion of newer IOS technologies, understand assimilation gaps, predict the adoption of other technologies, and equip practitioners with potential tools and skills to better manage the diffusion process. IOS diffusion research has provided insights for researchers and managers a like. Premkumar and Ramamurthy found that *competitive pressure, exercised power, top management support* and *internal need* were key factors differentiating between proactive adopters of EDI versus reactive adopters of EDI (1995). Grover and Goslar studied a grouping of telecommunication technologies and found that *environmental uncertainty* and *decentralized decision making* showed significant relationships with usage (1993). In Iacovou, Benbasat, and Dexter's study of EDI adoption in small organizations, the authors differentiated between organizational readiness attributes associated with EDI adoption and suggested techniques to EDI initiators to reduce resistance (1995).

Although the *innovation-organizational-environmental* framework provides a foundation to begin a study, key components are lacking in light of emerging trends in the IOS standards context. First, no known diffusion studies have comprehended the grouping of related technologies used in web-based IOS *standards* (XML, SOAP, WSDL and other APIs). Prior studies have examined the diffusion of telecommunication products used in an interorganizational system setting, such as fax-machines, e-mail, voice / data PBXs (Sabherwal and Vijayasarathy 1994; Kettinger and Grover 1997; Cavaye 1996; Grover and Goslar 1993). Web-based IOS solutions, however are structured around cross-company business *process* standards (as opposed to *product* standards). Researchers have conducted diffusion studies related to web and e-commerce technologies (Chatterjee, Grewal, Sambamurthy 2002; Gosain 2001; Zhu, Kraemer and Xu 2002). The fuller breadth, broader scope, and richer depths enabled by web-based IOS standards bring new industry wide interoperability challenges. Chau and Tam (1997) studied the adoption of open-systems, which the authors defined to be a Type 1b internal IS innovation that result in only 'weak order' effects on end-users and / or the underlying business process (Swanson 1994). The group of technologies in our study can be considered Type III (combined) innovations that are centered around core work processes, tightly integrated with the shared business processes throughout the supply chain and able to be extended to the firm's basic business products and services (Swanson 1994). Which raises the second component, little research has examined attributes associated with cross-company business processes (also referred to as shared business processes) as possible antecedent conditions of IOS diffusion. Although several researchers have examined IOS diffusion across business processes (Premkumar, Ramamurthy, and Nilakanta 1994; Iacovou, Benbasat, and Dexter 1995; Premkumar and Ramamurthy 1995; Kettinger and Grover 1997; Crook and Kumar 1998; Chatterjee, Grewal, Sambamurthy 2002). Industrial group members maintain an industry-wide data dictionary, collaboratively develop semantic XML standards and structure IOS standards around discretely defined cross-company business processes. Modularity, scalability, and interorganizational business process reengineering have become embedded in modern-day IOS development. Finally, the third component is the role of an industry-based standards development organization (SDO) in the study of IOS diffusion. As described by Swanson (1994), found by Teo, Wei, and Benbasat (2003) and anticipated by others (Grover 1993; Premkumar and Ramamurthy 1995), industry-based SDO's have emerged to play an increasingly important role in the development and diffusion of IOS standards.

Industry-based Standards Development Organizations (SDO)

To briefly distinguish between the tiers of organizations influencing IOS standards (and to pinpoint the type of SDO in consideration for this study), the Internet Engineering Task Force (IETF) develops bit-orientated standards for the Internet. The World Wide Web Consortium (W3C) develops syntactic standards (that ride atop of the IETF's standards) for the World Wide Web (HTML, XML, etc.). The International Organization for Standardization (ISO) is described to have a top-down or structuralist approach with standards development (Libicki 2000). Structuralist-based SDOs develop comprehensive sets of standards in hopes of encompassing current and future endeavors in relation to their constructs. Industry-based SDO's, on the other hand, are depicted as minimalist towards their standards development activities. Minimalist-based SDO's develop standards in small sub-sets (*develop a little, test a little*) and only after there's a sufficient and demonstrated need for the standard by the targeted user group(s). Development of specific semantic standards is the scope of consortia organizations that either have a horizontal (cross-industry) or vertical (industry group) focus. ANSI X12 and OASIS are two of the most publicized horizontally focused (cross-industry) SDOs. ANSI developed X12 standards for formatting EDI business messages and OASIS is developing ebXML and UBL for the formatting of XML-based business messages. Industry focused SDO organizations include RosettaNet, papiNet, CIDX, PIDX, and many others and are the type of SDO under examination in this paper.

Appendix A provides a comparison of fifteen industry-based SDOs. Despite variations in membership size, year incepted, completed messages, and message types many similarities remain. Participation in the SDO is voluntary, the IOS standards are made freely available to the public, they have a non-profit orientation, and decision making is consensus driven (typically based on voting rights associated with membership type). In addition, SDO members include stakeholders from the extended industrial group (producers, distributors, small and medium sized firms, non-profit industry interests groups, university research centers, governmental units and others). With levels of cooperation rarely witnessed, industrial group members are jointly decomposing cross company business processes into task-level interoperability needs between organizations. They are agreeing on common sets of parameters that enable choreographing cross company processes that are in compliance with contractual agreements, industry practices, governmental regulations and technical requirements. If inconsistencies or inefficiencies are detected, consensus is reached and the processes are reengineered. Utilizing an industry-wide data dictionary, they are developing common sets of business terms, definitions and forms. By integrating these process standards with recent technological innovations (XML, WSDL, SOAP and other APIs) industrial groups are developing a comprehensive set of interorganizational system standards structured around discrete cross company business processes (referred to as IOS standards).

IOS Standards Development Process

Based on a synthesized understanding from several SDOs, the IOS standards development process works as follows: (1) Develop and maintain an overarching data model for the industrial group. (2) Choreograph business data flows and modularize these flows into shared business processes that need to occur between partners. (3) Reach consensus and prioritize which shared business processes will be documented, standardized and the associated timing. (4) Standardize and document the common business fields, terms and definitions, including the development of document type definitions (DTD), XML messages and ISO compliance checks. A discrete (modularized) shared business process that has completed step four is commonly referred to as a completed *message* in industry. Upon completion of the initial version of a message, they proceed through development with (5) Testing & Reviews, (6) Deployments and (7) Certifications and Compliance.

An illustration of this can be briefly explained in the chemical industry. CIDX is a non-profit SDO for the chemical industry. In late 2000, CIDX members voted to ratify new by-laws thereby broadening and transforming the association into a neutral standards body focused on improving the ease, speed and cost of transacting business electronically between chemical companies and their trading partners. CIDX membership is voluntary, the standards development process is consensus-driven, the technology standards are platform independent, vendor neutral and are based on open standards (made freely available to the public). As of 2004, CIDX had 75 member firms and had developed IOS standards for 52 messages ranging from *Order Create, Qualification Requests,* and *Quality Testing Report*. The 52 messages are grouped into 8 broader functional categories (*Customer, Catalog and RFQ, Purchase Order, Logistics, Financials, Forecasting, Exchange Interactions,* and *Product Information*). The SDO provides a strict hierarchy of guidelines to following when formalizing their IOS standards. Each message has a DTD (document type definition) with a hierarchy of messaging guidelines, structure guidelines, and data element guidelines that must be adhered to. Each DTD provides compliance with ISO related guidelines (e.g. ISO 8601 is a format for structuring date and time elements, ISO 639-1 is the two-character language code and ISO 639-2/T is the three-character code). In addition, developers provide a corresponding set of sample XML messages for each of the 52 DTDs. Although the messages are modularized around discrete shared business processes, a single data dictionary is used throughout CIDX to insure consistent use and interpretation of business terms, data types, data lengths, definitions, synonyms and so on throughout their current (and forthcoming) messages.

This scenario is not unique to the chemical industry. RosettaNet develops IOS standards for the semiconductor and IT industries. Their focus on standardized shared business processes (i.e. messages) in RosettaNet are referred to as PIPs® (Partner Interface Processes) and examples include *Request PO, Ship from stock and Debit, Request Quote*, and 50 others (Nelson, et. al. 2002). HR-XML develops IOS standards for the human resources industry (e.g. *Background Checking, Benefits Enrollment* and 26 others). Open GIS develops IOS standards for the geo-spatial industry (e.g. *Image Coordinate Transformation Specification, Geography Markup Language* and 31 others). In fact, *XML.org* (a portal that acts as a registry for XML-based IOS standards) had registered submissions from 42 different industrial groups as of 2004.

Collectively, the existence of this phenomenon represents a significant change in the development and diffusion of IOS standards. Modern-day IOS solutions are open standards-based, collaboratively developed, structured around narrowly defined cross-company business processes and able to be distributed via the web. Compared with EDI solutions from the past, the notions of modularity, scalability, open-source code and interorganizational business process reengineering are embedded in modern-day IOS development. What are the antecedent conditions leading towards greater diffusion of IOS standards?

RESEARCH MODEL

The intent of this study is to address these research questions by examining the diffusion of IOS standards throughout an industrial group. This scope is defined to include the diffusion of information technology standards innovations used strictly in an *interorganizational system* context. The innovations are a grouping of related technologies that include XML, SOAP, WSDL and other APIs (referred to as the IOS technology standards grouping). Although this grouping is considered to provide the key components underlying web-services, the *commonly accepted* notion of web-services entails a greater breadth of services than comprehended in this study (e.g. data storage services, application service providers) (Hagel and Brown 2001; Koch 2003). Thus, this study's focus is on the diffusion of the IOS technology standards grouping in a business to business web-based, *interorganizational system* context, among members of an industrial group where an SDO exists.

This study will introduce a conceptual IOS standards diffusion model, empirically compare the model in a real work environment and report the findings. The unit of analysis is the firm. Based on the framework described above, Figure 1 contains the proposed conceptual IOS Standards Diffusion model. The measurement variables are grouped into four categories as defined below (*innovation, organization, external environmental* and the *SDO*). The dependent variable is categorical including non-adoption, adoption, limited deployment and general deployment. Non-adopters (also referred to as fence-sitters) are firms that have expressed an awareness, an interest, or are in the midst of evaluating or conducting trials with the innovations. Adopters are firms that have reached the decision to begin utilizing the IOS standards technology grouping in an interorganizational system context, but have not yet implemented the innovations. Limited deployers are firms that have actually implemented the innovations in at least three interorganizational systems in the firm. General Deployers are firms that are implementing the innovations in the majority of new IOS development projects in the firm (where applicable).

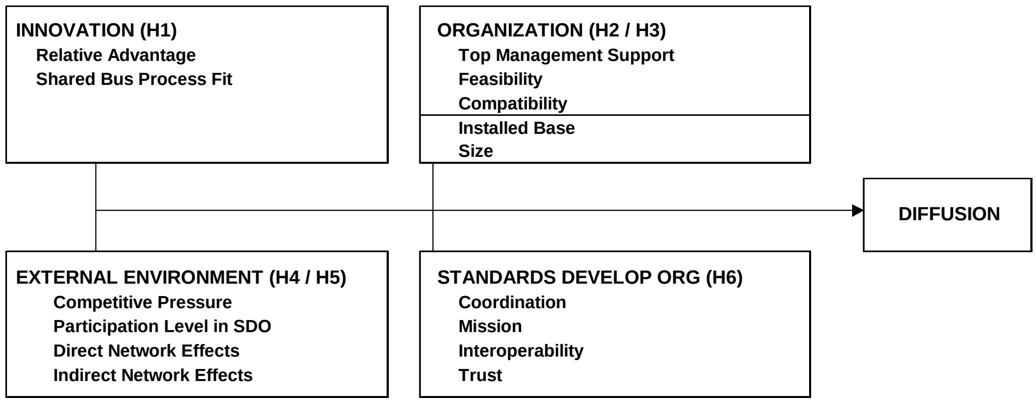

Figure 1. IOS Standards Diffusion Conceptual Model

Innovation Attributes

Innovation attributes are the first component in the IOE lens to view diffusion of IOS standards (Rogers 1995). Attributes associated with the innovation itself are some of the most frequently tested and significant predictors in diffusion models (Rogers 1995; Tornatzky and Klein1982). IOS diffusion is no exception with attributes such as *relative advantage, complexity and cost* of the technology as some of the most frequently found determinants. Two innovation attributes that are anticipated to be key in this study include *relative advantage* and *shared business process fit*. *Relative advantage* is defined as the extent to which a potential adopting organization views the innovation as offering direct financial and operational benefits over previous ways of performing the same tasks (Rogers 1995). This includes the direct firm-level financial and operational benefits enabled by implementing the innovation. Since the relative cost to benefits of the innovation is comprehended in the definition, the direct 'cost' of the technology is not isolated as a separate measurement variable. Requirements of the underlying shared business process are also examined. By first identifying these requirements and secondly understanding the functionality of the IOS standards technology grouping, the task-technology fit (TTF) model provides a useful framework for evaluating the innovation's ability to meet cross-company business process needs (Goodhue 1995). Shared business process requirements include (among others) required response times, exchange volumes, exchange frequency, consistent field terminology and business definitions. As previously described web-based IOS standards are tightly structured around the cross-company business processes that they are intended to automate. Compared with EDI based solutions from the past, modern-day IOS solutions are highly standards based, modular, and narrowly defined around shared business processes. With the heightened role of cross-company business processes, the ability of these innovations to meet shared business process needs are essential towards their success.

Hypothesis (H1). *Relative Advantage and Shared Business Process Fit will have a positive and significant relation towards IOS standards diffusion.*

Organizational Attributes

The organizational category captures firm level attributes of the organization that assess the overall readiness of the firm towards diffusing the innovations. Assessing an organization's readiness is a fundamental and necessary step prior to launching a new information systems development project (Hoffer, George and Valacich 2002). This step is particularly relevant when an organization is considering the use of IOS standards with external trading partners. Compared with other technologies, the effective diffusion of IOS standards are an outward manifestation of an organization's ability to plan, commit and execute according to requirements established with external trading partners. This requires evaluating top *management's support, financial* and *technical feasibility* (Iacovou, Benbasat, and Dexter 1995) and the *compatibility* with the organization. Top management's leadership and support will be essential for successful involvement in IOS standards diffusion. The risk of failure could have far reaching impact into supplier contracts, customer contracts and the organization's reputation in the industry. Examples of *top management support* include the commitment of resources (human and capital) and the existence of a project champion who is enthusiastic, willing and capable to act as the organization's focal point (Premkumar and Ramamurthy 1995; Grover 1993; Chatterjee, Grewal, Sambamurthy 2002). *Compatibility* assesses the consistency of the IOS solution with the organization's IS infrastructure and work procedure needs of the firm. Financial feasibility includes conducting cost-benefit analysis, forecasting total cash expenditures, and estimating the indirect impact of the new technology (product costs, process re-engineering efforts, etc.). Likewise, technical feasibility includes assessing skill sets of the IS staff, identifying infrastructure enhancements necessary to accommodate the new technology, and evaluating and prioritizing which shared business processes should be automated.

The organization's *size* and *installed base* are two additional organizational attributes under consideration. In prior EDI and other IOS diffusion studies, *size* was found as a significant factors towards diffusion by enabling an organization to absorb up-front investments, as well as through subsidizing and pressuring downstream firms towards deployment (Premkumar, Ramamurthy and Crum 1997: Grover 1993). In light of the emerging trends in modern-day IOS solutions (platform independence, industry-wide shared development expenses, and the ability to leverage public transport), *size* is anticipated to no longer be a significant determinant towards diffusion. An organization's *installed base* of older IOS solutions has already been discussed as an inhibitor towards adoption. Referred to as generating lock-in effects, firms have larger hurdles to overcome with respect to their sunk costs associated with their former IOS solutions, impact on their underlying business processes and the ripple effect to back-end systems and business processes (David and Greenstein 1990).

> **Hypothesis (H2):** *Top Management Support, Feasibility and Compatibility will have a positive and significant relation towards IOS standards diffusion.*
> **Hypothesis (H3):** *Installed Base will have a negative and significant relation towards IOS standards diffusion.*

External Environment

Intuitively, the external environment should be considered a potential significant factor in the diffusion of IOS standards. External environment variables such as *competitive pressure*, *partner power*, and *market uncertainty* have evolved as common determinants towards IOS adoption (Iacovou, Benbasat, and Dexter 1995; Premkumar, Ramamurthy and Crum 1997; Zhu, Kraemer and Xu 2002). Our study will examine four external environment attributes that include *competitive pressure, participation level in an SDO, direct network effects* and *indirect network effects*. Since, the majority of prior IOS diffusion studies were conducted using EDI or EDI-like technology the overall 'pressure' to adopt IOS technology was primarily from one or two dominant firms[1]. In the current business climate (where co-opetition is evolving towards the industrial-group level) perceived pressure on a firm to adopt IOS standards is felt from the entire industry (as opposed to a single firm). Thus when comparing the present study to prior IOS diffusion models, the notion of *partner power* has been dropped and *competitive pressure* is anticipated to be greater. Second (as previously discussed) participation in an industry-based SDO has been found to be a significant influence in IOS standards diffusion (Teo, Wei, and Benbasat 2003). This study will expand these findings to include several participation alternatives in an SDO, such as participating in development activities, becoming a member firm, or a user of an SDO's IOS standards. Finally, one of the underlying reasons of IOS standards usage is the anticipation of increasing levels of benefits that accrue to participating firms with the widespread deployment of standards throughout an industrial group (Nelson et.

al. 2002; David and Greenstein 1990). Referred to as positive consumption network effects, Katz and Shapiro formally define them as, "the utility that a user derives from the consumption of a good increases with the number of other agents consuming the good" (Katz and Shapiro 1985). Liebowitz and Margolis advocate distinguishing between direct versus indirect network effects due to differences in the economic implications and consequences of each (1994). Direct network effects being the type that are a "direct physical effect of the number of purchasers on the quality of the product", whereas indirect network effects are "side effects" or "market mediated effects" (Liebowitz and Margolis 1994, page 135). *Indirect network effects* in an IOS standards context will include enhanced trading partner loyalty, accessibility to new potential customers and improved product lead times. *Direct network effects* will include reduced standards negotiation time (and expenditures) with new trading partners, cost savings associated with pooling development expenditures and reduced IOS implementation efforts.

Hypothesis (H4). *Competitive Pressure and Participation Level in an SDO will have a positive and significant relation towards IOS standards diffusion.*

Hypothesis (H5). *Favorable Perceived Direct and Indirect Network Effects will have a positive and significant relation towards IOS standards diffusion.*

Standards Development Organization (SDO)

The SDO category examines attributes of the SDO and its' potential influence towards diffusion of the innovations. IOS diffusion researchers have recommended examining the role of an IOS standards alliance organization (Premkumar and Ramamurthy 1995; Grover 1993; Swanson 1994: Teo, Wei, and Benbasat 2003). As previously discussed, the role of an SDO has emerged as pivotal in the development of IOS standards. Industrial groups are viewing an SDO as a moderator in the collaboration process, an enabler towards generating cost savings through leveraged development efforts, and as a means towards integrating 'best-in-class' IOS standards. Since this construct has rarely been used in prior IOS diffusion studies, a survey of critical success factors in alliance organizations was conducted to develop an SDO role continuum. This continuum provides criteria to evaluate the SDO with respect to its' organizational attributes and impact on the target technology's diffusion. [See the prior discussions in the IOS standards hierarchy and development sections, as well as Appendix A]. Components of this role continuum include SDO *coordination* practices such as collaboration mechanisms, ability to meet performance expectations, problem resolution techniques, demonstrated neutrality towards member firms, and clarity of goals and objectives (Monczka, Petersen, and Handfield 1998; Whipple and Frankel 2000; David and Greenstein 1990).

Trustworthiness and open and honest communications from industrial group members is an important ingredient as well to facilitate the voluntary, consensus-driven decision making inherent in the development process. *Interoperability* assesses attributes associated with the output from the IOS standards setting process. Components include architectural attributes such as the standards modularity levels, vendor neutrality, quality of standards documentation, their conduciveness towards interoperability and their compatibility with underlying business processes. *Mission* includes attributes associated with the governance and structure of the SDO such as its' non-profit status, high-level objectives and it's value to participating firms.

> **Hypothesis (H6).** *Coordination, Mission, Interoperability and Trust will have a positive and significant relation towards IOS standards diffusion.*

One final proposition examines determinants between adoption versus the deployment of IOS standards. Distinguishing between adoption versus deployment is advocated in situations where significant assimilation gaps are likely to exist (Fichman and Kemerer 1999). Assimilation gaps (large time differences between adopting a new technology versus deployment of the new technology) have been found to exist when a technology is susceptible to network externalities and knowledge barriers (Fichman and Kemerer 1999). The nature of IOS standards is such that, if a firm's trading partners fail to mutually co-adopt the standards, few benefits will be gained. Evidence of assimilation gaps and delayed adoption decisions by individual firms (and industrial groups) with respect to IOS standards are mounting. Key inhibitors already discussed include lack of a clear and cohesive standards development and coordination strategy, underestimating the impact on cross-company business processes, overcoming a large EDI installed base, threats of standards being superceded and antiquated by competing standards bodies and more (Senf 2005; Birman 2004; Knorr 2003; Worthen 2002; Zeichick 2005; Brandel 2004). Structuring the conceptual model in this fashion (*non-adopters versus adopters* and *non-deployers versus deployers*) enables close examination and identification of such factors toward a firm's adoption and deployment decisions.

> **Proposition (P7).** *A different set of significant attributes will be associated with IOS standards adoption versus IOS standards deployment.*

RESEARCH SETTING AND METHOD

The final research design selected for this study was the culmination of a two-year development effort. The preliminary work began with a detailed examination of a single implementation instance of IOS standards between a distributor and manufacturer in the electronic components industry. This provided insight into the technology under study, the use of interoperability standards and the mutual operational and economic benefits to firms on each side of the IOS. The number one challenge identified by participants in the study was adoption. That is, how to encourage other partner firms to co-adopt IOS standards developed by their industry's SDO. These findings fueled the development of an initial conceptual IOS standards adoption model and survey instrument. This first pre-test of the instrument was administered to eight firms (encompassing four different IOS solutions) from a single industrial group. The results shed light on the pivotal role of an SDO, performance measures for assessing consequences of diffusion and qualitative insights into constructs that influence the diffusion process and how the mixture of these constructs may vary with diffusion levels. The first pre-test resulted in several changes (improvements) to the survey instrument and all responses were dropped. The second pre-test was conducted with ten firms from three industrial groups and resulted in only minor changes to the survey instrument (item sequence and minor phrase changes to better enable cross-sectional understanding). Responses from the second pre-test were retained. Add to these insights the results of literature survey work in alliance organizations, IOS diffusion, and standardization and the following research design was crafted [2].

A cross-sectional firm level survey was conducted to empirically compare the conceptual model to a real work environment and test the hypotheses. Appendix B outlines the survey structure, item counts and hypothesized impact. The sampling frame includes firms that are members of an SDO or a user of IOS standards, or who are considering the possibility of either. The organizational title associated with the targeted individual respondent from the firm is Director of IT Standards, Assistant Director of IT Standards, CIO or one of their direct reports (respectively). The identification of specific candidate firms to send surveys was a two-staged approach. First, a candidate list of all firms and SDO organizations that submitted IOS standards to the XML.org registry were identified. The XML.org registry, launched in 1999 by OASIS, was utilized since its' mission is to "provide an environment and community where technologists and businesspeople alike are encouraged to unite in the adoption of interoperability standards". XML.org acts as a portal for industries to submit IOS standards in order to minimize overlap and duplication of efforts. As of 2004, this portal had registered IOS standards from 46 industries and received 16,700 page views from over 4,400 visitors per day. The second stage was to identify firms that are members (or affiliated) with an SDO. In total, 979 firms were identified that fit the sampling profile. The candidate list was then reduced to exclude organizations that were developing standards for intra-organizational purposes only, duplicates, no longer in existence, or was individuals (as opposed to a firm). A total of 579 firm level surveys were distributed.

Operationalization of Variables

A summary of the survey items, categories and constructs is provided in Table 1. The survey instrument is provided in Appendix B and includes four sections (organizational, SDO, industry consequences and demographics). The organizational section includes items referring to the firm's use of the IOS technology standards grouping (strictly in an interorganizational system context) and comprehends items associated with the Innovation, Organizational and External Environment categories. For the SDO section of the survey, respondents were asked to consider their firms predominant SDO (one in which they were participants in, or aware of for their industrial group). The majority of survey items are perception-based measures on a 7-point Likert scale. IOS standards diffusion is measured on a technology assimilation scale that includes non-adopters (whom are also referred to as fence-sitters since they have indicated the firm's awareness, interest, evaluation or trial of the innovations and have not rejected nor discontinued use of the innovations), adopters (indicating the firm has reached a decision and commitment towards implementing the innovations), limited deployers (indicating the firm has deployed the innovations in at least three interorganizational systems) and general deployers (indicating the firm is deploying the innovations in all new major systems development initiatives where applicable). Please note; this study is not examining *intentions to adopt*, but rather actual technology assimilation in firms (along the scale defined above). Also note the term 'use' implies neither adoption nor deployment. Some respondent firms are users of IOS standards (e.g. for evaluation or trial purposes, or as a developer), but have not necessarily committed to adopt nor implement the innovations within their own firm.

Two variables evaluate attributes of the specific innovation under study: *relative advantage* and *shared business process fit*. The definition of *relative advantage* is the extent to which a potential adopting organization views the innovation as offering direct financial and operational benefits over previous ways of performing the same tasks (Rogers 1995). Examples of direct financial benefits include increased inventory turnover, ROI, and enhanced payback as a direct result of implementing the IOS standards. Examples of direct operational benefits include reduced cycle times, increased throughput capability, and improved response times. *Shared business process fit* evaluates the innovation' ability to satisfy key needs associated with the underlying cross-company business process (e.g. transaction volume, timeliness, effectiveness, accuracy, integrity and other collaboration level needs). Due to the similarity in potential effects of *relative advantage* and *shared business process* fit, the possibility of replacing and / or combining the two variables will be examined. Although *relative advantage* has routinely been proven to be a significant factor in technology adoption across numerous studies, the chief complaint about *relative advantage* is its lack of specificity (Tornatzky and Klein 1982). An attempt will be made to develop a set of *shared business process* attributes that are 'generic' enough to span across multiple types of business processes, yet comprehensive enough to include the theoretical support for both *relative advantage* and *shared business process* attributes.

Organizational attributes consist of five variables: *top management support, feasibility, compatibility, installed base and size*. Consistent with Chatterjee, et. al.'s top management participation dimension, three activity-based items are used to assess this variable; the assignment of a champion, communication of support, and active participation in developing the vision and strategy for the new technology (Chatterjee, Grewal, and Sambamurthy 2002). *Compatibility* is a single-item measure based on the innovations consistency with the firm's operating practices and IS infrastructure needs of the firm (Rogers 1995; Tornatzky and Klein 1982; Premkumar, Ramamurthy, and Nilakanta 1994). *Feasibility* considers financial and technical readiness. Iacovou et al, defines financial readiness as the 'financial resources available to pay for installation costs, implementation of any subsequent enhancements, and ongoing expenses during usage' (Iacovou, Benbasat, and Dexter 1995, page 469). Technical readiness is referred to as 'the level of sophistication of IT usage and IT management in an organization' (Iacovou, Benbasat, and Dexter 1995, page 469). Two survey items are used for each that request respondents to assess the firms financial and technical readiness of developing, implementing and maintaining the technology, as well as the resources to make work-flow changes to accommodate the new technology. *Installed Base* refers to the extent of older IOS solutions (e.g. EDI or EDI-like) installed in the firm, relative to the extent of modern-day IOS solution implementations. *Installed base* is derived from a combination of five types of IOS solutions (manual-based, semi-automated, EDI or EDI-like, proprietary and IOS standards).

Respondents are asked to indicate the extent of their firms' use of these solutions on a 5-point scale ranging from 0-for no use to 4- extensive use. The organization's *size* is a single item measure based on the firm's sales (or annual budget).

TABLE 1 - SUMMARY OF INDEPENDENT VARIABLES, GROUPED BY CATEGORIES

Category	Measurement Variable	Item Code in SPSS		Item Measure Description	Scale
		Loadings	Variable Code	(Abbreviated)	
ORGANIZATION ATTRIBUTES	Top Management Support	3	TMSAP4a	- Actively participate	7-point Likert (SD~SA)
			TMSPC4b	- Assigned project champion	7-point Likert (SD~SA)
			TMSEC4c	- Effectively communicates support	7-point Likert (SD~SA)
	Feasibility	4	FeasFinWF6a	- Financial resources to implement & maintain	7-point Likert (SD~SA)
			FeasFinDM6b	- Financial resources to make work flow changes	7-point Likert (SD~SA)
			FeasTechDM5a	- Technical sophistication to implement & maintain	7-point Likert (SD~SA)
			FeasTechWF5b	- Technical sophistication to make work flow changes	7-point Likert (SD~SA)
	Compatibility	1	Compatibility	- Required work procedure changes are consistent	7-point Likert (SD~SA)
				operating practices and IS infrastructure.	7-point Likert (SD~SA)
	Size	1	DemoAnnSales	- Firm annual sales or budget	9-point ascending scale
	Installed Base	1	InstallBase	- Installed base of older IOS (EDI, manual, proprietary, semi-auto) comared to web-based IOS solutions.	5-point (None to Extens)
INNOVATION ATTRIBUTES	Relative Advantage	2	DOB11	- Direct operational benefits	7-point Likert (SD~SA)
			DFB12	- Direct financial benefits	7-point Likert (SD~SA)
	SBP Fit	4	BusProcTim15b	- Enhances volume and timeliness	7-point Likert (SD~SA)
			BusProcCom15c	- Provide reliable data communications	7-point Likert (SD~SA)
			BusProcRes15d	- Enhance problem resolution & detection	7-point Likert (SD~SA)
			BusProcInt15e	- Improve data integrity	7-point Likert (SD~SA)
EXTERNAL ENVIRONMENT	Competitive Pressure	3	ComPresTP7	- Meet trading partner requirements	7-point Likert (SD~SA)
			ComPresInd8	- Industrial group pressure	7-point Likert (SD~SA)
			CompAdvtg9	- Firm will loose competitive edge	7-point Likert (SD~SA)
	Participation Level in SDO	4	SDOMemberStatus	- Member Status in SDO	Dichotomous 'yes' / 'no'
			SDOUserStatus	- User status of SDO Standards	Dichotomous 'yes' / 'no'
			SDODevelopmtStatus	- Firms participation in development activities	Dichotomous 'yes' / 'no'
			SDODeploymtStatus	- Committment to implement IOS SPI next 12 mths	7-point Likert (SD~SA)
	Direct Network Effects	1	Direct Network Effects	- Direct financial benefits	5-pt (SI ~ SD) over 3 periods
				- Direct operational benefits	5-pt (SI ~ SD) over 3 periods
				- IOS development	5-pt (SI ~ SD) over 3 periods
				- IOS implementation	5-pt (SI ~ SD) over 3 periods
				- Negotiation time of IT standards	5-pt (SI ~ SD) over 3 periods
	Indirect Network Effects	1	Indirect Network Effects	- Compliance with trading partner mandates.	5-pt (SI ~ SD) over 3 periods
				- Trading partner loyalty.	5-pt (SI ~ SD) over 3 periods
				- New revenue opportunities	5-pt (SI ~ SD) over 3 periods
				- Manufacturing lead times	5-pt (SI ~ SD) over 3 periods
				- Product / service costs	5-pt (SI ~ SD) over 3 periods
STANDARDS DEVELOPMENT ORGANIZATION	Trust	2	SDOTrust27	- Trustworthiness amoung all firm participants in SDO	7-point Likert (SD~SA)
			SDOallfirms28	- Open & honest communications	7-point Likert (SD~SA)
	Coordination	4	SDOPerfExp29	- SDO meets performance expectations	7-point Likert (SD~SA)
			SDODelegt30	- Responsibilities are appropriately delegated	7-point Likert (SD~SA)
			SDOClrgoals31	- SDO's goals are well communicated	7-point Likert (SD~SA)
			SDOFirmNeutral32	- SDO is neutral w.r.t. to all member firms	7-point Likert (SD~SA)
	Interoperability	1	Interop	- Appropriatness of modularity levels, conduciveness	7-point Likert (SD~SA)
				to interoperability, vendor neutrality, quality of	7-point Likert (SD~SA)
				standards documentation.	7-point Likert (SD~SA)
	Mission	1	MissionPurp	- SDO's mission, objectives & non-profit status	7-point Likert (SD~SA)

Table 1. Independent (Measurement) Variables used in the Study Grouped by Four Research Categories

Four external environmental factors under consideration include *competitive pressure, participation level in an SDO, direct network effects and indirect network effects*. *Competitive pressure* includes three items based on the perceived external influence from trading partners, the industry, and the firm's potential for loosing competitive advantage (Premkumar, Ramamurthy and Crum 1997). *Participation level in an SDO* is derived from a combination of four general types of interactions that may occur between an SDO and a respondent firm. These interactions include the firm's membership status in an SDO (dichotomous with 'member' or 'non-member'), participation status in SDO developmental efforts (dichotomous with 'yes' or 'no'), user status of the SDO's IOS solutions (dichotomous with 'user' or 'non-user') and the firm's projection of whether they will implement an IOS standards in the next 12 months (on a 7-point Likert scale). Ten perceived *network effects on the industrial group* are assessed by respondents for three time periods (current, mid-term and longer-term). Each time period utilizes a perception-based measure on a 5-point scale ranging from (-2) significant decrease, (-1) decrease, (0) no change, (+1) increase, to (+2) significant increase. Using guidelines from Liebowitz and Margolis, perceived network effects are split between *direct effects* (IOS development, IOS implementation, IOS standards negotiation, financial benefits and operational benefits) versus *indirect effects* (trading partner loyalty, lead times, compliance, enhanced revenue opportunities, and product costs) (1994). Responses are cumulative and meaned over the three time periods and scales are consistent such that favorable direct network effects would be expected to rise and unfavorable effects would be expected to decrease.

Four measurement variables are used in the industry-based SDO category and include *coordination, trust, mission,* and *interoperability*. *Coordination* refers to the standard development organization's techniques and norms to manage, coordinate and interact as an independent alliance organization for the industrial group(s) it is intended to serve. Four items are used to measure this including the SDO's ability to meet performance expectations, neutrality to all partner organizations (no favoritism), delegation of responsibilities and clarity of goals and objectives. Two items are used to measure *Trust* including (a) the extent of open and honest communication levels and (b) the compatibility and trustworthiness of participating firms in the SDO. *Mission* is a single item measure derived from the SDO's intended function and manner as an IOS standards setting organization (including their non-for-profit status and their ability to enable industry-wide benefits) for the industrial group(s) it is intended to serve. *Interoperability* refers to the information and communication technology (ICT) standards framework as managed by the SDO. *Interoperability* is a single item measure based on a combination of respondent's perceptions regarding the modularity levels (message scope), conduciveness to high collaboration levels, vendor neutrality and quality of technical standards documentation.

Respondents

590 firm-level surveys were distributed with a total of 102 responses and 18 rejections received. An additional 34 firms indicated their willingness to respond but only provided partially completed surveys (which are excluded). Multiple responses from a single firm were averaged and considered as a single response. The overall effective response rate is 17.3%.

TABLE 2 - RESPONDENT DEMOGRAPHICS

COUNTRY OF ORIGIN		INDUSTRY	
UNITED STATES	59	GEO-SPATIAL	17
UK	12	ELECTRONIC COMP	17
TAWAIN (ROC)	10	PETROLEUM	16
GERMANY	5	HUMAN RESOURCES	11
CANADA	3	SEMI-CONDUCTOR	11
SWITZERLAND	2	EDUCATION	8
JAPAN	2	AUTOMOTIVE	8
BELGIUM	2	PAPER	6
COUNTRIES WITH A		CHEMICAL	5
SINGLE RESPONSE	7	MARINE	3
TOTAL	102	TOTAL	102

TRADING PARTNERS		ANNUAL BUDGET (REVENUES)	
LESS THAN 25	19	LESS THAN $1 million	12
25 ~ 49	5	$1M ~ $9 MILLION	10
50 ~ 74	4	$10M ~ $49 MILLION	10
75 ~ 99	2	$50M ~ $99 MILLION	4
100 ~ 149	4	$100m ~ $499 million	12
150 ~ 199	4	$500M ~ $999 MILLION	7
200 ~ 250	21	$1 BILLION OR GREATER	44
GREATER THAN 250	43	GOVERNMENT OR N/A	3
TOTAL	102	TOTAL	102

Candidate firms were provided the option to have the survey administered via (a) paper copy through postal mail, (b) digital copy through electronic mail, or (c) conference call interview. Of the 102 respondents, three chose the paper option, 67 chose the digital option and 32 chose the interview option. Survey questions are the same regardless of the option selected by the respondent and the same individual conducted all interviews. Collectively, the firms originate from 14 countries, represent ten industrial groups, and participate in 15 SDOs. The firms can be classified into 12 organizational types, ranging from manufacturers, distributors, energy exploration / production, printers / publishers, and a host of service orientated firms (staffing, governmental, geo-spatial, and automotive retail). See Table 2 for a summary of respondent firm demographics. Contrary to some other studies, responses from technology providers and non-profit industry interest groups were retained for analysis purposes (Chatterjee, Grewal, and Sambamurthy 2002). These types of organizations fit the sampling profile for this study. In addition, most of these firms are users, implementers, or (at a minimum) stakeholders with respect to the diffusion of IOS standards throughout the industrial group.

Potential response bias was examined from four perspectives: completed surveys as percent of SDO members, non-responses as percent of surveys distributed, rejections as percent of SDO members and respondents with an interview versus those without an interview. For larger SDO organizations (those with 75 members or more) results were consistent at the industrial group level and demonstrated no potential response, non-response or rejection bias. For smaller SDO organizations, ratios did significantly vary (up to a maximum of 51% of variation) with respect to three industrial groups. These variations were attributed to a low absolute count of participating members and the short time horizon since the inception of the industrial group's SDO. Caution should be taken in interpreting these results for industrial groups under those circumstances. To test whether there were significant differences between responses with an interview (option c) versus those without an interview (options a and b), two tailed t-tests for differences in mean responses was conducted for the variables. The means, standard deviations and p-value results are provided in Table 3. Overall, evidence of systematic differences in responses between the two groups could not be found. Fifteen of the sixteen variables examined (including the dependent variable) did not result in statistically significant differences in mean responses. The one exception is *direct network effects* which was found significant at the $p < .05$ level. As previously discussed, survey questions were the same regardless of the option selected by the respondent and the same individual conducted all interviews. Survey questions immediately preceding (*coordination*), immediately following (*installed base*) and in the same section (*indirect network effects*) of the survey instrument as *direct network effects* did not result in significant differences in mean responses.

TABLE 3 - RESPONDENTS WITH VERSUS WITH OUT INTERVIEW

	Respondents (with Interview)		Respondents (with out Interview)		p-Value*
	n = 32		n = 70		
	Mean	S.D.	Mean	S.D.	
Relative Advantage	5.3125	1.0832	5.0786	1.2028	0.350
Shared Bus Process Fit	5.6484	0.9105	5.5089	0.9052	0.473
Size	4.7500	2.2433	5.0143	2.3312	0.592
Installed Base	6.7188	3.8373	7.0429	3.2856	0.662
Top Management Support	5.3854	1.3966	5.0571	1.5819	0.316
Feasibility	5.7031	0.9299	5.6143	0.9961	0.671
Compatibility	5.6563	0.8940	5.2762	0.9614	0.061
Competitive Pressure	5.1146	1.3825	5.3286	1.2218	0.433
Participation Level in SDO	4.3125	1.2297	4.2857	1.1935	0.917
Direct Network Effects	1.7413	1.2372	1.1381	1.4394	0.043
Indirect Network Effects	1.3688	0.7258	1.5743	0.9448	0.278
Coordination	5.3594	0.8635	5.0679	0.9963	0.157
Mission	6.0417	0.7608	5.8905	0.7082	0.331
Interoperability	5.4313	0.6327	5.1686	0.8591	0.125
Trust	5.7188	0.9914	5.3286	1.0456	0.079
Assimilation Scale	2.7500	1.1360	2.5700	1.0980	0.453

** two-tailed t-tests of sample means*

Test of Factors

Content validity was qualitatively assessed through three preliminary studies, two pre-tests, and multiple reviews of the survey instrument. Content and construct validity were further qualitatively substantiated through a literature survey conducted in alliance organizations, ICT standardization and IOS diffusion (including a comprehensive coding of measurement variables and significance findings[1]). See Table 1 and Appendix B for descriptions of constructs, measurement variables, survey items and item descriptions (Straub 1989). Reliability of the survey instrument's items was also quantitatively validated through calculating Cronbach alphas for the seven multi-item measurement variables and the four categories. ~~Reliability analysis at the categorical level revealed that the *size* and *installed base* variables should be removed from the organization category.~~ The alphas range from .60 to .86 and are itemized in Table 4 - Reliability of Factors. Although some of the Chronbach alphas are lower than Straub's (1989) .8 rule-of-thumb, all are near or above Nunnally's .6 threshold. Due to the rich mix of survey items based on prior research and the introduction of new items pertaining to the SDO's role, these levels are deemed appropriate for this context.

TABLE 4 - Reliability of Factors

		Cronbach Alpha (Standard)	Correlation Matrix Counting Results		
			Total Correlations	Violations (Count)	Violations (%)
Measurement Variables*					
Relative Advantage	2 items	0.77	57	0	0%
Shared Bus Process Fit	4 items	0.78	110	3	3%
Top Management Support	3 items	0.86	84	0	0%
Feasibility	4 items	0.82	110	2	2%
Competitive Pressure	3 items	0.72	84	8	10%
Coordination	4 items	0.82	110	4	4%
Trust	2 items	0.61	57	0	0%
Totals		0.83	435	17	4%
Categories					
Innovation Attributes	2 variables	0.62	27	0	0%
Organization Attributes	3 variables	0.72	39	0	0%
External Environment	4 variables	0.60	50	13	26%
Standards Dev Org	4 variables	0.74	50	6	12%
Totals		0.76	105	19	18%

** See Pearson Correlation Coefficients
* Multi-Item variables only

Convergent validity and discriminant validity were also quantitatively assessed through factor analysis. Principle Components Analysis (PCA) with Varimax rotation and Kaiser normalization was conducted for the seven multi-item factors (see Table 5). Out of the 154 possible loadings, all but one of the survey items had the greatest value and loaded high (>.50 threshold) within

TABLE 5 - ROTATED COMPONENT MATRIX							
For Multi-item variables only							
	Component						
	1	2	3	4	5	6	7
	Top Mgmt Support	Coordination	Shared Business Process Fit	Feasibility	Competitive Pressure	Relative Advantage	Trust
TMSAP4a	***0.888***	0.156	-0.038	0.057	0.034	0.094	-0.004
TMSPC4b	***0.745***	0.101	-0.074	0.074	0.236	0.200	-0.025
TMSEC4c	***0.821***	0.121	0.057	0.258	0.017	0.157	0.049
SDOTrust27	-0.058	0.263	0.052	0.129	-0.028	-0.004	***0.735***
SDOallfirms28	0.109	0.153	0.002	-0.003	-0.011	-0.022	***0.840***
SDOPerfExp29	0.048	***0.800***	-0.023	-0.018	0.000	0.226	0.181
SDODelegt30	0.057	***0.717***	0.203	-0.192	0.150	0.074	0.248
SDOClrgoals31	0.063	***0.827***	0.119	0.119	0.119	0.042	-0.006
SDOFirmNeutral32	0.193	***0.696***	0.215	-0.127	-0.179	-0.201	0.186
FeasTechDM5a	0.419	-0.223	0.142	***0.503***	0.299	-0.164	0.168
FeasTechWF5b	0.519	-0.206	0.272	***0.407***	0.272	-0.179	0.262
FeasFinWF6a	0.140	-0.068	-0.054	***0.928***	0.045	0.081	-0.021
FeasFinDM6b	0.166	0.038	-0.068	***0.904***	0.110	0.138	0.087
ComPresTP7	0.035	0.048	-0.206	0.340	***0.688***	0.250	0.017
ComPresInd8	0.066	0.064	0.143	0.023	***0.826***	0.114	0.035
CompAdvtg9	0.333	0.023	0.300	0.028	***0.717***	0.003	-0.130
DOB11	0.213	0.163	0.138	0.112	0.154	***0.791***	-0.038
DFB12	0.278	0.049	0.393	0.075	0.291	***0.556***	-0.122
BusProcTim15AandB	0.071	-0.052	***0.544***	0.043	0.032	0.571	0.107
BusProcCom15c	-0.026	0.137	***0.826***	0.010	-0.022	0.134	0.046
BusProcInt15e	-0.093	0.063	***0.653***	-0.186	0.127	0.247	0.163
BusProcRes15d	0.089	0.249	***0.811***	0.041	0.137	-0.032	-0.130
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.							

their respective measurement variable. Thus, demonstrating a good degree of convergent validity. Discriminant validity was further quantitatively assessed using an item correlation matrix 'counting' technique (Chau and Tam 1997). Generally speaking, validity is established by counting the number of higher correlations outside of an item's factor (referred to as violations) and then comparing the result with the total possible number of correlations. The general rule of thumb is discriminant validity is established if the above ratio is less than 50%. This technique was conducted across all items (to their respective measurement variables) and across all measurement variables (to their respective categories). The results are provided in Table 4. Out of the 435 total *item to measurement variable* correlations possible, 17 (or 4%) experienced higher correlations outside of their own variable. Out of the 105 *measurement variable to category* correlations possible, 19 (or 18%) experienced higher correlations outside of their own category. Thus, these results outperform the general rule of 50% at all levels (item, measurement variable, category and in total) and provides substantive support of discriminant validity. Table 6 includes the Pearson Correlation Matrix depicting that all intra-categorical variable correlations are significant at the .05 level (or lower). Table 7 includes descriptive statistics of the measurement variables.

TABLE 6 - PEARSON CORRELATION MATRIX

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 Relative Advantage	1		***Innovation***												
2 Shared Bus Process Fit	.419(**)	1													
3 Top Management Support	.357(**)	0.109	1			***Organization***									
4 Feasibility	.249(*)	0.031	.444(**)	1											
5 Compatibility	.343(**)	0.022	.516(**)	.439(**)	1										
6 Competitive Pressure	.398(**)	.235(*)	.347(**)	.384(**)	.391(**)	1				***External Environment***					
7 Participation Level in SDO	0.155	-0.035	.399(**)	0.189	.408(**)	.354(**)	1								
8 Direct Network Effects	.401(**)	.208(*)	0.113	0.101	0.118	.297(**)	.196(*)	1							
9 Indirect Network Effects	0.134	.217(*)	0.176	0.104	0.142	.233(*)	.227(*)	.236(*)	1						
10 Coordination	.211(*)	.287(**)	.216(*)	-0.08	.308(**)	0.084	0.075	.210(*)	-0.012	1				***SDO***	
11 Mission	.234(*)	.230(*)	.336(**)	0.13	.356(**)	.233(*)	.230(*)	0.104	-0.032	.530(**)	1				
12 Interoperability	.246(*)	0.123	.273(**)	0.008	.317(**)	.227(*)	0.172	*.280(**)*	0.08	.558(**)	.498(**)	1			
13 Trust	-0.024	0.104	0.089	0.149	0.148	-0.008	0.115	0.175	0.135	.384(**)	.302(**)	.239(*)	1		
14 Size	0.004	0.031	0.073	0.134	-0.089	0.094	.212(*)	0.172	-0.021	0.083	-0.052	0.063	0.181	1	
15 Installed Base	0.051	0.024	-0.13	-0.034	-0.085	0.013	0.009	-0.019	0.007	0.011	0.053	-0.081	0.042	.343(**)	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

TABLE 7 - DESCRIPTIVE STATISTICS

	N	Min	Mean	Std Dev
Relative Advantage	102	2.00	5.15	1.17
Shared Bus Process Fit	102	2.00	5.55	0.90
Size	102	1.00	4.93	2.30
Installed Base	102	-3.00	6.94	3.45
Top Management Support	102	1.00	5.16	1.53
Feasibility	102	2.00	5.64	0.97
Compatibility	102	2.00	5.40	0.95
Competitive Pressure	102	1.33	5.26	1.27
Participation Level in SDO	102	0.00	4.29	1.20
Direct Network Effects	102	-1.61	1.33	1.40
Indirect Network Effects	102	-1.00	1.51	0.88
Coordination	102	2.50	5.16	0.96
Mission	102	3.33	5.94	0.72
Interoperability	102	2.20	5.25	0.80
Trust	102	2.00	5.45	1.04

RESULTS

Logistics regression was chosen to examine the conceptual model (Neter 1996). The discrete and ordinal nature of the dependent variables would have necessarily broken assumptions of traditional linear multiple regression analysis. The benefit of logistic regression is its' flexibility and ability to accommodate dichotomous and scaled (intervals) responses. The logistic function predictor variables may be quantitative, qualitative, and may represent curvature or interaction effects (Neter 1996). Maximum likelihood estimates (MLE) is used to estimate parameters of the multiple logistic response function.

Using Menard's suggested protocol for logistic regression diagnostics, the model was examined for non-linearity, outliers, and interaction effects (1995). Non-linearity diagnostics employed the

Box-Tidwell transformation by adding natural log terms [in the form *(x)ln(x)*] for each of the retained independent variables in the reduced model. None of the coefficients for these added terms were statistically significant and other evidence of non-linearity could not be found. Outlier and residual analysis was conducted and resulted in two cases with moderately high studentized residuals of 8.3 and 4.0. Both cases involved non-adopters from separate industrial groups (petroleum and automotive, respectively) whom also considered themselves users of the innovations. Although this combination of a *non-adopter and user* was not unusual for the data set, the firms' predicament is. Both firms forecasted substantial deployment levels in ensuing years pending the firms' adoption decision. Thus, the firms' adoption decision and deployment decisions will occur nearly simultaneously. Testing was conducted with and without these cases which did not result in significant changes in model fit and no changes in the composition of significant predictors. These scenarios were plausible and the cases retained. Finally, numerous potential interaction effects between predictor variables within each category (and between categories where applicable) were examined. This technique is advocated in logistics regression diagnostics to reduce the likelihood of omitting relevant variables and to examine the existence of collinearity and non-additivity in predictor variables. Of the 18 potential interactions tested, two interactions (*Participation Level in SDO and Competitive Pressure)* and *(Compatibility and SBP Fit*) were approaching significance. All four predictors were mean centered (a common remedial measure for multi-collinearity) and the resultant interactions were substantially reduced and found non-significant (Neter 1996). Additional subsequent collinearity diagnostics procedures were also found to be at acceptable levels and did not support further investigation into this matter.

Polytomous logistics regression with ordinal classification was initially chosen to examine the model (McCullagh 1980). IOS diffusion is treated as the dependent variable in the model and includes *non-adopters, adoption, limited deployment* and *general deployment.* Overall, there are 22 non-adopters, 22 adopters, 30 limited deployers and 28 general deployers of the innovations in an IOS context. The first three columns in Table 8 summarize the significant variables from the reduced (final) model, including the coefficients, and significance levels based on the polytomous logistics function (Neter 1996). In distinguishing between the diffusion stages the following measurement variables were found to be significant: *installed base, top management support*, *feasibility, participation level in an SDO, direct network effects, mission* and *interoperability.* Thus, not supporting Hypothesis 1 (regarding the significance of Relative Advantage and Shared Business Process Fit). Hypothesis 2 is partially supported with respect to the significance with a positive relation to greater levels of *top management support* and *feasibility*, but not supported regarding *compatibility*. Hypothesis 3 is partially supported regarding significance, except we found that greater *installed based* levels of older IOS solutions (such as EDI), have a positive relation to web-based IOS standards diffusion. Also noteworthy here is (as anticipated) firm *size* was found non-significant. [Actually, firm size was examined from three perspectives (sales or annual budget, trading partner count and employee count) and was found non-significant from all perspectives.] Hypothesis 4 is partially supported regarding greater *participation levels in an SDO* have a positive and significant relation to IOS standards diffusion. Hypothesis 4 is not supported with respect to *competitive pressure*. Hypothesis 5 is partially supported regarding significance, but we found that *direct network effects* have a negative relation with IOS standards diffusion. Hypothesis 5 is not supported with respect to *indirect network effects*. Hypothesis 6 is partially supported with respect to greater conduciveness of i*nteroperability* has a significant and positive relation with IOS standards diffusion. An SDO's *mission* was found to have a significant but negative relation with IOS standards diffusion. Hypothesis 6 was not supported regarding *coordination* and *trust*.

Overall, the model fit was improved between the initial and final model from an Akaike Information Criterion (AIC) of 286.81 to a final AIC of 247.98. The final model significance is at the $p<.000$ level and utilizing techniques outlined by Menard (1995) the percentage of explained variation (R^2_L) is .2879 (derived from Hosmer and Lemeshow 1989). In terms of predictive efficiency, the model's overall prediction rate is 54.9%. Using Goodman and Kruskal's λ_p predictive efficiency index [which is largely based on the mode of the dependent variable and measures the proportional reduction in expected versus actual prediction errors], the model improved the expected prediction rate by 42.5% and is significant ($\lambda_p = .425$, d = 8.185, F-distribution) at the $p<.000$ level (Menard 1995). Thus, the model provides significant improvement in predictions rates over expected prediction rates.

The prediction rates of each of the individual categories, however, do leave room for improvement. The model's correct prediction rates for the dependent variable categories are as follows: non-adopters (77%), adopters (27%), limited deployment (50%), general deployment (64%). Thus, the model performs well at predicting the two extremes (non-adopters and general deployers), but performs rather poorly at predicting the middle two stages (adoption and limited deployers). Polytomous logistics regression is appropriate for nominal and ordinal categorical data, but it is also a constrained model in that the predictor variables in the reduced (final) model are *fitted across all dependent variable categories*. Thus we may be able to obtain an enhanced understanding of predictors by isolating effects between categories, rather than constraining the model to predictors consistent across all categories. Likewise this may lead to improved prediction rates, higher explained variation and better overall model fit. Since Proposition 7 is intended to examine specific determinants towards adoption and deployment, we have supplemented the results with two additional binary logistics regression models that examine specific determinants between *non-adopters versus adopters* and *non-deployers versus deployers*. This will enable us to more appropriately test Proposition 7 and is consistent with the practical managerial challenges currently confronting industrial groups "What are the discriminating factors that will move fence-sitting firms towards implementation?". This also provides us with an opportunity to better examine causes of technology assimilation gaps plaguing IOS standards diffusion. Including supplemental analysis such as this in logistics regression modeling is advocated by researchers (McCullagh 1980; Menard 1995). Prior studies in IOS diffusion that were conducted on a post-hoc basis (where the focus was on adoption as opposed to the *intention to adopt*) have included respondent firm scores (whom have implemented the innovation) also as an adopting firm (Grover and Goslar 1993; Grover 1993).

TABLE 8 - RESULTS

PREDICTOR	DIFFUSION (4-Stage Polytomous)			ADOPTION (Binary)			DEPLOYMENT (Binary)		
	Coefficient	Standard Error	Significance	Coefficient	Standard Error	Significance	Coefficient	Standard Error	Significance
Main Effects									
Relative Advantage	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Shared Bus Process Fit	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	2.289	1.362	0.093
Size	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Installed Base	0.363	0.169	0.032	0.397	0.157	0.011	n.s.	n.s.	n.s.
Top Mgmt Support	1.136	0.422	0.007	0.723	0.342	0.035	n.s.	n.s.	n.s.
Feasibility	1.798	0.688	0.009	1.773	0.601	0.003	0.433	0.200	0.031
Compatibility	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	2.758	1.407	0.050
Competitive Pressure	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Part Level in SDO	1.785	0.625	0.004	1.143	0.419	0.006	0.464	0.189	0.014
Direct Network Effects	-0.663	0.381	0.082	-0.949	0.386	0.014	n.s.	n.s.	n.s.
Indirect Network Effects	n.s.	n.s.	n.s.	0.941	0.523	0.072	n.s.	n.s.	n.s.
Coordination	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Mission	-1.272	0.748	0.089	n.s.	n.s.	n.s.	-0.476	0.274	0.083
Interoperability	1.731	0.740	0.019	1.711	0.625	0.006	0.385	0.225	0.087
Trust	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Intercept	-25.428	7.506	0.001	-27.420	7.489	0.000	17.737	7.813	0.023
MODEL FIT									
	Goodness of Fit			Goodness of Fit			Goodness of Fit		
	-2LLH	Per DF		-2LLH	Per DF		-2LLH	Per DF	
INITIAL MODEL (SST)	280.81	2.753		106.36	1.043		139.47	1.367	
FINAL MODEL (SSE)	199.98	2.105		43.66	0.455		105.14	1.107	
MODEL CHI-SQUARE (SSR)	80.83	0.860		62.71	0.653		34.34	0.365	
FINAL MODEL SIGNIFIGANCE	p < .000			p < .000			p < .000		
R^2L - Hosmer & Lemeshow	0.2879			0.5895			0.2462		
Correct Prediction Rate	54.9%			88.2%			73.5%		

From the IOS Standards Adoption Model

Binary logistics regression was selected in the adoption model due to the dichotomous nature of the dependent variable *non-adopters* versus *adopters*. The same set of predictor variables is used in the initial model as are used in the initial diffusion model. Respondents are stratified into two groups, those that have not adopted the innovations (22) and those that have adopted the innovations (80). The middle three columns in Table 8 summarize the significant variables from the reduced (final) adoption logistics function, including the coefficients, standard errors, and significance levels. In distinguishing between adopters versus non-adopters the following measurement variables were found to be significant: *installed base, top management support, feasibility, participation level in an SDO, direct network effects, indirect network effects,* and *interoperability*. Goodness of fit for the final model (which includes main significant effects only) is significant at the p <0.000 level on a χ^2 distribution. Utilizing techniques outlined by Menard (1995) the percentage of explained variation (R^2_L) is .59. In terms of predictive efficiency, the model's prediction rate is 88.2%. Using Goodman and Kruskal's λ_p predictive efficiency index, the model improved the expected prediction rate by 85% and is significant (λ_p = .85, d = 16.370, F-distribution) at the p<.000 level (Menard 1995). The model provides significant improvement in predictions rates over expected prediction rates. Thus, when comparing the adoption and diffusion models, the adoption model resulted in a greater explained variation (R^2_L), a lower -2 log likelihood, a lower AIC, and a substantially more accurate adopter prediction rate.

From the IOS Standards Deployment Model

Binary logistics regression was selected in the deployment model due to the dichotomous nature of the dependent variable *non-deployers* versus *deployers*. The same set of predictor variables is used in the initial model as are used in the initial diffusion model. Respondents are stratified into two groups, those that have not deployed the innovations (44) and those that have deployed the innovations (58). The far right three columns in Table 8 summarize the significant variables from the reduced (final) deployment logistics function, including the coefficients, standard errors and significance levels. In distinguishing between non-deployers versus deployers the following measurement variables were found to be significant: *shared business process fit, feasibility, compatibility, participation level in an SDO, mission* and *interoperability.* Proposition (7) is supported in that the adoption and deployment models share three determinants in common (*shared business process fit, feasibility,* and *interoperability*), but also have determinants unique to each; towards adoption (*installed base, top management support, competitive pressure, direct network effects, indirect network effects*) and towards deployment (*compatibility, participation level in SDO, mission*).

Goodness of fit for the final deployment model (which includes the main significant effects only) is significant at the p<.000 level on a χ^2 distribution. Utilizing techniques outlined by Menard (1995) the percentage of explained variation (R^2_L) is .2462. In terms of predictive efficiency, the model's prediction rate is 73.5%. Using Goodman and Kruskal's λ_p predictive efficiency index, the model improved the expected prediction rate by 53.4% and is significant (λ_p = .534, d = 6.198, F-distribution) at the p<.000 level (Menard 1995). Thus, when comparing the deployment and diffusion models, the deployment model resulted in less explained variation (R^2_L), but a lower -2 log likelihood, a lower AIC, and a more accurate deployer prediction rate.

TABLE 9 - RESULTS OF TESTS OF HYPTHESES		
H1	Relative Advantage and Shared Business Process Fit will have a positive and significant relation towards IOS standards diffusion.	Not supported.
H2	Top Management Support, Feasibility and Compatibility will have a positive and significant relation towards IOS standards diffusion.	Partial Support w.r.t. TMS and Feasibility. Not supported w.r.t. Compatibility.
H3	Installed Base will have a negative and significant relation towards IOS standards diffusion.	Partial Support w.r.t. signifigance, but with a positive relation.
H4	Competitive Pressure and Participation Level in an SDO will have a positive and significant relation towards IOS standards diffusion.	Partial Support w.r.t. Participation Level in an SDO. Not supported w.r.t. Competitive Pressure.
H5	Favorable Perceived Direct and Indirect Network Effects will have a positive and significant relation towards IOS standards diffusion.	Partial Support w.r.t. signifigance of Direct Network Effects, but with a negative relation. Not Supported w.r.t. Indirect Network Effects.
H6	Coordination, Mission, Interoperability and Trust will have a positive and significant relation towards IOS standards diffusion.	Partial Support w.r.t. Interoperability and Mission (but with a negative relation). Not supported w.r.t. Coordination and Trust.
P7	A different set of significant attributes will be associated with IOS standards adoption versus IOS standards deployment.	Supported.

DISCUSSION

An industrial group's ultimate intentions with developing IOS standards may be cost cutting, process efficiency, outsourcing, co-opetition, building a foundation for web-services or simply enhancing industry-wide interoperability. The emergence of this phenomenon is clear and the diffusion process is proving to be an extraordinary challenge. This study sought to examine the development and diffusion process of IOS standards throughout an industrial group. A conceptual IOS standards diffusion model was proposed, defined, segmented into multi stages and empirically compared to a real work environment. The significant antecedent conditions are summarized in Table 8 and Figure 2. The analysis and empirical results suggest the findings can be grouped into the following emerging patterns (major findings) associated with IOS standards diffusion.

- Common IOS Diffusion Determinants
- Shifted Focus / Strategies between Adoption and Deployment Stages
- Contrasts between EDI versus web-based IOS standards Diffusion Determinants
- The Emerging Role of an Industry-based SDO
- IOS Standards Diffusion across Industrial Groups

Figure 2 - Determinants Towards IOS Standards Diffusion

Diffusion Stage	**Adoption**	**Deployment**	**Diffusion**
Determinants	Feasibility* Interoperability* Part. Level in SDO* Top Mgmt Support Installed Base Direct Network Effects (-) Indirect Network Effects	Feasibility* Interoperability* Part. Level in SDO* Shared Bus Process Fit Compatibility Mission (-)	Feasibility* Interoperability* Part. Level in SDO* Top Mgmt Support Installed Base Direct Network Effects (-) Mission (-)

** Shared significant attributes across all IOS diffusion stages.*

Common IOS Diffusion Determinants: *The common determinants across IOS diffusion stages* include *installed base, top management support*, *feasibility, participation level in an SDO, direct network effects, mission* and *interoperability.*

First, as expected *top management support* was found as one of the most significant determinants of IOS standards diffusion. The development of interorganizational system standards is a direct outward manifestation of the firm and their willingness to participate with their industrial group. *Top management support* is essential towards achieving this and can manifest through assigning a project champion, actively participating in establishing a vision and communicating support for the innovations. *Feasibility, participation level in an SDO* and *interoperability* have emerged as significant determinants in the diffusion model, but also in both supplemental models for adoption and deployment determinants (highlighted in Figure 3).

Feasibility, similar to the notion of readiness (Chwelos, Benbasat, and Dexter 2001; Iacovou, Benbasat, and Dexter 1995), refers to the firms' technical sophistication to develop and make workflow changes to use IOS standards technology, and their financial resources to purchase and maintain the technology. The start-up cost associated with implementing a firm's first series of IOS standards was approximately $100,000 in 2001 (Behrman 2002). The incremental cost thereafter was considered minimal and could be incurred on a piece-meal basis (e.g. an additional server or software license purchase as volumes necessitated). By the end of 2003 firms had estimated this initial start-up cost to be cut in half (and dropping). Based on survey responses an emerging group of firms no longer associate these start-up costs with IOS standards (*per se*), but rather view them as part of the firm's ongoing IT infrastructure maintenance. Although limited use of the *interoperability* variable was found in the literature survey, it was a significant antecedent condition across all diffusion stages. *Interoperability* of an SDO's IOS standards includes their defined scope (modularity level), conduciveness towards interoperability, vendor neutrality and quality of technical standards documentation. Collectively, these provide rich attributes that an industry-based SDO may seek to achieve. The external environment's *participation level in an SDO* can manifest in several ways. Some firms participate in the industrial groups' standards development process, but then fail to internally deploy IOS standards. Some firms implement IOS standards, but then fail to become a formal member of the SDO. Some firms choose to adopt IOS standards, but then fail to participate in the SDO's standards development process. Overall these findings suggest the greater the number of participation touch-points with an SDO, the greater the levels of IOS standards diffusion. The result is a clear recommendation to SDOs, to improve diffusion levels, actively engage firms with a rich diversity of participation alternatives (standards development efforts, membership, testing / evaluation, etc.). This finding is consistent with findings from recent researchers (Teo, Wei, and Benbasat 2003) and recommendations from others (Reekers and Smithson 1994; Grover 1993; Cavaye 1996).

The results are particularly revealing for the following three variables since they resulted in significance findings but in opposite directions than were hypothesized. *Installed base*, for example, was included in the model based on reports from the business press and standards literature as an inhibitor of adoption and its' propensity to develop lock-in effects. Our study indicates that the firm's installed base of older IOS solutions (e.g. EDI or EDI-like) has a positive influence towards achieving greater levels of IOS standards diffusion. Perhaps the implementation experience and insights of firms with a larger installed based of older (antiquated) IOS solutions, provides them with the necessary enticements and motivation to upgrade. Similarly, the *mission* of an industrial group's SDO (anticipated to have a positive influence), was found significant but with a negative relation towards IOS standards diffusion. Recall, *mission* reflects the SDO's scope, purpose and the perceived benefits provided to firms. Further investigation revealed that firms with the greatest diffusion levels are the same firms seeking the greatest number of services from an SDO. They often disagree with the SDO's mission since they seek additional value-added services. Finally, *direct network effects* (also anticipated to have a positive influence) was found significant but with a negative relation towards IOS standards diffusion. Recall that this variable measures the respondent's perceptions of the direct network effects of deploying IOS standards *on their industrial group* and includes IOS development, implementation and standards negotiation efforts, as well as other direct financial and operational considerations. All measures were consistently reported such that favorable direct network effects would be expected to rise and unfavorable effects would be expected to decrease. Further investigation into the descriptive consequence measures revealed that non-adopter firms anticipated greater direct network benefits than firms whom had already adopted and deployed the innovations. [In fact, non-adopter's anticipated ROI from investing in IOS standards exceeded those of deploying firms at nearly a 2:1 ratio.] Thus, the implementation experience of adopter and deployer firms moderated (reduced) the anticipated direct network benefits provided to the industrial group.

Shifted Focus / Strategies between Adoption and Deployment Stages: *The supplemental models revealed that a different mix of determinants is associated with IOS standards adoption versus deployment.* The models were structured with the intent to provide further insights into fence-sitting firms (delayed adoption decisions) and technology assimilation gaps (delayed deployment). In the adoption stage, the external environment and broader enterprise-wide considerations are paramount (refer to Table 6). These include organizational readiness attributes such as demonstrated *top management support*, technical and financial *feasibility* and the relative installed base of older IOS solutions (e.g. EDI, proprietary or semi-automated solutions). These also include external environment considerations such as the *participation level in an SDO* and the perceived network effects of diffusing the innovations across the industrial group. In contrast, the deployment stage is based more on lower level operational considerations specific to the *cross company business process fit* and the *compatibility* of the technology. Thus, as firms progress from adoption to implementation, the types of decisions shift from "Whether the firm should adopt IOS standards", towards "When and how do we implement the standards with trading partner X, for business process Y". The decisions become more finite and organizational attributes become less important and attributes associated with the technology become more important. In fact, an examination of Table 6 indicates the lack of any attributes associated with the innovation itself to be significant during adoption. Likewise, only one external environment attribute is significant during deployment.

Contrasts between EDI versus web-based IOS standards Diffusion Determinants: *The diffusion of web-based IOS standards entails a different mix of antecedent conditions than EDI diffusion. Compared with EDI diffusion from the past, size, relative advantage and competitive pressure are no longer significant antecedent conditions*. The majority of prior innovation studies that examined IT standards diffusion in an interorganizational system context pertained to ANSI X12 standards for use in EDI (e.g. purchasing and inventory interorganizational systems). As previously discussed, a literature survey of prior IOS diffusion studies was conducted as part of our preliminary work [1]. Based on synthesizing the findings across all studies, the most frequent determinants of EDI (and EDI-Like) diffusion are *competitive pressure, relative advantage, compatibility, size* and *top management support* [1]. Two of these measures are consistent with our findings: *top management support* is significant towards diffusion and (to a lesser extent) *compatibility* is significant in the supplemental deployment model. Three of the measures however (*size* of the firm, *competitive pressure* and *relative advantage* of the technology) are non-significant antecedent conditions with modern-day web-based IOS standards diffusion and merit further discussion. Traditionally, a firm's *size* and *competitive pressure* have long been considered significant factors in IOS diffusion due to EDI's large up-front expenses and coercive adoption practices along the supply chain. Similarly, the *relative advantage* of an innovation has been a significant determinant in IOS diffusion studies, and is routinely found to be significant in innovation diffusion studies (Tornaksk and Rojers). Web-based IOS solutions are open standards-based, collaboratively developed, modular, scaleable and flexible. Compared with EDI, they comprehend a broader scope of cross company business processes, a richer depth of task-level interoperability, to a fuller breadth of firms across the industrial group. With these inherent *industry-wide* benefits, sharply declining up-front infrastructure investments, shared development expenditures, and a *non-profit voluntary-consensus* SDO acting as an intermediary (and reaching out to the industrial group), a firm's *size,* the *relative advantage* and *competitive pressures* are no longer as significant as once was the case.

The Emerging Role of an Industry-based SDO: *IOS standards diffusion determinants are closely linked to the emerging role of an industry-based SDO. While maintaining a base line of services through all stages, SDO focus areas should advance as diffusion levels progress.* As this study has examined, the members of an SDO management team are in a precarious position. The SDO management team must accommodate firms at varying levels of diffusion, while relentlessly being their industry's leader in the standardization efforts. The SDO management team must be *look beyond* their own industrial group for consistency and new technological developments, while also *looking above* their industry to higher order SDOs for compliance and certification. Not to mention their day-to-day tasks of managing conflicts, reaching consensus, establishing priorities, and promoting uptake throughout the entire industrial group. They are bound to upset some members most of the time, and rarely have the opportunity to exceed expectations any of the time. They are independent moderators in managing a shift from competition to co-opetition and enablers towards true pie-expansion among members of an industry group. Despite these challenges, this study provides needed insights into the emerging role of an SDO. Using the significant determinants that have emerged across diffusion stages (*installed base, top management support*, *feasibility, participation level in an SDO, direct network effects, mission* and *interoperability*) SDO's may extend these findings to develop a base line of services. First, technical *feasibility* can be enhanced throughout the industrial group via collaborative research and development sessions, lessons learned, best practices and other knowledge sharing techniques. Second, *SDO participation levels* can be sustained by offering an array of participation alternatives (touch-points) through all diffusion stages. Third, despite headlines from the business press, caution should be taken regarding the commonly accepted notion that a large installed base of older IOS solutions acts an inhibitor towards diffusion. Our findings suggest that it actually has a positive influence with a firm's decision to upgrade and diffuse web-based IOS standards. Similar comments can be made regarding a firm's *size*, *competitive pressure* and the technology's *relative advantage*. Collectively, these were determinants associated with older (EDI or EDI-like) diffusion and they are declining in significance in light of the technological innovations and industry-wide benefits enabled with modern-day web based IOS standards. Fourth, manage the industrial group's expectations regarding the favorable network benefits. Unfortunately, fence-sitting firms already anticipate higher direct network benefits from diffusion than what should reasonably be expected. Heed the implementation experiences and lessons learned from general deployer firms, communicate their findings and better balance these expectations in the industry. Similarly, *indirect network* benefits are an opportunity area for

SDO management with fence-sitting firms. Non-adopting firms were found to have significantly less favorable perceptions regarding indirect network effects than their general deployer counter-parts. These under-estimated expectations are in areas such as trading partner loyalty, manufacturing lead times, attraction of new customers and product costs were found to be significant determinants in the supplemental IOS standards adoption model. Fifth, SDO's should utilize an architecture that is conducive to industry-wide *interoperability* with key considerations including vendor neutrality, platform independence, and open-standards based that are well documented and structured around discretely defined shared business processes. Although achieving all of these may be a challenge for some SDOs, they do provide a rich mix interoperability attributes to seek.

Sixth, consider shifting strategies when dealing with fence-sitting firms where prolonged adoption decisions exist. During adoption, focus on higher-order strategic benefits provided to the potential adopting firm and the external environment. With organization-level attributes important during adoption, SDOs should actively engage a firm's *top management support* and assist them to clearly enumerate the interoperability benefits, the feasibility and with the assignment of project champion(s). SDOs can leverage the indirect network benefits to ease fence-sitter firms into the diffusion process.

Seventh, consider shifting strategies where technology assimilation gaps have emerged. During deployment, determinants shift from external environment and organization-level attributes towards SDO and innovation related attributes. Firms are more focused on "When and how to implement IOS standards with trading partner X, for business process Y". Further, the newly deployed firm is likely confronting internal resistance to change and their recently spent capital expenditures have yet to provide returns. Internal pressures rise during deployment, making SDO outreach and support crucial. By demonstrating the *compatibility* of these innovations with the firm's future and correlating the investments with web-services readiness, an SDO can assist a newly deployed firm manage the pressures. S*hared business process fit* attributes provide additional avenues to demonstrating the ensuing benefits (enhanced timeliness, improved data accuracy and data integrity), in addition to improved compliance with governmental regulations and better enforcement of contractual arrangements.

The significance of the *mission* variable (but with a negative relationship) is indicative of this emerging role of an SDO. Recall, *mission* includes items related to the SDO's scope and mission, its' non-profit status, and the perceived benefits provided to firms. Firms with the greatest assimilation levels are the same firms seeking the greatest number of services from an SDO. They often disagree with the SDO's governance since they seek additional value-added services. For example, respondents from the electronics industry are seeking case studies (or white papers) regarding the business process reengineering associated with IOS standards implementations (rather than just the technical-based case studies). Respondents in the geo-spatial industry are seeking permanent walk-in hosting labs to allow potential IOS standards users to 'kick the tires' at any time. Respondent firms from several industries are seeking improved compliance and conformances testing procedures, including assurances that the standards are compliant and / or compatible with similar IOS standards on a cross-industry (horizontal) basis. One of the highest points of feedback regarding additional SDO services sought is IOS standards adoption assistance among members from the *entire* industrial group. Many respondent firms indicated their willingness to change the SDO's status to *for-profit* in order to fund additional services. The point of these illustrations is not to further burden an SDO. Rather, it is to illustrate the emerging role of an SDO and how their focus areas should advance as IOS standards diffusion levels progress throughout the industrial group. The SDO management team should acknowledge these untapped needs, enlist assistance, delegate accordingly and manage expectations. Recall, the greater the number of participation touch-points, the greater the likelihood of IOS standards diffusion.

IOS Standards Diffusion across Industrial Groups: *Industrial groups have varying levels of IOS standards diffusion that can be explained by the determinants from this study. By examining the circumstances surrounding each, the industrial group's relative position on the IOS standards diffusion curve can be explained in relation to the significant antecedent conditions identified in the study.* Figure 4 depicts an IOS standards deployment curve assessment for several industrial groups. The vertical axis approximates diffusion levels based on equal weighting of the number of members and completed messages from the industrial group's primary SDO (in rank order from the greatest to the least). The horizontal axis tiers the industrial groups based on IOS standards adoption timeliness (qualitatively assessed from the consolidated survey responses). Conceptually, this graph provides the ability to compare the relative progression of each industrial group along an innovation diffusion curve. Findings from this study can explain this relative progression and further illustrates the emerging patterns in IOS standards diffusion. For example, the semi-conductor industry is an Early Adopter of IOS standards (located in the far right of Figure 4). RosettaNet, an SDO for semi-conductor industry, has assembled over 500 member firms, completed 53 messages (with another 52 pending review) and developed the RosettaNet Interoperability Framework (RNIF v2.0) that is accepted throughout their industrial group (and beginning to be adopted by other industrial groups). Their recent alliances with UCC and OASIS squarely positions them to confront the horizontal convergence issue. RosettaNet's ability to develop an effective architectural framework, nurture an industry-wide collaborative working environment, and confront diffusion inhibitors has contributed to the industrial group's ability towards managing extraordinary pressures.

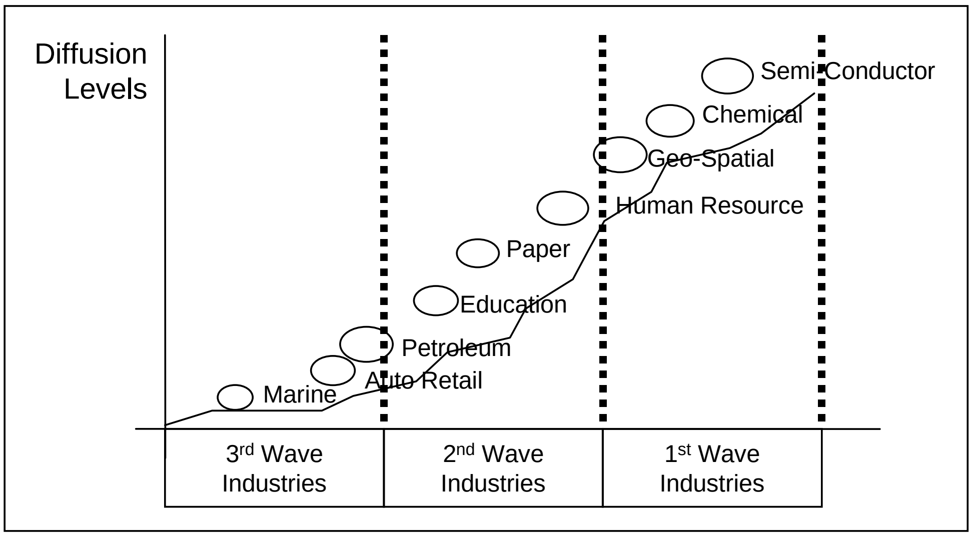

Figure 3 – Industrial Group IOS Standards Diffusion Levels

A second example is the human resources industry (towards the middle of Figure 4). HR-XML, an SDO for the human resources industry, has assembled over 150 member firms, completed 27 messages (with many more under review) and serves both a vertical focus (with HR staffing firms) and horizontal focus (HR departments). HR-XML's recent launch of compliance and certification programs in 2003 will further build the awareness and support for HR specific interoperability needs and possibly encourage vendors to integrate IOS standards into off-the-shelf (less costly) solutions. This SDO's ability to tightly integrate complex shared business processes into IOS standards, promote the need for interoperability, and mediate interests from an extraordinary diverse set of stakeholders has assisted their industrial group members to manage through substantial regulatory pressures. A third example is the petroleum industry (towards the left of Figure 4). IOS standards development is split between three primary SDOs

(POSC, PPDM and PIDX). Collectively, the primary inhibitors of further diffusion are the lack of a clear and consistent IOS standards *interoperability* architecture. The industry may consider taking advantage of their strong management support and collaborative working relationships and better align the mission, scope and efforts of the three SDOs into a unified IOS standards architecture. Mature industries should avoid the trap of clinging to out-dated procedures and consider developing a comprehensive set of IOS standards in light of modern day IOS solutions.

CONCLUSIONS

Despite the profound industry-wide interoperability benefits, the diffusion of web-based IOS standards has proven to be a challenge. By extending the IOE framework to include attributes of the SDO and the cross-company business process, this study developed a conceptual innovation diffusion model and segmented the IOS standards diffusion process into multi-stages. The conceptual model was empirically compared to a real work environment based on a cross-sectional survey of 102 firms from 10 industrial groups representing15 SDOs. The significant antecedent conditions towards each diffusion stage were identified and the hypothesis tests results reported. Contributions, implications and recommendations were provided to researchers and practitioners throughout the discussion and are briefly highlighted below.

This paper is intended to bridge the research gap between prior studies in IOS diffusion (based predominantly on EDI) versus web-based IOS standards. This is one of the first known studies to examine diffusion of the technology grouping (XML, SOAP, WSDL, and other APIs) in an IOS standard, industrial group context. The overwhelming result was the emergence of an industry-based SDO as pivotal from development through assimilation in the IOS standards process. The multi-stage conceptual model and empirical analysis revealed insights into a common set of determinants that influence all stages of diffusion, as well as distinct determinants to each stage. The findings were discussed for each diffusion stage and in the context of the emerging role of an SDO. Just as determinants vary between IOS diffusion stages, so should the role of an SDO. Since IOS standards are merely on the brink of widespread assimilation, the determinant findings provide a basis for researchers to begin development of more advanced assimilation models. Additional research recommendations include examining the impact of an SDO's standards versioning policy and assessing the likelihood of industry-based IOS standards to be adopted on a cross-industry (horizontal) basis. Both items may significantly influence an SDO's success and the assimilation of IOS standards in the future. The paper concluded with the development of an industrial group IOS standards deployment curve. By correlating the unique contextual factors of each industrial group to the determinants found in our conceptual model, the relative position of each industrial group along the IOS standards deployment curve was better understood.

[1] A literature survey of IOS diffusion studies was conducted as part of the preliminary work leading to this study. The survey coded findings from 21 publications (encompassing 6,092 samples and 187 measurement variables) towards IOS adoption and diffusion. The studies are identified with footnote 1 in References. Based on vote-counting techniques for synthesizing research, a common framework and the most frequent determinants towards IOS diffusion were assessed. An extended discussion regarding the results will be provided in a forthcoming paper.

[2] A RosettaNet white paper entitled "Measuring Business Benefits of RosettaNet Standards: A Co-Adoption Model " examines similar issues in detail and can be found at http://www.rosettanet.org/roistudies.

REFERENCES

Bensaou, M. and Venkatraman, N. "Configurations of Interorganizational Relationships: A Comparison Between U.S. and Japanese Automakers", Management Science (41:9), September 1995, pp. 1471-1492.

Berhman, William, *"*Best Practices for the Development and Use of XML Data Interchange Standards*",* Center for Integrated Facility Engineering Technical Report #131 Stanford University, http://www.stanford.edu/group/CIFE/online.publications/TR131.pdf).

Brandel, Mary "Message Received", *Computerworld*, August 16, 2004 pp36.

Cash, J.I. and Konsynski, B.R. "IS redraws competitive boundaries", *Harvard Business Review*, March – April 1985, pp. 134-142.

Cavaye, Alm "The implementation of customer orientated interorganizational systems: an investigation from the sponsor's perspective", *Eur. J. Info. Systs.*, 1996, pp. 103-119. [1]

Chatterjee, D., Grewal, R., and Sambamurthy, V. "Shaping Up for E-commerce: Institutional Enablers of the Organizational Assimilation of Web Technologies", *MIS Quarterly* (26:2), June 2002, pp. 65-89. [1]

Chau, P. and Tam, K. "Factors Affecting Adoption of Open Systems: An Exploratory Study", *MIS Quarterly*, March 1997, pp. 1-24. [1]

Chwelos, P., Benbasat, I., and Dexter, A. "Research Report: Empirical Test of an EDI Adoption Model*",* *Information Systems Research* (12:3), September 2001, pp. 304-321. [1]

Cho, I. and Kim, Y. "Critical Factors for Assimilation of Object-Orientated Programming Languages", *Journal of Management Information Systems* (18:3), Winter 2001-2002, pp. 125-156.

Choudhury, V. "Strategic Choices in the Development of Interorganizational Information Systems", *Information Systems Research* (8:1), March 1997, pp. 1-24.

Clark, Theodore H. and Stoddard, Donna B. "Interorganizational Business Process Redesign: Merging Technological and Process Innovation", *Journal of Management Information Systems* (13:2), pp. 9-28.

Cooper, Harris, *Synthesizing Research 3rd Ed: A Guide for Literature Reviews, Applied Social Research Methods Series V2* (1998).

Cooper, R. and Zmud, R. "Information Technology Implementation Research: A Technological Diffusion Approach", *Management Science* (36:2), February 1990, pp. 123-139.

Crook, Connie W. and Kumar, Ram L. "Electronic data interchange: a multi-industry investigation using grounded theory", *Information & Management* (34), 1998, pp. 75-89. [1]

Damanpour, F “Organizational Innovation: A meta-analysis of effects of Determinants and Moderators”, *Academy of Management Journal* (34:3), 1991, pp. 555-590.

David, Paul A. and Greenstein, Shane, "Economics of Compatibility Standards: An Introduction to Recent Research", *Econ. Innov. New Techn*., 1990 Vol 1, pp. 3-41.

Fielder, K.D., Grover, V. and Teng, J.T.C., "An empirical study of information technoloyg enabled business process redesign and corporate competitive strategy", *Eur. J. Inf. Systems* (1995) 4, pp. 17-30.

Fichman, Robert G. “The Role of Aggregation in the Measurement of IT-Related Organizational Innovation”, *MIS Quarterly* (25:4), December 2001, pp. 427-455.

Fichman, Robert G. “Information Technology Diffusion: A Review of Empirical Research”, *Proc. Thirteenth International Conference on Information Systems, Association for Computing Machinery,* 1992, Dallas, TX, pp. 195-206.

Fichman, R. and Kemerer, C. "The Assimilation of Software Process Innovations: An Organizational Learning Perspective", *Management Science* (43:10), 1997, pp. 1345-1363.

Fichman, R. and Kemerer, C. “The Illusory Diffusion of Innovation: An Examination of Assimilation Gaps”, *Information Systems Research* (10:3), September 1999, pp. 255-275.

Gebauer, J. and Buxmann, P. "Assessing the Value of interorganizational Systems to Support Business Transactions" *International Journal of Electronic Commerce*, 2000.

Goodhue, Dale L., Thompson, Ronald L,"Task-Technology Fit and Individual Performance", *MIS Quarterly (19:2),* June 1995, pp. 213-237.

Goodhue, Dale L., "Understanding user evaluations of information systems", *Management Science (41: 12)*, December 1995, pp. 1827-1845.

Gosain, S. “Web Technology Diffusion – Initial Adoption, Assimilation and Network Prominence”, *DIGIT 2001 Workshop*, New Orleans, LA (2001). [1]

Grover, V. “An Empirically Derived Model for the Adoption of Customer-based Interorganizational Systems”, *Decision Sciences* (24:3), 1993, pp. 603-639. [1]

Grover, V. and Goslar, Martin D. "The Initiation, Adoption and Implementation of Telecommunication Technologies in U.S. Organizations", *Journal of Management Information Systems* (10:1), Summer 1993, pp. 141-163. [1]

Hagel III, J. and Brown, J.S., "Your Next IT Strategy", *Harvard Business Review*, October 2001.

Hammer, M “The Superefficient Company”, *Harvard Business Review*, September 2001.

Hart, P. and Saunders, C. “Emerging Electronic Partnerships: Antecedents and Dimensions of EDI Use from the Supplier’s Perspective” *Journal of Management Information Systems* (14:4), Spring 1998, pp. 87-111. [1]

Hart, P. and Saunders, C. "Power and Trust: Critical Factors in the Adoption and Use of Electronic Data Interchange", *Organization Science* (8:1), Jan~Feb 1997, pp. 23-42.

Hoffer, J.A., George, J.F., Valacich, J.S., *Modern Systems Analysis and Design 3rd Edition*, Prentice Hall, Upper Saddle River, New Jersey, 2002.

Iacovou, C., Benbasat, I., Dexter, A. “EDI and Small Organizations: Adoption and Impact of Technology”, *MIS Quarterly*, December 1995, pp. 465-485. [1]

Jaccard, James, *Interaction Effects in Logistic Regression*. Sage University Papers on Quantitative Applications in the Social Sciences 07-135, Sage Publications, Thousand Oaks, CA 1995.

Jap, Sandy D., "Pie-Expansion Efforts: Collaboration Processes in Buyer-Supplier Relationships", Journal of Marketing Research (36:4), (1999), pp. 461-476.

Johnston, Robert B., Gregor, Shirly. "A Theory of Industry-Level Activity for Understanding the Adoption of Interorganizational Systems", *Proceedings from 8th European Conference of Information Systems, Vienna, Austria (2000)*.

Johnston, H.R., and Vitale, M.R., "Creating Competitive Advantage with Interorganizational Information Systems", *MIS Quarterly*, June 1998, pp. 153-165.

Katz, M. L., and Shapiro, C., "Technology adoption in the presence of network externalities", *Journal of Political Economy* (94), 1986, pp. 822-841.

Katz, M. L. and Shapiro, C., "Systems competition and network effects", *Journal of Economic Perspectives* (8), 1994, pp. 93-115.

Katz, M. L. and Shapiro, C. "Network Externalities, Competition and Compatibility", *The American Economic Review* (75:3), 1985, pp. 424-440.

Lafe, Low, 100 Integration Imperatives, CIO Magazine, August 2002. http://www.cio.com/archive/081502/integration.html
Berners-Lee, Tim, *Business Model for the Semantic Web: Enterprise Application Integration and other stories: Why, when XML gives us interoperability, do we need the Semantic Web?,* W3C web address: http://www.w3.org/DesignIssues/Business (2001).
Berners-Lee, Tim, *Web Services: Program Integration across Application and Organization boundaries,* W3C web address: http://www.w3.org/DesignIssues/WebServices.html (2003).
Birman, Kenneth, P. "Like it or not, Web Services are Distributed Objects", *Communications of the ACM* (47:12), December 2004, pp 60-63.
Libicki, Martin, Schneider, James, Frelinger, Dave R., Slomovic, Anna*. Scaffolding the New Web: Standards and Standards Policy for the Digital Economy*, Science and Policy Institute RAND 2002.
Kettinger, W. and Grover, V. "The Use of Computer-mediated Communication in an Interorganizational Context", *Decision Sciences* (28:3), Summer 1997, pp. 513-555. [1]
Klein, S. "The configuration of inter-organizational relations", *Eur. J. Inf. Systems* (1996) 5, pp. 92-102.
Knorr, Eric "The stars will align in 2004 to make Web services a significant success story", *CIO Magazine*, December 15, 2003.
Koch, Christopher "The Battle for Web Services", *CIO Magazine*, October 1, 2003.
Massetti, B. and Zmud, R. "Measuring the extent of EDI usage in complex organizations: Strategies and Illustrative Examples" *MIS Quarterly* (20:3), 1996, pp. 331-345. [1]
McCullagh, Perter, "Regression Models for Ordinal Data", *Journal of the Royal Statistical Society, Series B (Metholodogical)* (42:2), 1980, pp. 109-142.
Mead, Scott, *Applied Logistic Regression Analysis Series: Quantitative Applications in the Social Sciences*, Sage Publications, Thousand Oaks, CA 1995.
Monczka, R.M., Petersen, K.J., and Handfield, R.B. "Success Factors in Strategic Supplier Alliances: The Buying Company Perspective", *Decision Sciences* (29:3), Summer 1998, pp. 553-576.
Nelson, M., Shaw, M., Shen, S., Schoonmaker, M., Qualls, W., Wang, R., "Co-Adoption Of XML-Based Interorganizational Systems: A Case Of Adopting RosettaNet Standards", *e-Business Management* (ed. Michael J. Shaw). Springer-Verlag, Berlin, Heidelberg, 2002.
Nelson, M., Shaw, M., Shen, S., and Schoonmaker, M., " Measuring Business Benefits of RosettaNet Standards: A Co-Adoption Model Conducted by the University of Illinois". An unpublished industry white-paper between RosettaNet and the University of Illinois, http://www.rosettanet.org/roistudies (July 2001). [2]
Neter, J., Kutner, M., Nachtsheim, C., Wasserman, W., *Applied Linear Statistical Models*, *4th ed*., WCB McGraw-Hill, Boston, MA, 1996.
OASIS and RosettaNet Form Standards Development-to-Implementation Alliance Consortia Collaborate to Advance E-Business Standards Across Industries (http://www.oasis-open.org/news/oasis_news_06_03_03a.php).
Premkumar, G. and Ramamurthy, K. and Nilakanta, S. "Implementation of Electronic Data Interchange: An Innovation Diffusion Perspective", *JMIS* (11:2), Fall 1994, pp. 157-186. [1]
Premkumar, G., and Ramamurthy, K. "The Role of Interorganizational and Organizational Factors on the Decision Mode for Adoption of Interorganizational Systems", *Decision Sciences* (26:3), 1995, pp. 303 – 336. [1]
Premkumar, G., Ramamurthy, K. and Crum, M. "Determinants of EDI adoption in the transportation industry", *Eur. J. Info. Systs*, 1997, pp. 107-121. [1]
Rai, A. and Bajwa, D. "An Empirical Investigation into Factors Relating to the Adoption of Executive Information Systems: An Analysis of EIS for Collaboration and Decision Support" *Decision Sciences*, Fall 1997.
Rai, A., Borah, S. and Ramaprasad, A. " Critical Success Factors for Strategic Alliances in the Information Technology Industry: An Empirical Study", *Decision Sciences* (27:1), Winter 1996, pp. 141-155.
Reekers, N. and Smithson, S. "EDI in Germany and the UK: strategic & operational use", *Eur. J. Info. Systs* (3:3), 1994, pp 169-178. [1]
Riggins, Frederick J. and Mukhopadhyay, Tridas "Interdependent Benefits from Interorganizational Systems: Opportunities for Business Partner Reengineering", *Journal of Management Information Systems* (11:2), Fall 1994, pp. 37-57.
Rogers, Everett M., *Diffusion of Innovations 4th ed*., The Free Press, New York, 1995.

Sabherwal, R. and Vijayasarathy, L. “An empirical investigation of the antecedants of telecommunication-based interorganizational systems”, *Eur. J. Info. Systs.*(3:4), 1994, pp. 268-284. [1]
Saunders, Carol S. and Clark, Sharon "EDI Adoption and Implementation: A Focus on Interorganizational Linkages", Information Resources Management Journal (5:1), Winter 1992, pp. 9-19. [1]
Senf, David "Web Services Caution Abounds", *IDC Analyst Report* January 11, 2005 http://www2.cio.com/analyst/report3235.html.
Smith, T. and Scheminske, E., *Standard & Poor’s, Industry Surveys – Semiconductors*, May 2001.
Straub, Detmar, "Validating Instruments in MIS Research", *MIS Quarterly*, June 1989, pp. 147-162.
Swanson, B. E. “Information Systems Innovation Among Organizations”, *Management Science* (40:9), September 1994, pp. 1069-1092.
Tan, K. “Supply Chain Management: Practices, Concerns, and Performance Issues”, *The Journal of Supply Chain Management*, Winter 2002, pp. 42-53.
Tashakkori, Abbas and Teddlie, Charles*, Mixed Methodology Combining Qualitative and Quantitative Approaches,* A Series in Applied Social Research Methods, Sage Publications v46, Thousand Oaks, 1998.
Teo, H.H, Wei, K.K., and Benbasat, I. "Predicting Intention to Adopter interorganizational Linkages: An Institutional Perspective", *MIS Quarterly* (27:1), 2003, pp. 19-49. [1]
Tornatzky, L.G. and Klein, K.J. “Innovation Characteristics and Innovation Adoption Implementation: A Meta-Analysis of Findings”, *IEEE Transactions on Engineering Management* (29:1), February 1982, pp. 28-45.
Webster, Jane and Watson, Richard T., “Analyzing the Past to Prepare for the Future: Writing a Literature Review”, *MIS Quarterly* (26:2), 2002.
Whipple, J.M. and Frankel, R. “Strategic Alliance Success Factors”, *The Journal of Supply Chain Management*, Summer 2000, pp. 21-28.
Willet, Shawn, "Integration and Web Services Market Assessment", *CIO Magazine*, March 5, 2004
World Wide Web Consortium (W3C) related web-sites:

- XML in 10 Points http://www.www.w3.org/XML/1999/XML~in-10-points
- Flynn, Peter (2002) editor for The XML FAQ Special Interest Group, v.2.1, 2002 http://www.ucc.ie/xml/#index is the web-site for

Worthen, Ben " Web Services Still Not Ready for Prime-time", *CIO Magazine,* September 1, 2002.
XML.org site statistics was taken from this web-site: http://www.xml.org/xml/sponsors/site_stats_08_01.pdf, May 2003.
Zaheer, A. and Venkatraman, N. “Determinants of Electronic Integration in the Insurance Industry: An Empirical Test”, *Management Science* (40:5), May 1994, pp. 549-566.
Zeichick, Alan "Desparately Seeking SOA", *Infoworld*, January 3, 2005, pp. 36-37.
Zhu, K., Kraemer, K., Xu, S. “A Cross Study of Electronic Business Adoption using the Technology-Organization-Environment Framework”, *Proceedings of the 23rd International Conference on Information Systems, December* 2002. [1]

APPENDIX A

Industry-based SDO Illustrations

Industry-Based Standards Development Organization (SDO) Examples

Example SDO	HR-XML	papiNet	Open GIS	PIDX	STARS	IMS	eMSA	RosettaNet
	http://www.hr-xml.org	http://www.PAPINet.org	http://www.opengis.org	http://www.pidx.org	http://www.starstandard.org/	http://www.imsglobal.org	http://www.emsa.org	http://www.rosettanet.org
Industrial Group	Human Resources	Paper	Geo Spatial	Petroleum & Oil	Automotive	Education	Marine	Semi-Conductor Mfr
Profit Orientation / Partnerships	Non-Profit	Partnered with Idealliance. Non-profit orientation.	Non-Profit	American Petroleum Institute's (API) committee on Electronic Business. Non-profit orientation.	Non-Profit	A project within the National Learning Infrastructure Initiative of EDUCAUSE	European Marine STEP Association (EMSA). Non-Profit orientation.	Merged with UCC in 2002. Non-profit orientation.
Membership Fee Structure	Fixed annual fees based on Charter, General, Associate or Academic membership types. Fees also vary by end-user versus technology vendors.	Annual fees based on firm revenues. Fees also vary by technology vendors and industry champions.	Fixed annual fees based on Strategic, Principle, Technical Committees, Associate or Academic and Governmental membership types.	Annual fees based on firm revenues (distinctions made for governmental and academic institutions).	Fixed annual fees based on organization type (Dealerships, Mfrs, SIG) and membership status (active versus associate).	Annual fees based on firm revenues.	Annual fees based on firm employee count. Distinctions made for academics.	Fixed annual fees based on geography and voting privelages.
Industry Participation	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary
Development Process	Consensus based on membership voting rights.	Consensus based on membership voting rights.	Consensus based on membership voting rights.	Consensus based on membership voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.
Standards Availability	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public
Members	150	47	258	27	39	64	15	500
Year	1999	1999	1994	2002*	2001	1997	1994	1998
Messages Completed Pending (In Review)	27 not known	28 5	7 12	11 5	15 not known	9 3	6 2	53 52
IOS Standards Examples	Background Checking Benefits Enrollment Competencies Contact Method Education History	Credit Debit Note Goods Receipt Availability Order Confirmation Business Acknowledgment	Imagery Mark Up Language Spec Image Coordinate Transform Web Map Service Interfaces Grid Coverages Gazetteer Service Interface	FieldTicket FieldTicketResponse Invoice InvoiceResponse OrderCreate	Parts Inventory Delivery Reporting Financial Statement General Acknowledgements Labor Operations	Learner Information Package Question & Test Interoperability IMS Vocabulary Definition Learning Design IMS Digital Repositories	Hull Structural Design Data Society type approval & product Quote machinery product data Integration & catalogue procureme Machinery design data	Notification of Failure Distribute Design Engineering Info Distribute Product Master Request Quote Request Purchase Order

Example SDO	CIDX	EIDX	PPDM	POSC	OAG	SIF	IdeaAlliance
	http://www.cidx.org	http://www.eidx.org	http://www.ppdm.org	http://www.posc.org	http://www.openapplications.org	http://www.sifinfo.org	http://www.idealliance.org
Industrial Group	Chemical	Electronic Components	Petroleum & Oil	E&P Industry	Multiple, but primarily Automotive	K-12 Education	Publishing and other info-driven enterprises
Profit Orientation / Partnerships	Non-Profit orientation.	Merger with CompTIA in 2001.	Non-Profit	Non-Profit	Non-Profit, but founding members include the major ERP vendors.	Non-Profit	Non-profit orientation.
Membership Fee Structure	Annual fees based on firm revenues. Distinctions made for Founding members.	Reciprocal memberships through Edifice (one-time membership & fixed annual fee), AIAG and OAG	Annual fees based on firm revenues.	Annual fees based on firm revenues.	Annual fees based on firm revenues.	Annual fees based on firm revenues.	Annual dues based on firm revenues and firm types.
Industry Participation	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary
Development Process	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category and / or voting rights.
Standards Availability	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public
Members	75	55	98	100	37	120	202
Year	2000*	1987	1989	1990	1995	1997	1966
Messages Completed Pending (In Review)	52 not known	16 broad curriculums not known	16 not known	23 8	61 Scenarios not known	11 not known	Not known (atleast 50) Not known
IOS Standards Examples	Qualification Request Qualification Response Customer Specific Catalog Update Product Catalog Update Request for Quote	Business Process EC Technologies Guidelines & Standards	Business Associates Work Orders Seismic Line Summaries Velocities Product and Information	Loggraphics Epicentre WellHeaderML WellPlotML V0.4	Production Synchronization Purchase Order Integration Purchase Order Process Purchasing to A/P Project Accounting Synchronizatio	Acknowledge Receipt Register Subscribe Unregister	Content Creation and Management Supply Chain Management Digital Advertising Workflow Color Mgmt & Production Workflow Postal & Newsstand Distribution Shipment 'n Logistics Specification

APPENDIX B

Survey Instrument

DIFFUSION
From an overall firm level perspective, to what extent has the firm assimilated the IOS standards technology grouping? Please check one that best describes the firms' assimilation level.

Unaware	The firm is not aware of these interorganizational system standard technologies.
Awareness	Key decision makers in the firm are aware of interorganizational system standards concepts and capabilities.
Interest.	The firm is preparing plans to investigate interorganizational system standards for possible use in the firm .
Evaluation /Trial	The firm has purchased 'trial' capabilities and is currently evaluating possible uses of the technology.
Commitment	The firm has specific plans and made formal commitments to utilize the technology in production in the next 12 months (or the near future).
Ltd Deployment	The firm has implemented IOS standards technology in three or more interorganizational systems.
Gen Deployment	IOS standards technology is now integrated in the majority of mission critical systems and in new systems development initiatives (where applicable).
Rejection	The firm has evaluated and rejected the use of interorganizational system standards technology.
Discontinuance.	The firm was committed to using the technology in the past, but is now not using it and does not foresee using it in the future.

INNOVATION ATTRIBUTES
Relative Advantage (2 items)

- The direct operational benefits (e.g. response times, through-put capability, cycle time) derived from utilizing web-based IOS standards are greater than our existing interorganizational system solutions.
- The direct financial benefits (e.g. ROI, payback, inventory turns) derived from utilizing web-based IOS standards are greater than our existing interorganizational system solutions.

Shared Business Process Fit (4 items)
Please indicate your agreement regarding the potential impact of interorganizational system web-based IOS standards on the following underlying business process needs.

- The ability to successfully handle large transaction volumes.
- The ability to provide effective and reliable communications.
- The ability to enhance problem detection and resolution.
- The ability to improve data accuracy and integrity.

ORGANIZATIONAL ATTRIBUTES
Top Management Support (3 items)
Top management in the firm:

- Actively participates in establishing a vision and formulating strategies for utilizing interorganizational system web-based IOS standards.
- Has assigned a project champion (focal point) for overseeing the utilization of interorganizational system Web-based IOS Standards.
- Effectively communicates its' support for the use of interorganizational system Web-based IOS Standards.

Feasibility (4 items)
The firm has the technical sophistication (experience and know-how) and IT management necessary to:

- Develop, implement, and maintain Web-based IOS Standards.
- Make work flow changes to accommodate the use of Web-based IOS Standards.

The firm has the financial resources necessary to:

- Make work flow changes to accommodate the implementation of interorganizational system Web-based IOS Standards.
- Implement, purchase and maintain interorganizational Web-based IOS Standards.

Compatibility (1 item based on three sub-parts)

- Changes in work procedures associated with adopting interorganizational system Web-based IOS Standards are NOT compatible with the firm's existing operating practices.
- Interorganizational system Web-based IOS Standards is compatible with the future direction (vision) of the IS infrastructure in the firm.
- Interorganizational system Web-based IOS Standards is compatible with the existing IS infrastructure needs of the firm.

EXTERNAL ENVIRONMENT

Competitive Pressure (3 items)

- There is pressure to utilize interorganizational system Web-based IOS Standards to meet trading partners (suppliers and customers) requirements.
- There is pressure from our industry to use the technology.
- Our firm will lose it's competitive edge if it fails to utilize the technology.

Participation Level in an SDO (1 item based on four sub-parts)

- Member Status (Please check only one)
    - Member (Firms that have formally joined the SDO Consortium (regardless of the type of membership).
    - Non-Member (Firms that have not formally joined the SDO Consortium.)
- User Status (Please check only one)
    - User (Firms that have already implemented one or more interorganizational technology standards from the SDO.)
    - Non-User (Firms that have NOT implemented interorganizational standards / technology from the SDO.)
- Several firms have elected to participate in the SDO's development activities. Examples of this participation have included assigning employees to participate in standards development work groups, providing feedback on technical or business documents and several others. Has the firm participated in SDO development activities?
    - Yes or No
- The firm has decided to implement at least one of the technology standards from the SDO consortium in the next 12 months.

Perceived Network Effects (2 items based on 5 sub-parts each)

Indicate the range of potential benefits (identified below) of implementing interorganizational system Web-based IOS Standards. Please indicate how these potential benefits change between short-term (immediate), mid-term (1 to 2 years) and longer-term (3 to 4 years) after the time of adoption. Please use the following scale to estimate the impact: (-2) SD - Significant Decrease, (-1) D - Decrease (0) NC - No Change (1) I - Increase, (2) SI-Significant Increase. (Please Note: None of these questions pertain to a specific firm, but rather the overall industry's best practices and expectations).

<u>Perceived Direct Effects (5 items)</u>

- Direct operational BENEFITS (e.g. improved response times, enhanced through-put capability).
- Direct financial BENEFITS (e.g. ROI, payback, inventory turns)
- Negotiation time of technology standards with new trading partners
- Interorganizational system development time and capital expenditures.
- Interorganizational system implementation time with new trading partners.

<u>Perceived Indirect Effects (5 items)</u>

- Manufacturing lead times.
- The cost of supplying the firm's services (or manufacturing the products).
- Revenue opportunities or the attraction of new customers.
- Trading partner loyalty
- Compliance with trading partner mandates.

STANDARDS DEVELOPMENT ORGANIZATION (SDO)

Interoperability (1 item based on five sub-parts)

- Modularity levels (scope) of the SDO's technology standards are appropriate.
- The SDO Consortium's technology standards are conducive to interoperability between supply chain partners.

- The SDO's technical standards & guidelines are vendor neutral (e.g. h/w and s/w recommendations are independent of any specific manufacturer.)
- Implementation of the SDO Consortium's technology standards require minimal changes to the firm's business processes.
- The SDO standards documentation are thorough, accurate and useful.

Mission (1 item with three sub-parts)

- An SDO should facilitate agreement and "codification" of common business terms, definitions, and choreography of cross-company business processes.
- An SDO should be established as a Non-profit entity.
- The benefits of participating in the SDO consortium are well understood.

Trust (2 items)

- A high level of trust & compatibility exists among partner firms in the SDO.
- Open and honest collaboration and participation levels are encouraged from ALL firms participating in the SDO consortium.

Coordination (4 items)

- The SDO Consortium meets performance expectations.
- Partner responsibilities are appropriately delegated and managed through out the SDO consortium.
- The SDO Consortium's goals and objectives are clear and well understood.
- Members of the SDO Consortium management team are neutral (independent) with respect to all firms participating in the consortium.

Sales (1 item)

Approximate Firm Annual Sales (US$) (please check one)

- Less than $1 million　　o $1m ~ $9 million
- $10m ~ $49 million　　o $50m ~ $99 million
- $100m ~ $499 million　　o $500m ~ $999 million
- $1 Billion or greater　　o Other (please specify)

Installed Base (1 item based on five sub-parts)

From the list below, please indicate the extent of interorganizational information system technology solutions utilized in the firm. On the five point scale, check 0 (No Use), 1 (Slight Use), 2 (Limited Use), 3 (Moderate Use), 4 (Extensive Use).

- Manual solutions (For example, exchanges with external organizations are conducted via phone, in person, or postal mail.)
- Semi-automated Solutions (For example, exchanges with external organizations are conducted via fax, e-mail or other semi-automated solutions.)
- EDI or EDI-like solutions (For example, exchanges with external organizations are conducted via electronic data interchange EDI-like solutions. This system is based on traditional technology standards (ANSI x.12, EDIfact))
- Other / Proprietary interorganizational solutions (For example, exchanges with external organizations are conducted via a dedicated proprietary based interorganizational system (based on proprietary standards mutually agreed upon with trading partners).

Internet interorganizational solutions (For example, exchanges with external organizations are conducted via web-based IOS solutions (e.g. web-PO, XML-based solutions).