

A b s t r a c t

E-business has seen significant growth over the past few years. To fully realize the benefits of e-business, common standards are required to define the syntax and semantics of Web-based information sharing among firms. Recently, numerous vertical standards developing organizations (SDO) have emerged to develop e-business standards. From a standard making perspective, this paper identifies the uniqueness of vertical e-business standards, explains why the consortium-based mechanism is popular among vertical e-business standardization projects and overviews the existing literature on consortia-based standardization. Based on literature reviews and anecdotal vertical e-business SDO cases, we propose a participant-technical content-institutional structure framework, which lays a foundation for vertical e-business SDO research and points out future research opportunities.

Keywords: vertical e-business standards, SDO, process standards, participants, technical content, institutional structure

A u t h o r s

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Vertical E-Business Standards and Standards Developing Organizations: A Conceptual Framework

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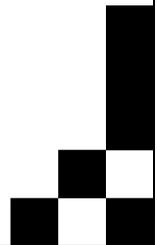
INTRODUCTION

Despite the burst of the dot-com bubble at the beginning of the 21st century, e-business, defined as business-to-business e-commerce, has seen significant growth over the past few years. According to the US Census Bureau, in 2002 (the latest data available), e-business accounted for 92.7% of total e-commerce (US Department of Commerce 2004). Meanwhile, International Data Corporation predicts that e-business spending in the US will reach \$870 billion in 2004 and it will continue to grow at a 50% annual rate through 2007 (Bhattacharyya *et al.* 2005). E-business leads to better coordination and better interoperability in the supply chain, as well as new business opportunities (Lee and Whang 2001; Straub *et al.* 2004). While its benefits are well established in many industries, e-business's growth is hindered by the lack of common standards. Even though the proliferation of new technologies, especially the eXtended Markup Language (XML), has laid the foundation for firms to facilitate such information sharing, standards are needed to define the syntax and semantics of information sharing among firms. Developing common

standards to facilitate information sharing in the value chain has been recognized by many industries as the foremost issue to tackle in order to increase efficiency to unleash the potential of e-business.

There exists an entire hierarchy of standards that work together to support web-based e-business transactions, from the foundational Internet standards, communication protocols, interaction standards, to data exchange formats (Figure 1). The vertical e-business standards we focus on are at the top layer and delineate formats of electronic data and information communication between firms within a particular industry.

Recently, many industry consortia have emerged to collaboratively develop e-business standards. Examples range from technically sophisticated industries such as the semi-conductor industry (RosettaNet), to traditionally less technical industries such as the paper industry (PapiNet), among others (Nelson and Shaw 2003; Steinfield *et al.* 2004; Xia *et al.* 2003). These standards consortia, or vertical standards developing organizations (SDOs), are less formal and rigorous than government-sanctioned standards institutions, such as the



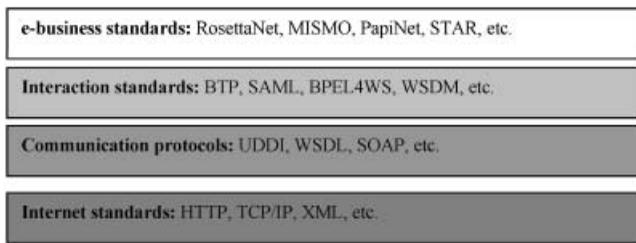


Figure 1. The set of hierarchical standards underlying e-business transactions *Source*: Based on Sleeper and Robins (2002)

International Standards Organization (ISO) and International Telecommunications Union (ITU) (Willingmyre 1997). While industries have been developing and promoting these standards through their SDOs for a period of several years, there has been little research on the making of vertical e-business standards. Many theoretical issues are still not known, such as what unique economic features separate e-business standards from traditional IT standards, why SDOs are popular among e-business standardization initiatives and what factors we should take into consideration when we study e-business standardization in a neutral consortium setting. In this paper, we try to address these questions based on reviews of the economics of standard making, especially within the context of SDO-based standardization, supported by anecdotal vertical e-business SDO cases. We find that e-business standards are different from traditional IT standards mainly due to the significant role of user groups and less fierce competition among standard adopters. Together with the highly collaborative nature of e-business, firms are willing to collectively develop e-business standards in consortia. At the end of the paper, we propose a participant-technical content-institutional structure framework, which provides a foundation for future SDO-based e-business standardization research.

The paper is organized as follows: in the following section, we distinguish e-business standards from traditional IT product standards and demonstrate the collaborative feature of e-business standards. We believe these features explain the popularity of SDOs among vertical e-business standardization initiatives. This is followed by a review of the existing literature on consortia-based standard making. We then present our theoretical framework for studying vertical SDOs. The final section summarizes our findings and discusses future research opportunities.

UNIQUE FEATURES OF VERTICAL E-BUSINESS STANDARDS

E-business standards versus IT product standards

E-business standards entail interorganizational Web-based communications, transactions, and business

processes. It shares several common economic characteristics with general IT product standards, including positive network externalities between standards users as well as various extents of path dependence in the choice of standards (David 1985; Leibowitz and Margolis 1995). Nevertheless, there are many other features that separate e-business standards from IT product standards. Two major distinctions are the critical role that users play in standardization processes and the indirect as well as less fierce competition among standards adopters. In addition, those two types of standards are also different on other aspects, such as involved processes, scope of forthcoming standards and intellectual property rights (IPR) issues. We summarize features that contribute to the uniqueness of e-business standards in Table 1 and discuss each of them in detail in this subsection.

There are two key features, which distinguish e-business standards from IT product standards and help to explain why the SDO is a good mechanism for e-business standards development. The first is the critical role of standards users. For IT product standards, users of corresponding standardized products do not need to know the technical details. For example, computer users utilize various standards such as those for the keyboard, the display and the operating systems. It is unnecessary for them to understand and implement these standards, which have been taken care of by computer component manufacturers and assemblers. Therefore, user groups usually have little control over the standards setting process (Jakobs 2003) and their involvement might even be counterproductive due to the lack of necessary expertise (Jakobs *et al.* 1998). However, users of standardized e-business processes, such as EDI users, are also immediate standard adopters who directly implement e-business standards. Technology know-how becomes very important for standards users since they have to deploy these standards with supply chain partners (Chwelos *et al.* 2001). Furthermore, e-business standards users have first-hand and in-depth process-related knowledge, such as how many steps and parties are involved in a typical procurement process. Consequently, they are very active participants in standards development (Jain and Zhao 2003). For instance, major users of e-business standards in the chemical industry, such as Dow Chemical, DuPont, and BASF, are also leaders in standards development projects (Ferguson 2000).

The second key feature is the competition faced by standards adopters. IT product standards can be used as a competitive weapon in the marketplace, where firms endeavour to bet on the 'right' standards and ride on the positive network externalities in order to drive out their rivals from the market. As a result, 'winner-take-all' outcomes appear quite often in the IT product standards wars (Stango 2004). In contrast, adopting firms of e-business standards, except software vendors, rarely compete with each other directly through standards.

Table 1. IT product standards versus e-business standards

	<i>IT Product standards</i>	<i>e-business standards</i>
Definition	The standards specify characteristics of an IT product that is consumed by end users.	The standards specify executions of web-based business procedures and transactions across firm boundaries. They do not affect end products directly.
Typical standard developer	Individual IT product producers as well as SDOs	SDOs
Standard users	End consumers of the products	Standard adopters, who implement the standards
Competition among adopters	Direct competition among standard adopters for market shares.	Indirect competition among standard adopters/users through improved process efficiency and reduced transaction costs. Direct competition among technical vendors.
Involved process	Product development process	The whole spectrum of organizational business activities, such as accounting, procurement, quality control, sales and product development.
Scope	The standards have to be well defined before it can be implemented in product.	The standards usually have a dynamic scope as they evolve to cover more processes and can be implemented incrementally.
Intellectual property right (IPR) issues	Very significant, because the standard also has much proprietary knowledge embedded (e.g. the new DVD standard)	Not as significant, as the standard is mainly for sharing business process information among firms
Examples	Computer hardware, software	MISMO specifications, RosettaNet Partner Interface Processes (PIPs)

They use standards to improve their process efficiency or foster relationships with their trading partners (Mukhopadhyay and Kekre 2002). Those two features are useful to explain why e-business standards development relies heavily on a consortia-based mechanism since:

1. Users are critical stakeholders directing the standardization process and they are usually against competing standards since they want to gain increasing returns from experience-based learning and positive network externalities and decrease switching costs and lock-in costs (David and Greenstein 1990).
2. For most e-business standards adopters, the competition role of process standards is indirect and 'hidden'¹. As long as the standard leaves space for innovation and differentiation, adopting firms have little incentive to compete on the standard level.

In addition to the different roles of user groups and standards competition implications, there are also other distinctions between IT product standards and e-business standards. IT product standards are usually only related to the product development process; however, e-business standards can involve the whole spectrum of organizational business activities, such as accounting, procurement and inventory management. The scope of IT product standards is usually more static than e-business standards, which evolve to cover complicated and comprehensive inter-organizational business processes. For example, RosettaNet has

completed standards modules for order management, shipping notices and many others. However, they still have ongoing projects such as sales reporting and warranty standards and they are forming new milestone programs to encompass more standardized electronic business processes. Consequently, many successful e-business SDOs prevail over a long time due to the progressing standards scope and new technologies. For instance, ACORD, an insurance industry SDO, has provided e-business standards for insurance companies for over 30 years. Intellectual property rights (IPR) are very complicated in IT product standards development because the standards usually have much proprietary knowledge embed (Lemley 2002). A typical example is the Rambus case, where several companies accused Rambus of holding SDRAM patents while attending JEDEC to develop an open standard for high-speed chips (Zuckerman 2001). For e-business standards, IPR issues are less significant due to fewer copyrights or patents claims associated with business processes, and the standard is mainly for sharing information among firms. However, e-business SDOs also need a clear and flexible IPR policy to 'ensures the participation of the software vendors for the implementation of the technical specifications and standards' (UNECE 2004).

The collaborative nature of e-business standards

The development of e-business standards also reflects the need for close interfirm collaborations in many industries. In the Web-enabled era, the ever-increasing

customer expectation for real-time integrated information requires that the industry as a whole has to provide new services and a higher level of customer satisfaction. For example, in the travel industry, travellers are increasingly booking their trips online. Due to the travellers' expectation to book everything including air tickets, car rentals, tours and show tickets, etc. in a one-stop fashion, a travel site must be able to integrate such information from different travel operators seamlessly. As more and more customer demand has to be served by collaborative efforts as illustrated above, the whole industry has to come together and devise standards for collaboration. This is especially true if the industry is service-oriented. To have a common standard for information sharing is a must first-step, and it is very difficult for any single company to develop standards involving parties from multiple sectors. In such a backdrop, e-business standards development takes a tone of collaboration more than competition. As a consequence, SDOs emerge to work on vertical e-business standards in various industries. Many of the vertical e-business SDOs working on XML-based standards are documented by xml.org. We further investigate these SDOs and collect information mainly from their websites and trade journals (Table 2).

Vertical e-business SDOs versus industry-neutral e-business SDOs

E-business standards and their supporting SDOs can be either industry neutral or industry specific. The former type has a broader coverage and intends to be used across industries, such as EDI standards published by ASC X12 and ebXML sponsored by OASIS. Vertical e-business standards have a narrower but often more focused objective, i.e., to facilitate e-business transactions in a specific industry. They can address unique industry requirements, such as the shipment of hazardous materials in the chemical industry. Due to their focused and in-depth coverage and thus direct and faster return on investment, vertical SDOs are more attractive to firms than industry neutral SDOs. For example, EIDX is a vertical e-business SDO in the electronics industry and only five out of 46 EIDX members also join ASC X12, the US based cross-industry e-business SDO. Thus, to motivate firms to participate in the consortium, many industry-neutral SDOs organize industry-focused groups within them. For instance, ASC X12 has subcommittees working in the insurance, transportation, and health care industries. It is not surprising, then, that most of its members are from these three industries.

It is important to note that the two types of SDOs may not be parallel. The content of their standards may overlap or complement one another. Therefore,

Table 2. Vertical e-business SDOs²

<i>Industry</i>	<i>SDO</i>
Agriculture	AgXML (http://www.agxml.org)
Accounting	XBRL
Automobile	AIAG (http://www.aiag.org)
Automobile Retail	STAR (http://www.starstandard.org)
Chemical	CIDX (http://www.cidx.org)
Electronics	EIDX (http://eidx.comptia.org)
Energy	PIDX, PPDM, POSC
Financial- Banking	BITS
Financial- Insurance	ACORD (http://www.acord.org)
Financial- Mortgage	MISMO (http://www.mismo.org)
Financial- Real estate	RETS, MITS
Financial	FISD, FIX Protocol (http://www.fixprotocol.org), FPML (http://www.fpml.org), IFX (http://www.ifxforum.org)
Geography	OpenGIS
Healthcare	CDISC (http://www.cdisc.org), HL7 (http://www.hl7.org)
Human Resources	HR-XML
Legal	LegalXML
Marine	EMSA, Maritime
Paper	PapiNet (http://www.papinet.org)
Retail	ARTS
Semiconductor, IT, and Electronic Components	RosettaNet (http://www.rosettanet.org)
Transportation	LandXML
Travel	OTA (http://www.opentravel.org)

collaborations between them are common, since many firms also need to deal with transactions across industries. For instance, ebXML proposed by OASIS has gained support from some vertical SDOs such as OTA and RosettaNet. It is also possible that standards from the two camps have significant overlap and therefore compete with each other. In this paper, we primarily focus on vertical e-business SDOs.

THEORETICAL FOUNDATIONS

SDOs are vital for the development of vertical e-business standards, but they face challenges such as rapid technology innovations and conflicting interests among members. To study e-business standardization in a neutral consortium setting, we review related SDO studies in this section. We first provide the formal definition of SDOs and compare standardization in SDOs with the other two typical standard making approaches. We then review earlier studies of SDOs in order to provide the foundation for a conceptual model of vertical e-business standards development.

SDO definition

In this paper, we use the term SDO to represent institutions that work on voluntary consensus standards. There is a range of diverse characterizations of SDOs in the literature, such as standards-writing organizations (David and Greenstein 1990), voluntary standards committees (Weiss and Sirbu 1990), or standards-setting alliances (Axelrod *et al.* 1995). Some researchers interpret a SDO as one type of cooperative technical organization (Rosenkopf and Tushman 1998), while others (Cargill 1989: 20) describe these institutions as ‘any cooperative joining to bring about the acceptance of a common thought or practice’. Our definition of SDOs is the following:

SDOs are cooperative organizations that develop and/or approve standards based on formal agreements through communication, political negotiation and coordination among participants.

A vertical e-business SDO is a special type of SDOs that develops and promotes standards for e-business transactions in a particular industry.

Standard making approaches

Three fundamental standard making approaches are shown in Table 3 (David and Greenstein 1990, Weiss 1993). *De facto* standards are developed by individual firms and their future acceptance is fully determined through the ‘free interplay of market forces’ (Weiss 1993: 36). *De jure* standards are established by legal authorities and as such face no challenges in the marketplace due to power of the regulatory authority. Voluntary consensus standards developed by SDOs are in the middle between *de facto* standards and *de jure* standards, since the extent to which the market can influence the standard setting process can range anywhere in the whole spectrum of control from full (such as *de facto* standards) to none (such as *de jure* standards). Some SDOs, such as ISO and ITU, have established authority and there are few uncertainties regarding the future acceptance of their standards, which are close to *de jure* standards. However, most vertical e-business

SDOs are less influential and may even be subject to rivalry in the market. For example, in the financial service industry, several SDOs including IFX, FIX Protocol, and FPML compete with each other to develop XML-based e-business standards. Standards proposed by these consortia are similar to *de facto* standards except that they have achieved coordination and support among SDO members before their release.

Previous SDO studies

Earlier SDO studies examine the non-market standardization process through different methodologies. In this section, we review related SDO literature, identify their contributions and limitations, and show what insights we can obtain that apply to the study of vertical e-business SDOs.

Based on a game theoretical model, Farrell (1996) shows how the vested interests of SDO participants will cause delays of standardization and influence the standard’s quality. To improve a SDO’s performance, the author recommends strategies such as early standardization, frequent meetings and changes in voting rules. Farrell suggests that the relevant participants, the technical focus and the internal processes of a SDO simultaneously influence its performance in terms of speed and quality.

Simcoe (2003) conducts another study focusing on factors that affect a SDO’s performance, which is measured as the speed of the standards setting process. He argues that influences on the standard setting process from firms’ vested interests are inevitable. Based on an analytical model and data on the standard setting process for several hundred IETF standards, he finds two factors closely associated with the duration of the standard setting process: (1) a large number of commercial participants, which is a proxy for technical maturity; and (2) the presence of intellectual property rights (IPR) in the material submitted for the standard. SDOs become less efficient with higher commercial pressure and IPR existence. In e-business SDOs, the commercial pressure mainly comes from IT vendors, who implement standards into software marketed as ‘standard compliant’. Users develop vertical e-business standards for

Table 3. Three standard making approaches

Standards	De facto standards	Voluntary consensus standards	De jure standards
Definition	Standards established through market-mediated processes.	Standards established by coordination and consensus.	Standards established by regulatory bodies.
Institutions behind the standards	Individual firms.	SDOs.	Governments or institutions with regulatory power.
Market impacts on standards setting	Full	Some	None

better supply chain cooperation instead of developing products based on them for future competition. Again, this paper indicates that participants, technical focus, and internal processes and policies jointly determine a SDO's performance. Both papers suggest that technical maturity is a key factor in that early standardization is helpful to reduce participants' vested interests and speed up the standard making process.

A limitation of the Farrell (1996) and Simcoe (2003) models is that they assume that the content for potential adoption is exogenous. They do not consider the collaborative aspect of SDOs, when members jointly develop actual technical specifications of standards without proprietary applications on hand. This collaborative feature is very important for e-business standards. Moreover, those two models only consider the 'war of attrition' within the SDO. When SDO members reach a final agreement, the models assume that the proposed standard will be the winner in the market. However, as we mentioned before, some SDOs may face competition from rival SDOs or firms with proprietary specifications (Weiss and Cargill 1992). SDO participants cannot be myopic, and they need to take outsiders' potential reactions into account when they cooperate and compete with each other within the committee (Xia *et al.* 2003).

Farrell and Saloner (1988) view SDO activities as communication and negotiation among participants for competing candidates. They find that the committee mechanism will outperform the market mechanism at the price of speed. We can apply the same view to study firms' interactions in vertical e-business SDOs. Consequently, we expect that SDO participants' bargaining power will play a significant role in determining outcomes of negotiations on standard candidates (Marx and Shaffer 2004). However, no formal analysis has studied the role of members' bargaining power in SDOs. One field study (Weiss and Sirbu 1990) explores the factors that influence the choice between two competing alternatives in 11 separate standards decisions. The study shows that the size of sponsoring firms and the extent of invested efforts in a consortium determine which contending alternative is selected. Both firm size and commitment in a SDO affect participants' bargaining power, suggesting that any SDO research needs to incorporate such bargaining power into the analysis.

In addition to participants' bargaining power, we also need to look at the number of participants in a SDO. Axelrod *et al.* (1995) combine analytical modelling with empirical validation to study the SDO formation process. They argue that firms prefer to join a large SDO in order to enhance the probability of future success of its standards, but they try to avoid working with rivals in the consortium.

Chiao *et al.* (2005) explore a consortium's institutional structure based on a large sample of SDOs. In their model, developers in a SDO propose a standard

and users only determine its adoption, which is common for IT product standards development. They find that if a SDO is oriented to developers, then the standard's quality is higher and required developers' concession level is lower. A SDOs' internal procedures, such as voting rules, licensing restriction and residual decision rights, are used as proxies to measure orientation to users or to developers and the concession level of developers. This paper also explores how SDOs' market power directs their policies. When SDOs face more competitors, their market power is lower. It is more important for them to achieve user-friendliness by requiring developers' concession, such as developers must commit to license key intellectual property needed to users. The paper shows that the market competition faced by a SDO is an important environmental factor.

While formal analysis of SDOs' institutional structure is quite limited, there are many SDO case studies describing the administrative and operational details of individual SDOs (Cargill 1989; Jakobs 2003; Steinfield *et al.* 2004). We summarize typical organizational features of SDOs:

1. *Organizational structures.* Typical SDOs consist of two parts: the administrative section and standards working committees (Cargill 1989). While the administrative section is in charge of strategic directions, the daily operations of the SDO's standards working groups focus on technical specifications of standards.
2. *Standards development and consensus procedures.* SDOs have rules guiding the standards development process. Some SDOs allow individual firms to propose their preferred technical specifications, some ask firms to send delegates to work on standards proposals as a group, while others hire full time staff to develop standards (Updegrave 1993; Weiss and Sirbu 1990). After SDOs receive technical proposals, they need to carefully design the way they assign voting rights to members. Voting rules have significant impacts on the final result of the standard setting process (Chiao *et al.* 2005; Farrell 1996). Other rules, such as those involving IPR protection and dispute resolution, are also part of a SDO's internal procedures.
3. *Openness:* SDOs need to determine the level of openness for both standards development and adoption. Some SDOs are open for all interested parties, while others are exclusive. Most SDOs obtain funding from fees paid by their participants (Updegrave 1993). SDOs have to decide whether both members and non-members can access the standards documents and by what means (Steinfield *et al.* 2004).

SDO case studies open the black box of SDOs and record the standards development process in such a

special organizational form. However, most SDO cases are conducted from practitioners' perspectives, which are descriptive in nature and make limited theoretical contributions. For example, while we understand how SDOs operate, we cannot explain why some structures and procedures work better in certain environments. We need more academic oriented case studies, which adhere to rules suggested by Yin (1984) and Benbasat (1987), to cumulate insights in SDO theory building.

A CONCEPTUAL FRAMEWORK

Overview

Based on our literature review and vertical e-business SDOs observations, we propose a unified conceptual framework for future vertical e-business SDO analysis (Figure 2). In the model, a vertical e-business SDO consists of three interrelated components: participants, technical content and an institutional structure. They interact with each other and jointly determine the performance of a SDO. A SDO's participants contribute financial, technical and personnel resources to sustain its operation. Firms participate in a SDO because they are interested in the technical content of standards and their behaviours are constrained by policies and bylaws within it. The content of standards are driven by participants' needs and majority preferences and are determined by multilateral negotiation and bargaining in the consortium. Internal procedures within a SDO, such as voting rules, will shape outcomes of standards. SDO members design the institutional structure, which should adjust dynamically to serve various participants and progressing e-business standards. In this section, we will identify key features of each component, explain how they interact with each other and influence the performance of SDOs, and raise a set of research questions and hypotheses with respect to those key constructs. Our

model is not a theory, but a framework that enables theorizing about e-business standardization in a neutral consortium setting. We use examples of vertical e-business SDOs to illustrate the framework. The SDOs' related data are collected from their websites, trade journals and a survey conducted by Nelson and Shaw (2003).

Vertical e-business SDO participants

SDO activities rely heavily on members, who initiate, develop and approve standard proposals and documents. To capture the role of participants within SDOs, we focus on three key characteristics of participants: the number of participants, the industrial sectors they come from and their bargaining power within the SDO.

Number of participants. For a SDO, the number of participants can range from a single digit number to hundreds or even thousands. For example, AgXML, a SDO in the grain and oilseed business, has 10 members; while RossettaNet, a SDO in the high-tech industry, has over 500 members. The number of participants is determined by two factors; the potential industry audience and the SDO's promotion efforts. It is not surprising that AgXML has fewer members as it caters to a narrower target industry sector than, say, RosettaNet. In addition, a SDO's marketing efforts will also influence the number. For example, in an interview, Sun and HP both indicate that they give serious consideration to a SDO's membership invitation (Updegrove 2003).

The number of participants has two different impacts on a SDO's performance (Fomin and Keil 2000). The more members a SDO has, the less external pressure it will face to diffuse its standards (Axelrod *et al.* 1995). However, as the size increases, SDOs have to face more internal challenges since the negotiation and consensus

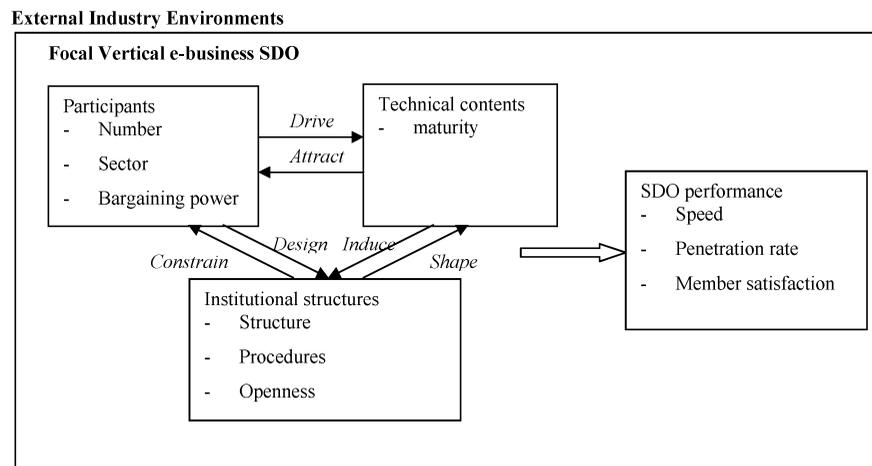


Figure 2. A vertical e-business SDO conceptual framework

process within the SDO will become more complicated, lengthy and difficult to control. Therefore, we hypothesize that the number of participants in a vertical e-business SDO is positively related to its standards penetration rate, but negatively related to the speed of the standard setting process.

Sectors of participants. A vertical e-business SDO, just like any typical standards consortium, has participants from user groups, technology vendors, as well as third parties such as government agencies and coalition SDO partners (Cargill 1989; Chiao 2005). In addition, a vertical e-business SDO's members come from various supply chain sectors, horizontally as well as vertically, since its process specifications involve the entire supply chain network. For instance, OTA has members from four major sectors: air, car, hotel, and travel integrators. STAR's members include automobile dealers, manufacturers and information system vendors. These sectors usually have different goals and perspectives on standards.

Vertical e-business SDOs' organizational structures need to address their sector divergence. Some, like OTA, arrange internal work groups and project teams based on sector-specific focus. Others employ the strategy of encouraging firms from various sectors to work together, such as STAR. Some other SDOs adopt mixed structures. For example, MISMO has both cross-sector work groups, such as the core data work group, and sector-specific work groups, such as the mortgage insurance work group. The landscape for vertical e-business SDOs is still evolving and it is uncertain which approach works better under what circumstance. We can only conjecture that the sector heterogeneity will lead to delays in a SDO.

Bargaining power of participants. Individual firms' bargaining power can affect outcomes of negotiation in a SDO. Firms' bargaining power in SDOs is determined by both external factors, such as their market shares and available technical and financial resources, and internal factors, such as contributing technical proposals to SDOs and lobbying other members (Weiss and Sirbu 1990).

In vertical e-business SDOs, a firm's bargaining power can also be affected by its position in the supply chain. Firms at the centre of an extended value web, such as EDI champions (Srinivasan, *et al.* 1994), enjoy relatively stronger bargaining positions than their counterparts at the periphery, as their standards adoption decisions will have impacts on many of their trading partners. For example, in 2002, Intel implemented RosettaNet standards together with over 90 trading partners (Greenemeier 2002). In addition, due to positive network effects, these firms will value standards more than peripheral firms that conduct e-business with only a limited number of partners. So firms at the centre of the

supply chain network might be expected to fight more aggressively in SDOs to maintain a strong bargaining position.

Firms with strong market power in supply chain networks are likely to have strong bargaining power within a vertical e-business SDO. Since those firms' e-business standard adoption can influence their partners, a SDO might enhance its standards penetration rate by designing rules in favour of powerful participants, such as inviting them to join administrative committees or changing voting rules to give them extra influence. This relationship remains to be examined.

Technical contents of standards

Technical maturity. The ultimate goal of vertical e-business SDOs is to develop an accepted suite of standards that defines the common format for electronic data and process sharing among supply chain partners. These standards are developed based on different underlying information and telecommunication technologies. For example, traditional EDI standards are built upon value-added networks or dedicated lines, but new generations of e-business standards, such as XML-based standards, are transmitted over the ubiquitous Internet. The maturity of underlying standards technologies has great impact on whether and how firms' vested interests shape forthcoming standards (Farrell 1996; Simcoe 2003).

A SDO's internal process should adjust according to the underlying technical maturity. If SDOs are organized for well-developed technologies and firms' proprietary applications already have significant installed bases, a SDO's main focus becomes resolving members' conflicting interests, which calls for an efficient and fair negotiation process. On the other hand, if firms form SDOs at an early stage of technical development and work on 'anticipatory standards' (David and Greenstein 1990), the vested interests are low. However, firms need to collaborate closely to examine technical feasibilities and develop standards from scratch. Many vertical e-business SDOs belong to this category as they work on standards for future development of the industry. For example, they began to develop XML-based e-business standards right after W3C published the first version of XML specifications in 1998 (W3C) (Table 4). When SDOs work on anticipatory standards, they face challenges, such as anticipating new uses of the standard, coordinating knowledge creation across firm boundaries, and educating members who are not familiar with 'arcane technical issues' (David and Greenstein 1990: 25). The process of interfirm knowledge sharing is then crucial for vertical e-business SDOs that develop standards based on leading edge technologies. We need further studies to explore the relationship between

Table 4. Years of vertical e-business SDOs launching XML-based standard projects

Name	Industry	Year
AgXML	Oilseed and grain	2000
CIDX	Chemical	2000
MISMO	Mortgage	1999
OTA	Travel	2000
RosettaNet	High-tech	1998
STAR	Automotive	2001

technical maturity, internal rules and the SDO's performance.

Institutional structures of SDO

Vertical e-business SDOs share several similar institutional structures. They typically have administrative committees and standards working committees (Cargill 1989). SDO's internal processes usually start from standards writing, reviewing and marketing to final implementation (Cargill 1989). Based on our review, we focus on three key institutional structures: organizational structures; internal procedures; and SDO openness.

Organizational structures. Most SDOs adopt the two-part organizational structure. One is the administrative committee that guides SDO policies and strategic directions and oversees daily operations. The other part is the standards working committee, which consists of various work groups. The way SDOs organize their work groups reflects the modularity of vertical e-business standards. For instance, MISMO has a credit report work group, a flood work group, a hazard insurance work group, among others, which correspond to various modules of the entire set of the mortgage industry's e-business standards. SDO work groups evolve as they complete old standards modules and continue exploring new ones.

Arranging various work groups to focus on sub-areas of the standard can speed up the development process. First of all, only a limited number of interested firms will join the work group and coordination between them will be easier than coordination among all members. For example, RosettaNet has over 500 members, but it only has 5 firms working on the product catalogue information standard. Second, SDOs can have multiple work groups developing different standard modules concurrently. However, highly fragmented subgroups also have a downside because they bring challenges for the overall control of the consortium and make interfirm communication hard, which may cause some redundant efforts across subgroups. Therefore, we hypothesize that the

speed of the standard setting process is positively related with the number of work groups at a diminishing rate. It is possible to testify this hypothesis in a longitudinal study since many vertical e-business SDOs evolve over a long period in order to cover the dynamic scope of e-business standards.

Procedures. There are two basic procedures within SDOs: the proposal development procedure and the decision-making and consensus-seeking procedure. For the proposal development procedure, SDOs can either require members to send delegates to contribute and cooperate in work groups, or they can ask them to submit proprietary designs (Rada 1999). In the decision-making procedure, SDOs need to determine how to assign voting rights to member companies, and the proportion of votes required to establish a standard. For example, CIDX uses a two-level member structure. Firms can be either associate members or principal members. Only CIDX's principal members have the voting rights and final decisions require support by at least two-thirds of the voting members.

These two procedures share a common key component: to disseminate information to and collect feedback from SDO members accurately and promptly. As a result, information sharing and communications are critical for both procedures and Internet technologies are playing an important role in facilitating inter-firm learning and knowledge sharing within the SDO (Rada 1999). We infer that a SDO's performance (speed, penetration rate and member satisfaction) is positively related with effectiveness and diversity of its communication channel.

Openness. SDOs have to determine the policy on openness of their standards for both development and adoption. SDOs can open standards development to all interested parties or keep it exclusive to invited members only. If SDOs are open, they have to maintain a neutral position and prevent some powerful firms from dominating the alliances. Due to fewer vested interests of participants, an open SDO might work better on anticipatory standards than fairly mature standards. Future research is needed to investigate the relationship between standard maturity, development openness and SDO performance.

For adoption, SDOs also differ in their policy of making the standard content available to outsiders. Many SDOs, such as MISMO and CIDX, make their standards available for anyone to download for free at their website. The absence of fees makes the standard more likely to be viewed and eventually be adopted by firms not in the consortium, which could lead to a larger installed base for their standards and increase the likelihood of post-development success. Yet other SDOs, such as HL7, only let their members obtain standards freely and charge fees for non-members. In

doing this, they aim to have more income and stimulate firms to become supporting members.

SDO performance and external industry environments

Previous sections describe three interrelated components of SDOs: members, technical maturity of standards technologies and institutional structures. They will jointly influence the performance of SDOs. To become efficient and effective, SDOs need to encourage firms' participation and contribution in the alliance, resolve conflicting interests and encourage standards adoption. Their standards have to address industry demand and they need to adjust their internal structures and procedures as technology advances and membership changes.

However, what is the best way to assess a vertical e-business SDO's performance? We can use both objective and subjective measures to evaluate the standard alliance's performance. Objective measurements include both the speed of standard publications and the penetration rate of the standards diffusion process. SDOs should be responsive to rapid IT technology development and industry's increasing e-business requirements. The speed can be estimated as the number of standard components delivered by a SDO per year. The penetration rate of standards diffusion measures how many targeted audiences have adopted and implemented standards in the industry. It reflects the market success and influence of standards developed by a SDO (Crowston *et al.* 2003), which can also be used as a proxy of the standard's quality. At present, this information is not routinely collected. Further empirical studies are needed to operationalize the penetration rate of standards in order to measure a SDO's performance more comprehensively.

The subjective measurement is whether members are satisfied with a SDO's work. Members want to see benefits from their investments in the SDO and their future involvement will depend on their earlier experience dealing with the SDO. In addition to creating fair and open internal processes and maintaining smooth communications with members, vertical e-business SDOs also need to pay special attention to the implementation of standards, since the leading players in the alliances are also e-business standards users. Most e-business SDOs provide standards implementation guides and compliance testing for their members. Some SDOs, such as CDISC and FPML, offer training programmes. Others, such as RosettaNet and FIX Protocol, even conduct case studies for members.

Vertical e-business SDOs work in various industries and industry characteristics will influence their features and performance. We only discuss this issue very briefly in this paper. Jain and Zhao (2003) have provided a more detailed discussion of SDOs' environmental

factors. One important industry characteristic is the industry level IT intensity. In high IT-intensive industries, firms have more experience utilizing IT to support interfirm transactions. However, they also face expensive lock-in costs in pre-Internet proprietary applications and may be reluctant to move to new e-business technologies. Some industries, such as the financial services industry and the oil industry, have more than one SDO working on similar e-business standards. Competition between SDOs makes the participation choices more complicated for firms, and only one paper (Chiao *et al.* 2005) so far has explored its economic implications. The age of a SDO also influences its performance. SDOs, which have worked in e-business standards for many years, have established interorganizational routines and are trusted to handle cooperation and coordination among members (Zollo *et al.* 2002). However, they also tend to incur organizational inertia and may not catch new technology development and opportunities in a timely fashion.

SUMMARY AND DISCUSSION

In this paper, we provide an analysis of consortia-based vertical e-business standardization processes. We first identify the uniqueness of e-business standards. With heavy user involvement, little competitive pressure among majority adopters and increasing industry-wide collaboration, SDOs emerge as the leading mechanism behind the vertical e-business standardization efforts in the field. However, vertical e-business SDOs face a lot of challenges such as rapid technology development and divergent preferences between various supply chain sectors. In order to address these issues, we propose a participant-technical content-institutional structure framework to study vertical e-business SDOs after reviewing previous SDO studies and examining related cases. In our conceptual model, we decompose focal SDOs into three interdependent components and identify key features of each component. To become efficient as well as effective, SDOs should optimize resources accumulated from members, deliver standards addressing industry trends and members' interests and adapt internal structures and procedures to dynamic member configurations and technical contents. Although we focus on vertical e-business SDOs, the overall participant-technical content-institutional structure framework can be extended to general firm-based SDOs.

Vertical e-business standards and e-business SDOs are promising research areas. Many interesting issues are emerging while the underlying technologies are advancing quickly. Our conceptual framework is helpful to identify future research opportunities at three different levels. First, we need to develop measurements for key constructs, since only very limited studies (Chiao *et al.* 2005; Simcoe 2003) have operationalized some of the

variables. Second, we can study how the three components – participants, technical content and institutional structure – interact with each other. For instance, we can study which procedures fit better in the early standardization process and which ones fit mature technologies better. Finally, our model also suggests that these three SDO components work together to determine the performance of a SDO. It is challenging to explore the interactive effects between the three components and their impacts on a SDO's performance. For example, we can study how institutional structures influence participants' bargaining power, which is closely related to standards choices in a SDO. We hope that our framework can serve as a foundation to build economic models and conduct empirical analysis of vertical e-business SDOs, such as firms' strategic behaviour within the consortium and methods to improve SDOs' performance in multiple dimensions.

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Notes

1. This excludes technical vendors of e-business standards, who provide services and solutions to help firms implement e-business standards.
2. We only provide the URL for SDOs we have mentioned in the paper.

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