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EDI, XML and e-business frameworks: A survey

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Abstract

Data formats and e-business frameworks are important standards for e-business. The ASC X12, EDIFACT and XML formats are utilized in e-business frameworks which are supported in information systems. The EDI formats have retained a position in cross-industry-document e-business frameworks, whereas the XML format dominates in cross-industry-process e-business frameworks and has gained a footing in industry-specific e-business frameworks. The use of XML-based e-business frameworks has increased more than the use of EDI-based e-business frameworks in 2004. XML-based e-business frameworks are more widely used in the new market economies and EDI-based e-business frameworks in the old market economies. XML-based e-business frameworks are more common in the industries for which there exists an XML-based but no EDI-based industry-specific e-business framework. In other industries, EDI-based e-business frameworks are more common. This paper also discusses a lock-in to the EDI formats and EDI-based e-business frameworks.

Keywords: E-business; EDI; Standards; XML

1. Introduction

Information and communication technologies (ICT) have had considerable effects on how companies do business with their business partners [3]. In a narrow sense, these effects are based on *electronic commerce* (e-commerce), which is the buying of products from suppliers and their selling to customers using ICTs. There are several models of e-commerce, namely, *business-to-business* (B2B) e-commerce between companies, *business-to-consumer* (B2C) e-commerce between companies and consumers and *business-to-government* (B2G) e-commerce between companies and government organizations. In a broad sense, *electronic business* (e-business) covers all kinds of collaborations with business partners using ICTs and reflects the effects of B2B e-commerce. A *business interaction*, which is the exchange of a business document or a message containing a business document in a business process, plays a key role in the collaboration. Since the late 1960s companies have used information systems for the electronic exchange of data with their business partners [10]. When the data is processed and communicated automatically, its re-keying and printing are reduced. Therefore, automated business interactions using ICTs can be faster and less error prone than manual business interactions using mail, phone calls or faxes. Unfortunately, it is not easy to automate business interactions. Information systems are not interoperable due to the differences between any two companies.

There would be fewer problems in e-business if all companies used the same information systems, the same meanings for terms and the same modes of operations [21]. If information systems are not interoperable, human intervention is needed to prepare the input data for information systems to produce the output data. Although differences between companies are often inevitable, they are also costly. Fortunately, standards can provide a way to cut these costs. Standards bring order into the complexity and uncertainty by reducing variety. Standardization of business documents and business processes promotes interoperability by harmonizing the meanings for terms and the modes of operations. In addition, standard messaging interfaces support scalability. Companies can change their information systems as long as they use the same kinds of business documents, business processes and messaging interfaces. In e-business, standardization happens at many levels. A *data format* is a low-level standard for e-business that defines the basic data structures and data elements in general. An *e-business framework* is a high-level standard for e-business that uses a data format to define the data structures, data elements and their purposes in the business context. The data formats and e-business frameworks enable information systems to communicate and process the data quickly and accurately.

Electronic Data Interchange (EDI) is aimed at the exchange of data without human intervention. American National Standards Institute (ANSI) Accredited Standards Committee (ASC) X12 [1] and UN Economic Commission for Europe (UNECE) EDI for Administration, Commerce and Transportation (EDIFACT) [31] are e-business frameworks as well as data formats. In this paper, the e-business frameworks that have been standardized to use the ASC X12 or EDIFACT format are called *EDI-based* e-business frameworks. E-business frameworks, such as Financial Information Exchange (FIX) or Society for Worldwide Interbank Financial Telecommunication (SWIFT), do not use the ASC X12 or EDIFACT format and, therefore, are not regarded as EDI-based e-business frameworks. In comparison, Extensible Markup Language (XML) [32] developed by WWW Consortium (W3C) is not only a metalanguage for electronic document management and web publishing but also a data format. Tens of e-business frameworks, such as Electronic Business XML (ebXML) and RosettaNet, have been standardized to use the XML format and are called *XML-based* e-business frameworks.

The use of EDI and XML formats takes place in the following way. *First, a standards developing organization (SDO) develops an e-business framework that is based on a data format. Then, a company uses an information system that supports the e-business framework.* This raises questions about the use of EDI and XML formats in e-business frameworks and especially the use of these e-business frameworks in companies. The paper proceeds by introducing the ASC X12, EDIFACT and XML formats as well as e-business frameworks and by reviewing the related literature. Next, the paper presents the research approach. Then, the paper compares the use of the ASC X12, EDIFACT and XML formats in 38 e-business frameworks and the use of EDI-based or XML-based e-business frameworks in 7593 European companies. Before conclusions, the paper discusses a lock-in to the EDI formats in e-business frameworks and to EDI-based e-business frameworks in companies. The findings can be expected to be useful to the researchers of ICT standards or e-business as well as to the practitioners who develop or use e-business frameworks.

2. Background

2.1. ASC X12 and EDIFACT

In 1968, Transportation Data Coordinating Committee (TDCC) was formed to standardize the electronic exchange of data for all the transportation industries in the US. In 1979, ANSI continued this work and started to develop ASC X12. The first version of ASC X12 was released in 1982. Based on the recommendations of a joint European-North American committee, UNECE engaged the development of EDIFACT in 1986. International Organization for Standardization (ISO) approved EDIFACT as an international standard in 1987. In 1992, ANSI announced that the development of ASC X12 would be abolished by 1997. However, many companies in North America that had invested in ASC X12 saw no benefit in switching over to EDIFACT. It became clear that the development of both ASC X12 and EDIFACT will continue for an unforeseeable future. Figure 1 represents the ASC X12 standards version 4 and the EDIFACT syntax version 4 in Extended Backus-Naur Form (EBNF).

```
Interchange ::= InterchangeHeader (Group+ | Message+) InterchangeTrailer
Group ::= GroupHeader Message+ GroupTrailer
Message ::= MessageHeader Segment+ MessageTrailer
Segment ::= Code (ESeparator Repetition)+ Terminator
Repetition ::= Composite (RSeparator Composite)*
Composite ::= Simple (CSeparator Simple)*
Simple ::= Data?
```

Fig. 1. The basic grammar of the ASC X12 and EDIFACT formats.

The EDI formats can be illustrated with an example concerning a purchase order document. According to this purchase order, a delivery is wanted to be shipped to the end user “SoberIT” in the organization “TKK” at the street address “Tekniikantie 14” and the postal code “02150” in the city of “Espoo” in the country of Finland. Figure 2 represents this information in the ASC X12 format and Figure 3 in the EDIFACT format. ASC X12 specifies the segment codes “N1”, “N2” etc..., EDIFACT the segment code “NAD” and both e-business frameworks the element values “ST” and “FI”.

```
N1*ST*TKK~
N2*SoberIT~
N3*Tekniikantie 14~
N4*Espoo**02150*FI~
```

Fig. 2. An excerpt from an ASC X12 850 Purchase Order document.

```
NAD+ST++TKK+SoberIT+Tekniikantie 14+Espoo++02150+FI'
```

Fig. 3. An excerpt from an EDIFACT ORDERS document.

2.2. XML

In 1969, IBM started to develop Generalized Markup Language (GML) to be used to manage industrial documents. ANSI became interested in GML and started the development of Standard Generalized Markup Language (SGML) for electronic

document management. ISO approved SGML as an international standard in 1986. Hypertext Markup Language (HTML), which is perhaps the most important use of SGML, was developed for web publishing at CERN. In 1995, Internet Engineering Task Force (IETF) standardized HTML. In 1996, W3C established a committee to develop a standard that would not be as complex as SGML and as fixed as HTML. As a result of this work, W3C published XML in 1998. Figure 4 represents the XML recommendation 1.0 in EBNF.

```

Document ::= Declaration Element Miscellaneous*
Element ::= EmptyTag | StartTag Content EndTag
EmptyTag ::= "<" Name (Space Attribute)* Space? "/>"
StartTag ::= "<" Name (Space Attribute)* Space? ">"
Content ::= CData? (Element CData?)*
EndTag ::= "</" Name Space? ">"
Attribute ::= Name Space? "=" Space? Value
Value ::= "'" VData? "'" | "" VData? ""

```

Fig. 4. The basic grammar of the XML format

Figure 5 represents a purchase order document in Figures 2 and 3 in the XML format. RosettaNet Partner Interface Process (PIP) specifies the element names “shipTo”, “BusinessDescription” etc..., the element contents “End User” and “FI”, the attribute name “xml:lang” and the attribute value “FI”.

```

<shipTo>
  <BusinessDescription>
    <businessName>
      <FreeFormText xml:lang="FI">TKK</FreeFormText>
    </businessName>
    <PartnerBusinessIdentification>
      <ProprietaryDomainIdentifier>SoberIT</ProprietaryDomainIdentifier>
      <ProprietaryIdentifierAuthority>TKK</ProprietaryIdentifierAuthority>
    <PartnerBusinessIdentification>
  </BusinessDescription>
  <GlobalPartnerClassificationCode>End User</GlobalPartnerClassificationCode>
  <PhysicalLocation>
    <PhysicalAddress>
      <addressLine1>
        <FreeFormText xml:lang="FI">Tekniikantie 14</FreeFormText>
      </addressLine1>
      <cityName>
        <FreeFormText xml:lang="FI">Espoo</FreeFormText>
      </cityName>
      <GlobalCountryCode>FI</GlobalCountryCode>
      <NationalPostalCode>02150</NationalPostalCode>
    </PhysicalAddress>
  </PhysicalLocation>
</shipTo>

```

Fig. 5. An excerpt from a RosettaNet PIP 3A4 Purchase Order Request document.

2.3. E-business frameworks

Before XML, standards for e-business were known as EDI standards or simply EDI. Since the late 1990s an increasing number of papers have discussed such standards. Shim et al. [27] called these standards B2B e-commerce frameworks, Gosain et al. [9]

B2B interface specifications, Medjahed et al. [17] B2B interaction standards, Hsieh and Lin [11] XML/EDI and Nurmilaakso and Kotinurmi [21] e-business frameworks.

Since business partners have to know what, when and how information should be shared before they can do business, data formats are useful in syntactic interpretation but insufficient in semantic interpretation [21]. An e-business framework is a standard for e-business that is a syntactic subset but a semantic superset of the data format. The e-business framework answers the questions of what, when and how. It deals with business documents, business processes and messaging in e-business. For *business documents*, the e-business framework can specify the data structure, data elements and their meanings in the business documents. For *business processes* can provide the means to specify business interactions and other business actions, i.e. the exchange of business documents and their processing in the business processes. For *messaging*, the e-business framework can define the packing, security and transportation standards to be used with business interactions. The e-business framework always has a certain target. The *cross-industry* e-business framework aims to cover all industries, whereas the *industry-specific* e-business framework focuses on one or a few industries. The *cross-industry-document* e-business framework uses a data format in the business documents, whereas the *cross-industry-process* e-business framework utilizes a data format as the means to specify *public* business processes, i.e. business processes between companies, or *private* business processes, i.e. business processes within a company. In comparison, the industry-specific e-business framework has used a data format in the business documents and not provided new means to specify the business processes.

3. Literature review

Although ICT standards are important in e-business, it is difficult to find papers describing them [20] or studying their adoption [18]. Kauffman and Walden [15] stress the importance of research that develops a better understanding of the role of the standard for e-business. There exist papers comparing e-business frameworks [17, 21, 27] and analyzing the use of ICT standards.

The literature has shown that EDI-based business interactions provide many advantages over manual business interactions. EDI-based e-business frameworks speed up business interactions [7] as well as reduce errors [28] and operating costs [19]. However, a company often uses EDI with a small fraction of its business partners and for only a few types of various business interactions performed with these business partners [24]. The use of EDI has concentrated on large enterprises, whereas small and medium-sized enterprises (SMEs) have hesitated with its adoption [2]. SMEs tend to lack the needed organizational readiness and perceived benefits for EDI and are reluctant to integrate EDI into their operations because of high costs [12]. The reasons are that the investment is not in EDI alone but also in an information system that supports its use, customers do not use EDI or the volume of business interactions is too small to justify the investment in EDI [29]. According to Sriram et al. [30], customer-initiated, long-time and larger users of EDI recognize both strategic and operational benefits arising from EDI in greater propositions than voluntary, recent and smaller users. In many studies [9, 11, 23, 25], XML has clear advantages over EDI. According to some studies [13, 34], XML is not replacing EDI in the near future because the benefits of XML do not outweigh its costs. 9% of European companies that use computers in business used EDI-based e-

business frameworks in 2003 and 19% in 2005, whereas 8% of these companies used XML-based e-business frameworks in 2003 and 14% in 2005 [5, 6].

Standardization may fail in many different ways. A standard may be adopted too quickly or too slowly. There may also be no standard or too many standards. This is a paradox. If too many nominal standards coexist, no real standard exists. Farrell and Saloner [8] pointed out that the adoption of non-proprietary technologies is always efficient when the users are certain about the other users' benefits and costs although they have different preferences. However, if the users are uncertain about the other users' benefits or costs, they may be locked into an inferior technology. According to Katz and Shapiro [14], there is a bias toward non-standardization of non-proprietary technologies when standardization would be optimal. If standardization of non-proprietary technologies occurs, the technology that initially is superior has an advantage although it is not the optimal technology. In a well-known example, David [4] argued that QWERTY, which was patented in 1868 by Christopher L. Sholes and became the prevailing keyboard layout early, is inferior given current needs. This keyboard layout was designed to minimize key sticking in typewriters, whereas computer keyboards cannot stick. Since Dvorak Simplified Keyboard (DSK) exists and its benefits outweigh the switching costs, there is a lock-in to the QWERTY layout. However, Liebowitz and Margolis [16] presented that the superiority of the DSK layout has never been firmly established. The classic tests of the DSK layout are inconclusive and possibly influenced by August Dvorak who patented this keyboard layout in 1932.

4. Research approach

This paper is based on a research approach that explores rather than tests hypotheses. The paper aims to answer the following two research questions.

To what extent do SDOs use EDI and XML formats in e-business frameworks? A comparative analysis was carried out to identify the effects of the XML format on the use of the ASC X12 and EDIFACT formats in e-business frameworks. A sample of 38 e-business frameworks was mainly formed on the basis of the web pages of Organization for the Advancement of Structured Information Standards (OASIS) [22] and UNECE [31]. This sample is not exhaustive but includes EDI-based and XML-based e-business frameworks developed in the EU or US. Pre-ASC X12 e-business frameworks, such as Uniform Communication Standard (UCS) in the US, as well as pre-EDIFACT e-business frameworks, such as GENCOD in France, SEDAS in Germany and Trading Data Communications (TRADACOMS) in the UK, were excluded. Information on the development and properties of the chosen e-business frameworks was collected from the web pages of their SDOs. For some e-business frameworks, this information had to be collected by contacting the SDOs involved in their development. The information was based on the situation at the beginning of 2006.

To what extent do companies use EDI-based and XML-based e-business frameworks? A statistical analysis was used to analyze the effects of the year, country and industry on the use of EDI-based and XML-based industry-specific and cross-industry-document e-business frameworks in companies. The data were based on two e-business surveys carried out by e-Business W@tch which had been launched to monitor the maturity of e-business across different sectors in the EU, EEA and Accession countries in 2001 by the European Commission, Enterprise & Industry Directorate General. The second part of the e-Business Survey 2003 was conducted in November 2003. It consisted of 4570

telephone interviews with companies from 25 European countries within ten sectors [5]. The e-Business Survey 2005 was carried out in January and February 2005. It had a scope of 5218 telephone interviews with companies from seven EU countries within ten sectors [6]. The following observations were included in the sample:

- A company has access to the Internet.
- A company does business in the old market economy, i.e. Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden or UK, or in the new market economy, i.e. Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovak Republic or Slovenia.
- A company does business in the food and beverages, textile, footwear and leather, publishing and printing, chemicals and chemical products, machinery and equipment, electrical machinery and electronics, transport equipment, construction, retail, ICT services or business services sector.

To ensure the maximum number of independent observations, i.e. the same company is not included twice in the sample, an observation was excluded if a company did business in the textile subsector or in the construction sector in Germany, France, Italy, Poland, Spain or UK in 2003 or in the pharmaceutical, automotive, aerospace or IT services subsector in Czech Republic or Poland in 2003. The statistical analysis focused on two variables:

- *EDI*: Does a company use EDI-based e-business frameworks to exchange business documents with its customers or suppliers?
- *XML*: Does a company use XML-based e-business frameworks to exchange business documents with its customers or suppliers?

Before the statistical analysis, observations in which a company did not know whether it used an EDI-based or XML-based e-business framework were removed so that 7593 usable observations were left.

5. Analysis

5.1. EDI and XML formats in e-business frameworks

To what extent do SDOs use EDI and XML formats in e-business frameworks? Tables 1 and 2 summarize 18 EDI-based and 20 XML-based e-business frameworks in alphabetic order. For each e-business framework, the summary covers the target, which includes a geographical area and an industry, a year in which the first version was published or the development was started, e-business frameworks, which have formed the basis of the development, and further development, i.e. whether it had ceased before 2005 or was active or inactive in 2005. The comparative analysis of e-business frameworks in Tables 1 and 2 supports the following finding.

Table 1. ASC X12-based and EDIFACT-based e-business frameworks¹

E-business Framework	Target	First version (started)	Based on e-business frameworks	Further development in 2005
AIAG EDI	North American automotive industry	1985	ASC X12	Active
ASC X12	All North American industries	1982	TDCC	Active
CEFIC EDI	European chemical industry	(1989)	EDIFACT	Ceased
CIAG EDI	North American construction industry	(1991)	ASC X12	Inactive
CIDX EDI	North American chemical industry	(1985)	ASC X12	Ceased
EANCOM	Retail industry	1990	EDIFACT, TRADACOMS	Active
EDIBUILD	European construction industry	(1991)	EDIFACT	Inactive
EDIFACT	All industries	1987	ASC X12, GTDI	Active
EDIFER	European steel industry	1992	EDIFACT	Active
EDIFICE	European electronics industry	(1986)	EDIFACT	Active
EDIPAP	European paper industry	1993	EDIFACT	Ceased
EDITEX	European textile industry	(1990)	EDIFACT	Inactive
EIDX	North American electronics industry	(1987)	ASC X12	Active
GCA EDI	North American publishing industry	(1991)	ASC X12	Inactive
ODETTE EDI	European automotive industry	1996	EDIFACT, ODETTE	Active
PIDX EDI	North American petroleum industry	(1986)	ASC X12	Ceased
RINET	European insurance industry	(1988)	EDIFACT	Ceased
VICS EDI	North American retail industry	1987	ASC X12, UCS	Active

The EDI formats have retained a strong position in cross-industry-document e-business frameworks, whereas the XML format dominates in cross-industry-process e-business frameworks and has gained a significant footing in industry-specific e-business frameworks.

There are a larger number of XML-based than EDI-based cross-industry-document e-business frameworks. The number of XML-based cross-industry-document e-business frameworks has been even larger. For example, Microsoft's BizTalk Framework and Vitria's Value Chain Markup Language (VCML) have closed down. UNECE and ANSI have also shown their interests in the XML format. In 2001, they announced joint participation in the development of ebXML Core Components Technical Specification (CCTS), which provides a method for building business documents, e.g. using the XML format. ebXML CCTS has been applied to, e.g. UBL and Context Inspired Component Architecture (CICA), which offers a modular approach to creating XML documents based on ASC X12.

¹ Table 1 includes the following acronyms: Automotive Industry Action Group (AIAG), Construction Industry Action Group (CIAG), Chemical Industry Data Exchange (CIDX), EDI Forum for Companies with Interests in Computing and Electronics (EDIFICE), Electronics Industry Data Exchange (EIDX), Graphic Communications Association (GCA), Organization for Data Exchange by Tele Transmission in Europe (ODETTE), Petroleum Industry Data Exchange (PIDX), Reinsurance and Insurance Network (RINET) and Voluntary Interindustry Commerce Standard (VICS).

Table 2. XML-based e-business frameworks²

E-business Framework	Target	First version	Based on e-business frameworks	Further development in 2005
ACORD XML	Insurance industry	1999	ACORD, RINET	Active
BPEL	Private business processes	2002		Active
BPML	Private business processes	2001		Active
CIDX XML	Chemical industry	2000	CIDX EDI	Active
cXML	All industries	1999	ASC X12, EDIFACT	Active
ebXML BPSS	Public business processes	2001		Active
ESIDEL	European steel industry	2003	EDIFER	Active
FIXML	Financial services industry	2002	FIX	Active
GS1 XML	Retail industry	2001	EANCOM, VICS EDI	Active
IFX	Financial services industry	2000	OFX	Active
MODA-ML	European textile industry	2003	EDITEX	Active
OAGIS XML	All industries	1998	OAGIS	Active
OFX XML	Financial services industry	1999	OFX	Active
papiNet	Paper, publishing, wood products industries	2001	EDIPAP, GCA EDI	Active
PIDX XML	Petroleum industry	2001	PIDX EDI	Active
RosettaNet PIP	Electronics, ICT, logistics industries	1998		Active
swiftML	Financial services industry	2002	SWIFT	Active
UBL	All industries	2004	xCBL	Active
xCBL	All industries	1998	CBL	Inactive
XPDL	Private business processes	2002		Active

Only XML-based cross-industry-process e-business frameworks exist. These e-business frameworks provide an approach not only to automate the exchange of individual business documents but to support the execution of entire business processes. Although these e-business frameworks are newcomers, they have already received a lot of attention. For example, OAGIS and RosettaNet offer guidelines for specifying their business processes using ebXML BPSS.

The XML format challenges the EDI formats in industry-specific e-business frameworks. In the financial services industry, FIX and SWIFT have not left much room for the EDI formats. Respectively, the XML format has been more successful due to FIXML and swiftML. In the chemical, insurance, paper and petroleum industries, SDOs abandoned the further development of their EDI-based e-business frameworks after

² Table 2 includes the following acronyms: Association for Cooperative Operations Research and Development (ACORD), Business Process Execution Language (BPEL), Business Process Modeling Language (BPML), Commerce XML (cXML), ebXML Business Process Specification Schema (BPSS), European Steel Industry Data Exchange Language (ESIDEL), FIX Markup Language (FIXML), Interactive Financial Exchange (IFX), Middleware Tools and Documents to Enhance the Textile/Clothing Supply Chain through XML (MODA-ML), Open Applications Group Integration Specification (OAGIS), Open Financial Exchange (OFX), SWIFT Markup Language (swiftML), Universal Business Language (UBL), XML Common Business Library (xCBL), Common Business Library (CBL) and XML Process Definition Language (XPDL).

XML-based e-business frameworks were introduced. In the electronics, publishing, retail, steel and textile industries, SDOs are involved in the development of both EDI-based and XML-based e-business frameworks. In the automotive industry, the SDOs of AIAG EDI and ODETTE EDI have been jointly developing an XML-based e-business framework since 2003. In the construction industry, there are ongoing development projects of XML-based e-business frameworks that are independent of CIAG EDI and EDIBUILD. There have also been many plans to unify XML-based industry-specific e-business frameworks, e.g. CIDX XML and PIDX XML as well as IFX and OFX XML, but so far the degree of realization of these plans has been modest.

5.2. EDI-based and XML-based e-business frameworks in companies

To what extent do companies use EDI-based and XML-based e-business frameworks? Of 7593 European companies, 6030 did not use EDI-based or XML-based e-business frameworks, 651 used at least EDI-based e-business frameworks, 625 at least XML-based e-business frameworks and 287 both EDI-based and XML-based e-business frameworks. *In all, 12.4% of the European companies used EDI-based and 12.0% XML-based e-business frameworks.* Figure 6 and Tables 3, 4 and 5 summarize the extent to which the European companies have used e-business frameworks in different years, countries and industries. A difference is made between the years 2003 and 2005, old and new market economies as well as industries taking into account industry-specific e-business frameworks. Based on Tables 1 and 2, there are no EDI-based or XML-based industry-specific e-business frameworks for the food and beverages, machinery and equipment and business services industries, only EDI-based industry-specific e-business frameworks for the transport equipment and construction industries, only XML-based industry-specific e-business frameworks for the chemicals and chemical products and ICT services industries and both EDI-based and XML-based industry-specific e-business frameworks for the textile, footwear and leather, publishing and printing, electrical machinery and electronics and retail industries. According to Pearson χ^2 (*degree of freedom*) tests and contingency coefficients, there are statistically significant associations between the use of e-business frameworks and years, countries and industries at the 0.001 level ($p < 0.001$). Tables 3, 4 and 5 lead to three findings.

Table 3. The use of EDI-based and XML-based e-business frameworks in different years

Year	Number of companies					% of companies	
	No EDI or XML	Only EDI	Only XML	Both EDI and XML	Total	EDI	XML
2003	2849	274	244	121	3488	11.3	10.5
2005	3181	377	381	166	4105	13.2	13.4
Pearson χ^2 (3) test (p -value)	21.67 (0.0)						
Contingency coefficient (p -value)	0.53 (0.0)						

The use of EDI-based and XML-based e-business frameworks has increased in 2004. However, the use of XML-based e-business frameworks has increased more than the use of EDI-based e-business frameworks ($0 < 13.2 - 11.3 < 13.4 - 10.5$).

This finding supports a view that e-business frameworks are becoming more common in companies. This also reflects the fact that EDI-based e-business frameworks have not

blocked the entry of XML-based e-business frameworks. On the other hand, XML-based e-business frameworks have not displaced all EDI-based e-business frameworks. XML-based e-business frameworks took less than a decade to achieve the degree of use that took EDI-based e-business frameworks nearly two decades.

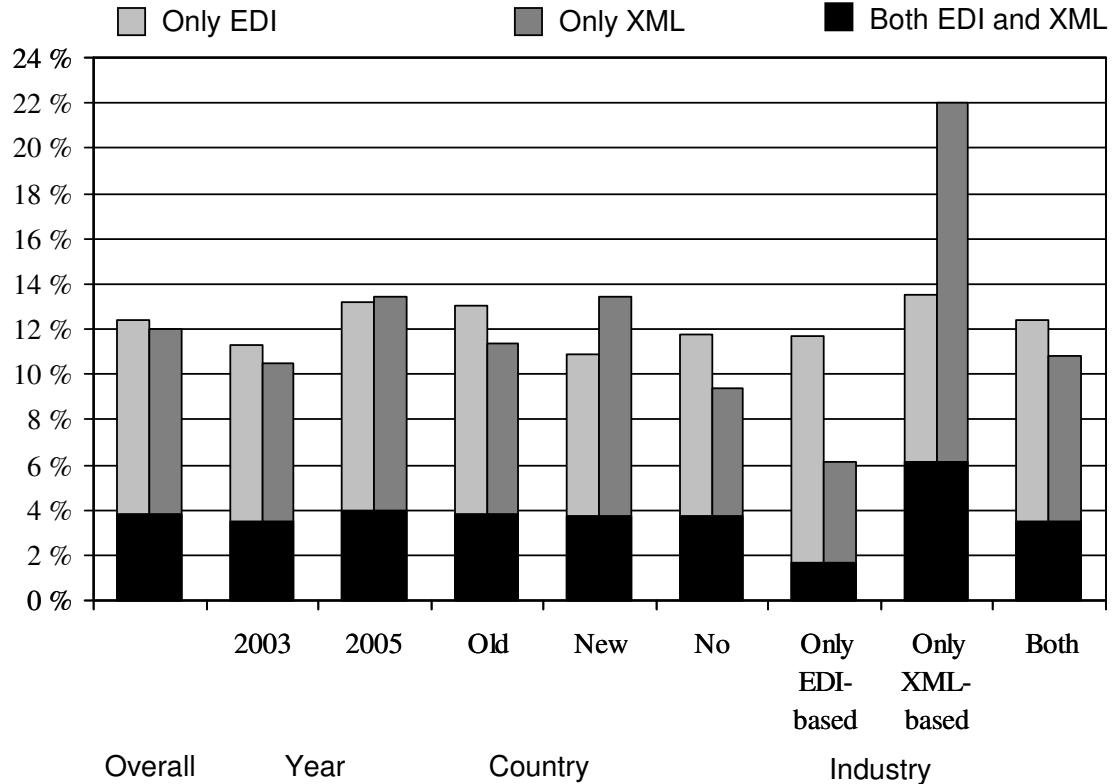


Fig. 6. A histogram of the use of EDI-based and XML-based e-business frameworks.

Table 4. The use of EDI-based and XML-based e-business frameworks in different countries

Countries	Number of companies					% of companies	
	No EDI or XML	Only EDI	Only XML	Both EDI and XML	Total	EDI	XML
Old market economies	4163	482	396	201	5242	13.0	11.4
New market economies	1867	169	229	86	2351	10.9	13.4
Pearson $\chi^2(3)$ test (<i>p</i> -value)	17.18 (0.001)						
Contingency coefficient (<i>p</i> -value)	0.05 (0.001)						

XML-based e-business frameworks are more widely used in the new market economies than EDI-based e-business frameworks ($10.9 < 13.4$). In comparison, EDI-based e-business frameworks are more widely used in the old market economies than XML-based e-business frameworks ($13.0 > 11.4$).

An empirical finding of Westarp et al. [33] indicates that ASC X12 and EDIFACT have a significant user base in the leading capitalist countries. According to these results, the use of ASC X12 and EDIFACT has increased from the end of the 1980s so that about 35% of the 1000 largest enterprises used EDIFACT in Germany and about 45% of the 1000 largest enterprises used ASC X12 in the US in 1997. In the former socialist

countries, e-business has had no room before the liberalization of the economy at the beginning of the 1990s. For this reason, the new market economies have lagged several years behind the old market economies in the use of e-business frameworks. A small user base of EDI-based e-business frameworks has made it easier to bring XML-based e-business frameworks into use in the new market economies.

Table 5. The use of EDI-based and XML-based e-business frameworks in different industries

Industries	Number of companies					% of companies	
	No EDI or XML	Only EDI	Only XML	Both EDI and XML	Total	EDI	XML
No EDI-based or XML-based industry-specific e-business frameworks	1594	158	111	71	1934	11.8	9.4
Only EDI-based industry-specific e-business frameworks	1347	160	69	28	1604	11.7	6.1
Only XML-based industry-specific e-business frameworks	1230	129	277	106	1742	13.5	22.0
Both EDI-based and XML-based industry-specific e-business frameworks	1859	204	168	82	2313	12.4	10.8
Pearson $\chi^2(9)$ test (p -value)	244.92 (0.0)						
Contingency coefficient (p -value)	0.18 (0.0)						

XML-based e-business frameworks are more common than EDI-based e-business frameworks in the industries for which there exists an XML-based but no EDI-based industry-specific e-business framework ($13.5 < 22.0$). In other industries, EDI-based e-business frameworks are more common than XML-based e-business frameworks ($11.8 > 9.4$, $11.7 > 6.1$, $12.4 > 10.8$).

Different industries have different needs. Although a cross-industry-document e-business framework may have more potential users than an industry-specific e-business framework, the value of the e-business framework does not only depend on the number of its users. An industry-specific e-business framework enabling a larger number of business interactions among a small number of companies can be more valuable than a cross-industry-document e-business framework enabling a smaller number of business interactions among a large number of companies. This explains the importance of industry-specific e-business frameworks.

If no industry-specific e-business framework exists for the industry, EDI-based e-business frameworks are important. A theoretical finding of Farrell and Saloner [8] can explain this strong position of EDI-based e-business frameworks in such industries. Selection of an e-business framework that matches the business partner's selection can be expected to be more difficult from a large than a small number of similar e-business frameworks. If the number of XML-based e-business frameworks is larger than the number of EDI-based e-business frameworks, the companies are more uncertain about their business partners' willingness to switch over to the same XML-based e-business framework than to stay in the same EDI-based e-business framework.

6. Discussion

Data formats can be considered as important as keyboard layouts but the EDI and XML formats have not received nearly as much attention in the literature as the QWERTY and DSK layouts. According to David [4] and Katz and Shapiro [14], a superior non-proprietary standard may not be adopted because an older non-proprietary standard has the advantage. Based on this, SDOs should be locked into the EDI formats in their e-business frameworks. The ASC X12 format is older than the EDIFACT format, which in turn is older than the XML format. The EDI and XML formats are also non-proprietary standards. In addition, the lock-in should apply to the e-business frameworks. EDI-based e-business frameworks are mostly older than XML-based e-business frameworks. Moreover, most of EDI-based and XML-based e-business frameworks are non-proprietary standards.

As the use of the XML format in e-business frameworks and the use of these e-business frameworks in companies point out, there is no lock-in to the EDI formats and EDI-based e-business frameworks. This is hardly possible if the XML format and XML-based e-business frameworks have no advantages over the EDI formats and EDI-based e-business frameworks. Firstly, XML-based e-business frameworks, e.g. RosettaNet, are often global, whereas ASC X12-based e-business frameworks, e.g. EIDX, are indented for North America and EDIFACT-based e-business frameworks, e.g. EDIFICE, for the rest of the world, especially for Europe. Moreover, EDI-based industry-specific e-business frameworks are mostly modified subsets of ASC X12 and EDIFACT. This improves the compatibility between different EDI-based e-business frameworks but impairs the possibilities of taking into account industry-specific needs. For example, GCA EDI has concentrated on the publishing industry and EDIPAP on the paper industry, whereas papiNet covers both of these industries as well as the wood products industry. It is also necessary to remember that all cross-industry-document and industry-specific e-business frameworks do not specify only business documents. They can specify business processes in which standardized business documents are exchanged [21]. Many XML-based e-business frameworks, e.g. papiNet and RosettaNet, but only few EDI-based e-business frameworks, e.g. EDIFICE, specify business processes. If standardized business processes have positive effects on the use of an e-business framework, EDI-based e-business frameworks lag behind XML-based e-business frameworks. In addition, there exist many XML technologies, e.g. to validate and transform the XML documents [32]. A large number of open-source tools support these technologies and IT professionals are well aware of these tools [22]. Finally, the support of some XML-based cross-industry-process and industry-specific e-business frameworks in middleware products is considerable. In 2004, the overall market share of BEA, Fujitsu, IBM, Microsoft and Oracle was nearly 60% of the middleware products [26]. The middleware products are very important in e-business because their purpose is to enable the interoperability of different information systems within and between companies. In 2005, all five leading middleware vendors supported BPEL and RosettaNet as well as ASC X12 and EDIFACT.

7. Conclusions

After comparing the use of the ASC X12, EDIFACT and XML formats in 38 e-business frameworks and the use of EDI-based or XML-based e-business frameworks in 7593 European companies, this paper provides two important findings. Firstly, the EDI

formats have retained a strong position in cross-industry-document e-business frameworks. The XML format has gained a significant footing in industry-specific e-business frameworks and dominates in cross-industry-process e-business frameworks. Although the EDI formats are older non-proprietary standards than the XML format, SDOs are not locked into the EDI formats in their e-business frameworks. The XML format seems to be superior to the EDI formats.

Secondly, the use of XML-based e-business frameworks has increased more than EDI-based e-business frameworks in 2004. The use of XML-based e-business frameworks has become more common in the new market economies, whereas the use of EDI-based e-business frameworks has remained more common in the old market economies. In addition, XML-based e-business frameworks are more widely used than EDI-based e-business frameworks in the industries for which there is an XML-based but no EDI-based industry-specific e-business framework. In other industries, the situation is the opposite. Although EDI-based e-business frameworks prevail in some countries and industries, companies are not locked into them in general. XML-based e-business frameworks seem to have significant advantages over EDI-based e-business frameworks.

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