Computers in Industry 63 (2012) 45–52

Contents lists available at SciVerse ScienceDirect

Computers in Industry

journal homepage: www.elsevier.com/locate/compind

Business-to-business integration: Applicability, benefits and barriers in the telecommunications industry

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ARTICLE INFO

Article history:
Received 3 February 2009
Received in revised form 7 August 2011
Accepted 10 October 2011
Available online 3 November 2011

Keywords:
B2Bi
Coordination costs
EDI
RosettaNet
Telecommunications industry

ABSTRACT

This paper statistically analyzes applicability of business-to-business integration (B2Bi), benefits from and barriers to electronic data interchange (EDI) and RosettaNet between major original equipment manufacturers and European operators in the telecommunications industry. Based on coordination costs and nine business processes, frequency of the business process and timeliness required in the business process have clearer positive influences on applicability of B2Bi than does accuracy required in the business process. Complexity of the business process does not have such a positive relation to this applicability. Comparison of 12 benefits and eight barriers between EDI and RosettaNet shows no considerable differences. RosettaNet yields only slightly higher direct benefits than EDI, whereas all indirect benefits from RosettaNet are significantly higher than indirect benefits from EDI. Surprisingly, barriers to RosettaNet are not lower than barriers to EDI although only a lack of knowledge on EDI or RosettaNet is a significantly higher barrier to RosettaNet.

1. Introduction

For over three decades companies have used *Electronic Data Interchange* (EDI) that is the interorganizational exchange of business documents in a structured machine-processable format [14]. There is empirical evidence that EDI can save money and time [24,32,33,40,45]. EDI is an important part of *electronic business* (e-business) that covers the use of information and communication technologies (ICT) in all kinds of business activities. However, EDI focuses on business documents. *Business-to-business* (B2B) *integration* refers to all business activities that have to do with the electronic exchange of business documents between the companies [5]. B2B integration (B2Bi) extends EDI by emphasizing that these business documents are exchanged as electronic messages following *public* business processes, i.e. business processes between the companies [5]. Respectively, business processes within the company are *private* business processes.

Standards play a key role in B2Bi [5,30,37,44]. A *data format* defines the data structures and data elements in general. *Accredited Standards Committee X12* (ASC X12), *EDI for Administration, Commerce, and Transportation* (EDIFACT), and *Extensible Markup Language* (XML) are data formats. An *e-business framework* uses a data format to specify the data structures, data elements, and their purposes in the business context [36]. ASC X12 and EDIFACT are also EDI-based e-business frameworks, whereas RosettaNet is an XML-based e-business framework.

The number of empirical studies on XML-based e-business frameworks is modest compared to EDI-based e-business frameworks [13]. Now, a few empirical studies [2,3,6,8,18,26,28] deal with RosettaNet. Transaction costs provide an approach that has been utilized in some studies on B2Bi [13]. These studies have focused on business relationships and motivation costs in terms of asset specificity or uncertainty, while business processes and coordination costs in terms of timeliness or accuracy have received very little attention. There are findings that higher frequency of transactions or complexity of products works for B2Bi [8]. Moreover, benefits from and barriers to B2Bi have been compared much more often between different kinds of companies than between EDI-based and XML-based e-business frameworks. According to some studies, RosettaNet is superior to EDI-based e-business frameworks [18,28]. This paper strives to be the first study that analyzes statistically the effects of frequency, complexity, timeliness, and accuracy on B2Bi at the level of business processes, and benefits and barriers between older EDI-based and newer XML-based e-business frameworks.

The telecommunications industry offers the possibility to study B2Bi in a context outside the typically studied automotive and retail industries [10,20,21,24,27,33,45]. In fact, only few studies have delved B2Bi in the telecommunications industry [39]. Given the growing demand for e-business in the telecommunications industry [25,39], it is important to understand factors that significantly

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doi:10.1016/j.compind.2011.10.006

facilitate or inhibit B2Bi and especially newer XML-based e-business frameworks when original equipment manufacturers (OEM) are suppliers and operators are customers. Since B2Bi can demand considerable investments, decisions about B2Bi, i.e. which business process are supported by which e-business frameworks, should be made carefully. Three research questions arise over B2Bi. How frequency or complexity of the business process or timeliness or accuracy required in the business process affects applicability of B2Bi? Are benefits from RosettaNet higher than benefits from EDI? Are barriers to RosettaNet lower than barriers to EDI? In this paper, EDI refers to certain EDI-based e-business frameworks, i.e. ASC X12, EDIFACT, EDI Forum for Companies with Interests in Computing, Electronics, and Telecommunication (EDIFICE), and Electronics Industry Data Interchange (EIDX), which have been used in the telecommunications industry. B2Bi covers both EDI and RosettaNet.

The paper proceeds by introducing B2Bi, coordination costs, EDI and RosettaNet, the telecommunications industry, business processes, and benefits and barriers. Next, the paper presents the research approach which is based on the survey data of perceptions and the statistical analysis of sample means. Then, the paper studies one factor measuring and four factors explaining applicability of B2Bi in nine business processes, and 12 benefits from and eight barriers to EDI and RosettaNet. The factors explaining applicability are based on coordination costs [29,31,50,51]. The benefits and barriers partly follow some empirical studies [4,12,20,34]. Finally, the paper discusses contributions, limitations, and further research, and presents conclusions.

2. Background

2.1. B2Bi

The purpose of B2Bi is to automate *business interactions*, i.e. the exchange of business documents in the public business process. In order to harmonize the meanings for terms, the modes of operations, and the messaging interfaces for B2Bi, the e-business frameworks specify the business documents, business processes, and messaging [36]. Without automation of the exchange of business documents in the private business process, B2Bi does not necessary work well. Effective and efficient B2Bi may require enterprise application integration (EAI) and even business process reengineering (BPR) [22].

2.2. Coordination costs

Williamson [51] has introduced three sources of *transaction costs* that are asset specificity, uncertainty, and *frequency*. Transaction costs can be divided into *motivation costs* that are associated with incentives and *coordination costs* that stem from information processing and communication [31]. Asset specificity and uncertainty cause motivation costs, while frequency also affects coordination costs. Milgrom and Roberts [31] recognize *complexity* of the transaction that is the connectedness of the transaction to other transactions. Malone et al. [29] propose complexity of the product description that is the amount of information needed to specify a product. Moreover, delays and errors result in coordination costs [31]. *Timeliness* reflects how less the system state differs from the real-time state, whereas *accuracy* depicts the similarity between the system state and the real-world state [50]. The system can get stuck in the past state due to the delay or end up in the fallacious state due to the error.

The frequency or volume of transactions has been found to facilitate B2Bi [8,46]. When transactions recur with higher frequency, investments in integration are easier to recover [51]. Considering B2Bi, frequency of the business process is proportional to the periodic volume of business interactions. For these reasons, applicability of B2Bi should be higher/lower in a more/less frequent business process. The complexity of products has also been observed to advance B2Bi [8]. Products with complex descriptions are more likely to be obtained through integration [29]. Complexity of the business process refers to the information in business interactions and the dependences between business interactions. A more complex business process demands more information processing and communication due to a larger amount of information in a business document or a greater number of business documents than a less complex business process. Since B2Bi can reduce information processing and communication costs [33], applicability should be higher/lower in a more/less complex business process.

The empirical studies on timeliness and accuracy in B2Bi are rare although B2Bi can reduce delays and errors [32,40,45]. Timeliness required in the business process is associated with the costs of delays and accuracy required in the business process is related to the costs of errors in business interactions. Based on the theoretical considerations [48,50], applicability should be higher/lower in a business process requiring higher/lower timeliness or accuracy. If the cost of the delay is high, the business process requires high timeliness, and the duration of the delay should be small in the business interaction. Respectively, the business process requires high accuracy, and the probability of the error should be small in the business interaction when the cost of the error is high.

2.3. EDI and RosettaNet

ASC X12 is an EDI-based e-business framework for all industries in North America, and EDIFACT for all industries, especially in Europe. They specify the structure of business documents and provide a dictionary of terms for these business documents. Furthermore, EDIFICE is an EDI-based e-business framework for the European electronics and ICT industries, and EIDX for the North American electronics and ICT industries. For a part of business documents, EDIFICE is a modified subset of EDIFACT and EIDX a modified subset of ASC X12. However, EDIFICE and EIDX are more comprehensive than ASC X12 and EDIFACT. They provide guidelines for public business processes where business documents are exchanged. They also recommend EDI over the Internet (EDIINT) in messaging instead of the value-added networks (VAN).

RosettaNet is perhaps the most successful XML-based e-business framework [11]. It has been designated for the electronics, ICT, and logistics industries in the worldwide. RosettaNet covers business documents, business processes, and messaging. The corner stone of RosettaNet is Partner Interface Process (PIP) that provides a building block of the business process. PIPs are detailed specifications of the public business processes and associated business documents. They set requirements for quality of service (QoS) in B2Bi. RosettaNet also includes RosettaNet Business Dictionary and RosettaNet Technical Dictionary which provide terms for the PIPs. RosettaNet Implementation Framework is the messaging interface used to execute the PIPs over the Internet.

Nurmilaakso [35] argues that since companies have not locked into EDI-based e-business frameworks such as ASC X12, EDIFACT, EDIFICE, and EIDX, XML-based e-business frameworks such as RosettaNet have advantages. EDI-based e-business frameworks have disadvantages in terms of inflexibility and costs, and their use is limited to a few business processes [18,28,38]. Correspondingly, XML-based e-business frameworks are mostly global, can take into account industry-specific needs in detail, rely on widespread technologies, and often specify business processes and messaging

Table 1
Studied business processes.

Business process	Definition	Reference	%[a]
1. Order creation	An operator issues, changes, or cancels an order, and an OEM confirms the order, its change, or cancellation.		42
2. Payment	An OEM issues an invoice, and an operator issues a remittance advice or rejects the invoice.		14
3. Shipment	An OEM sends a shipment notification, and an operator reports the receipt of a shipment.		13
4. Collaborative forecasting	An operator sends long-term or short-term demand forecasts to an OEM.	[16]	23
5. Inventory reporting	An OEM and an operator exchange inventory reports.	[49]	
6. Product information	An OEM distributes new product information (e.g. a catalog) or product information changes, or an operator queries product information.	[15]	2
7. Collaborative design	An OEM and an operator collaborate in designing new products and their revisions.	[43]	3
8. Product configuration	An operator develops a custom configuration of the products with an OEM.	[17]	0
9. Ticketing	An operator initiates case information (e.g. a technical problem), and an OEM confirms the revised case information (e.g. a technical solution).	[47]	

[a] Percentage of RosettaNet Council member implementations in 2003 [41]. Collaborative manufacturing with the share of 3% was excluded.

interfaces [35]. RosettaNet is the first e-business framework specifying both business documents, business processes, and messaging, and its standardization is incremental and strongly driven through pilot implementations by the industry [37]. Especially PIPs are regarded as a major advantage of RosettaNet [3,6,18,28]. RosettaNet is expected to enable a richer collaboration [6]. According to Bala and Venkatesh [3], RosettaNet is critical for performance in industries such as telecommunications that have faced significant financial challenges. In all, if a new standard does not outperform older standards, it hardly gets a footing in the industry. The advantages have to be significant to break a lock-in. Therefore, benefits from RosettaNet should be higher than benefits from ASC X12, EDIFACT, EDIFICE, and EIDX. In addition, barriers to RosettaNet should be lower than barriers to ASC X12, EDIFACT, EDIFICE, and EIDX.

2.4. Telecommunications industry

The telecommunications industry has undergone major changes during the past decade. Deregulation of telecommunication service markets and globalization of OEMs and operators are such changes [25,39]. Another distinguishing feature is that OEMs extensively use outsourcing [1]. Electronics manufacturing service providers (EMS) have increased their share of design and manufacturing of network equipment goods. In addition, the OEMs have electronics suppliers that manufacture electronic components and semiconductors. The OEMs develop and manufacture the various network equipment goods such as base stations, network switching systems, routers, and switches that the operators acquire to build fixed and mobile telecommunication networks. In addition, the OEMs provide maintenance, repair, and operations services (MRO) to the operators. The operators offer voice and data services to consumer and business customers. Fig. 1 illustrates OEMs and operators in the telecommunications industry.

Interestingly, some major OEMs extensively use B2Bi with their suppliers, whereas some European operators are both VAN and Internet service providers to their customers. However, B2Bi between these OEMs and operators has been quite limited. Now, fierce competition has forced both OEMs and operators to seek efficiency by B2Bi. For some years major OEMs and European operators have actively participated in the standardization of e-business frameworks, especially EDIFICE and RosettaNet. For example, RosettaNet Telecommunications Industry Council was established in 2003.

2.5. Business processes

Table 1 gives more information about the chosen business processes. We regard the business processes 1–3 as traditional, 4–6 as modern, and 7–9 as future areas of B2Bi. Order creation, payment, and shipment are traditional areas of B2Bi. They constitute the ground of B2B *electronic commerce*. Of future areas, EDI has enabled to a very limited extent collaborative design, whereas RosettaNet provides significant improvements to exchange of product design information. The same applies even more to ticketing that is an important part of MRO. Product configuration is only business process not yet supported by EDI or RosettaNet. Modern areas cover other potential business processes in the telecommunications industry.

2.6. Benefits and barriers

Tables 2 and 3 provide information about the chosen benefits and barriers. Based on the literature [19,23], the benefits can be divided into direct 1–6 and indirect 7–12. The barriers can also be classified direct 1–4 and indirect 5–8. We argue that the direct benefits and barriers are more measurable than the indirect benefits and barriers.

3. Research approach

This paper strives to answer three research questions related to B2Bi in the telecommunications industry:

How OEMs and operators perceive that applicability of B2B in terms of necessity is affected by frequency or complexity of the business process or timeliness or accuracy required in the business process?
Do OEMs and operators perceive benefits from RosettaNet higher than benefits from EDI?
Do OEMs and operators perceive barriers to RosettaNet lower than barriers to EDI?

In the pre-study phase during October–December 2006, we conducted interviews within two major OEMs and two European operators. These interviews included questions on the role, development, and use of B2Bi in the telecommunications industry. The interviewees were directors and managers responsible for the development or use of B2Bi. The pre-study interviews provided material on potential business processes, factors measuring and explaining applicability of B2Bi as well as potential benefits from and barriers to EDI and RosettaNet. Paralleling the pre-study interviews, we developed the questionnaire. Some interviewees also commented our draft questionnaire. Along with the comments and literature, the questionnaire was refined. In order to get as many respondents as possible, we aimed to keep the questionnaire very simple. A five-point scale was utilized to measure the respondents' perceptions on applicability, benefits, and barriers.

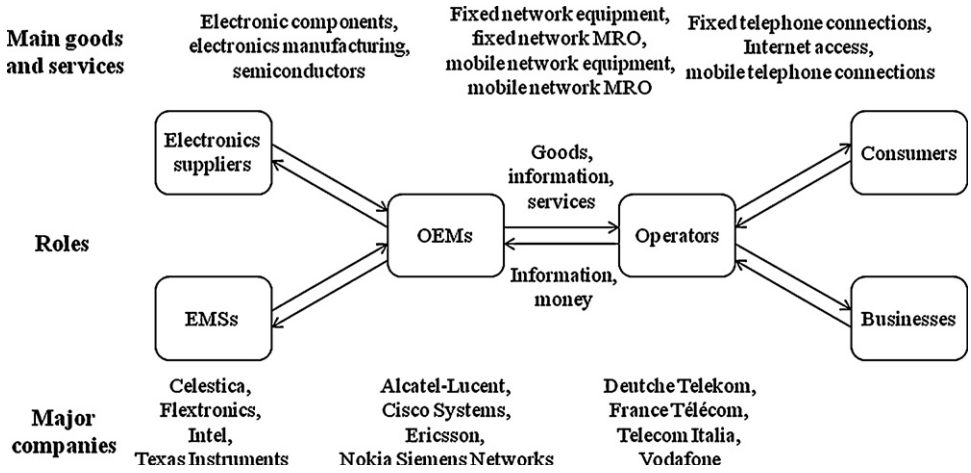

Fig. 1. OEMs and operators in the telecommunications industry.

Based on the pre-study interviews and literature, business processes in Table 1 were included in the questionnaire. For each of nine business process in the questionnaire, we asked the respondent to answer the following questions:

- Please rate how necessary do you regard B2Bi in the chosen business process with operators/OEMs (1 = not necessary, 5 = very necessary)? *Necessity* reflects applicability of B2Bi, and includes benefits, costs, and external pressure from business partners and competitors as proposed in the literature [9,19].
- Please rate how frequent do you regard the chosen business process with operators/OEMs on average (1 = very low, 3 = medium, 5 = very high)? *Frequency* measures how OEMs and operators perceived the volume of business interactions.
- Please rate how complex do you regard the chosen business process with operators/OEMs on average? *Complexity* means how OEMs and operators perceived the diversity of data in business interactions and the interdependency of business interactions.
- Please rate how time-critical do you regard the chosen business process with operators/OEMs on average? *Timeliness* measures how OEMs and operators perceived the timeliness of business interactions.
- Please rate how error-critical do you regard the chosen business process with operators/OEMs on average? *Accuracy* means how OEMs and operators perceived the accuracy of data in business interactions.

Table 2
Studied benefits from B2Bi.

Benefit	Reference
1. Reduces manual workload in data processing	[4,6,9,19–21,27,33,34,42]
2. Improves speed of business interactions	[4,6,9,20,21,23,27,32,34,40,42]
3. Reduces errors in business interactions	[4,6,9,20,21,27,32,34,40,42,45]
4. Reduces data transmission costs	[6,9,19,23,27,42]
5. Reduces inventory costs	[4,9,19–21,24,27,33,34,42]
6. Improves cash flow	[19,21,34]
7. Enables e-business with many potential business partners	[6,21]
8. Supports BPR	[9,10,24,34,40,42]
9. Enables better control of supply/demand processes	[27]
10. Improves customer/supplier responsiveness	[6,20,34]
11. Enables new business models	[10,24,40,45]
12. Improves business relationships	[4,19,21,23,27,34,42]

The questionnaire also contained benefits and barriers shown in Tables 2 and 3 that were selected on the basis of the pre-study interviews and literature. For each of 12 benefits and eight barriers in the questionnaire, we asked the respondent to answer the following questions:

- How do you see the chosen benefit from EDI with operators/OEMs compared to the situation without B2Bi (1 = strongly disagree, 5 = strongly agree)?
- How do you see the chosen benefit from RosettaNet with operators/OEMs compared to the situation without B2Bi?
- How do you see the chosen barrier to EDI with operators/OEMs compared to the situation without B2Bi?
- How do you see the chosen barrier to RosettaNet with operators/OEMs compared to the situation without B2Bi?

In the data collection phase during December 2006–September 2007, one contact who had participated in the standardization of EDIFICE and RosettaNet helped us to find other contacts familiar with EDI and RosettaNet. The questionnaires were sent via e-mail to 48 contacts within five major OEMs and five European operators. Eight of these companies had used ASC X12, EDIFACT, EDIFICE, or EIDX, while eight companies had RosettaNet in use. The contacts were mainly managers with responsibility related to e-business. 36 contacts responded to the questionnaires. As respondents 29 contacts from ten companies evaluated all five factors at least in eight business processes, 27 contacts evaluated at least 11 benefits from both EDI and RosettaNet, and 26 contacts evaluated at least seven barriers to both EDI and RosettaNet.

The data analysis phase was based on the statistical analysis of the respondents' perceptions. One-tailed tests of sample means were utilized in answering the research questions. The purpose was to find statistically significant differences between two

Table 3
Studied barriers to B2Bi.

Barrier	Reference
1. High implementation costs	[20,23,34,46]
2. High operating and maintenance costs	[20,23,46]
3. Low volume of business interactions	[9,46]
4. Lack of EAI	[9]
5. Most of current business partners do not support EDI or RosettaNet	[9,20,34]
6. Lack of knowledge on EDI or RosettaNet	[20,23,34]
7. Lack of e-business expertise	[20,23]
8. Lack of top management support	[9,20,34]

Table 4
Statistical results of perceived applicability of B2Bi in the business processes.

Business process[a]	Necessity	Frequency	Complexity	Timeliness	Accuracy	Respondents
1. Order creation	4.552^{+++} (0.686)	4.276^{+++} (0.882)	2.862^{--} (0.99)	4.414^{+++} (0.682)	4.69^{++} (0.541)	29
2. Payment	4.517^{+++} (0.95)	4.103^{+++} (1.145)	2.862^{-} (1.125)	4.138^{++} (0.743)	4.724^{+++} (0.528)	29
3. Shipment	4.31^{+} (0.761)	4.207^{+++} (0.902)	2.724^{--} (1.066)	4.414^{+++} (0.682)	4.414 (0.733)	29
9. Ticketing	4.138^{+} (0.875)	3.862^{++} (1.026)	3.207 (1.014)	4.31^{+++} (0.806)	4.345 (0.857)	29
8. Product configuration	3.786 (0.995)	3.286 (1.15)	4.286^{+++} (0.713)	3.464 (1.201)	4.464^{+} (0.881)	28
4. Collaborative forecasting	3.586^{-} (1.086)	2.69^{---} (0.968)	3.379 (0.942)	3.035^{--} (1.18)	3.552^{---} (0.985)	29
5. Inventory reporting	3.586^{-} (1.086)	3.069^{-} (0.923)	2.897^{-} (0.9)	3.0^{--} (1.165)	3.724^{--} (1.099)	29
6. Product information	3.5^{-} (1.036)	2.393^{---} (0.956)	3.536 (1.071)	3.143^{--} (0.971)	4.143 (1.044)	28
7. Collaborative design	2.593^{---} (0.931)	2.148^{---} (0.818)	4.074^{+++} (1.035)	2.407^{---} (1.01)	3.704^{--} (1.235)	27
Summary	3.852 (1.094)	3.35 (1.232)	3.304 (1.108)	3.603 (1.175)	4.198 (0.982)	

[a] Ordered by *Necessity*.
$^{+}$/$^{-}$Statistically higher/lower than others on average at the 0.1 level, $^{++}$/$^{--}$at the 0.01 level, $^{+++}$/$^{---}$at the 0.001 level.

samples, i.e. different business processes or EDI and RosettaNet, in respect of some factor, i.e. a factor measuring or explaining applicability, a benefit or a barrier. In one-tailed tests, we used the Mann–Whitney *U* test that is a well-known non-parametric test. The Mann–Whitney *U* test is robust to the violation of normality assumption even the sample size is small.

4. Analysis

4.1. Applicability of B2Bi

Table 4 summarizes means and standard deviations of the factors *Necessity*, *Frequency*, *Complexity*, *Timeliness*, and *Accuracy*. The analysis of the statistical results in Table 4 revels three patterns. Except for product configuration, all the factors *Necessity*, *Frequency*, and *Timeliness* are either significantly higher or lower in a business process. Moreover, a business process with the significantly higher/lower factor *Necessity* does not have the significantly lower/higher factor *Accuracy*. With regard to the factor *Complexity*, there seems to be an opposite pattern but inventory reporting deviates from this pattern. These patterns support the following finding.

> B2Bi is more/less applicable in more/less frequent business processes requiring higher/lower timeliness and accuracy. However, frequency of the business process and timeliness required in the business process have clearer positive associations with applicability of B2Bi than does accuracy required in the business process. Complexity of the business process does not affect positively this applicability.

B2Bi has the highest necessity in order creation and payment but the lowest necessity in collaborative design. Shipment and especially payment are important, whereas B2Bi in ticketing provides new opportunities in the telecommunications industry. On the one hand, collaborative forecasting or inventory reporting that support collaborative planning, forecasting, and replenishment or vendor-managed inventory has not replaced order creation in the telecommunications industry [26] as they have partly done in the retail industry [10,24]. Since network equipment goods are very expensive, it is likely that OEMs make to orders, and operators order on demand. On the other hand, order creation does not always require product information or product configuration. Collaborative design is common between EMSs and OEMs [1] but not between OEMs and operators.

As expected, frequency of the business process and timeliness required in the business process have a strong positive effect, and accuracy required in the business process a weak positive effect on necessity of B2Bi. Surprisingly, complexity of the business process does not have a positive effect. The strong effects separate the more applicable business processes 1–3 and 9 from the less applicable ones 4–7. When the weak effects are also taken into account, the most applicable business processes 1–2 can be distinguished from the others. The influence of frequency of the business process fits well with previous studies on frequency or volume of transactions [8,46]. Frequency aggregates all kinds of coordination costs whether they result from information processing, communication, delays, or errors. The high volume of business interactions can justify B2Bi although the benefits from B2Bi in a single instance of a business process are low. Since OEMs and operators strive to reduce additional uncertainty [1], accuracy and especially timeliness are important. Delays and errors also cause conflicts between an OEM and an operator, and thus impair their business relationship. Business processes requiring high timeliness and accuracy tend to be business-critical. Compared to complexity of products which has a positive effect on B2Bi [8], complexity of the business process seems to have no such influence. Possibly, the costs of B2Bi in a more complex business process are so high that they exceed the benefits from B2Bi.

4.2. Benefits from EDI and RosettaNet

Table 5 contains means and standard deviations of benefits. Table 5 leads to the following finding.

> Although benefits from RosettaNet are higher than benefits from EDI, only all indirect benefits are significantly higher benefits from RosettaNet.

According to the statistical analysis, improved speed, reduced errors, and reduced manual workload are the most important benefits from B2Bi. They have also been shown by empirical studies [32,33,40,45]. Of course, B2Bi alone cannot result in these benefits if data quality is poor [48]. Also in the telecommunications industry companies see B2Bi primarily as a tool for operational efficiency rather than a means for strategic advantages [2]. Except for reduced inventory costs, direct benefits are higher than most of indirect benefits. B2Bi can reduce inventory costs by improving inventory turnover [24,33] but this benefit is least important in the telecommunications industry. OEMs and operators seem to prefer other means to minimize inventories.

Comparison of benefits confirms that RosettaNet as an XML-based e-business framework has some advantages over EDI-based e-business frameworks [35]. However, it is important to note that there are no statistically significant differences between RosettaNet and EDI for six of 12 benefits. In particular, the three highest benefits from B2Bi, i.e. improved speed, reduced errors, and reduced manual workload, seem equal for EDI and RosettaNet. This is consistent with Downing [12] who shows that the performance effects of B2Bi over the Internet do not exceed the performance effects of B2Bi over the VANs. For a part of indirect benefits, RosettaNet is on the cutting edge. In a way, this reflects that RosettaNet is more detailed than EDI. RosettaNet has enabled new business models. The best example is B2Bi in ticketing that benefits

Table 5
Statistical results of perceived benefits from EDI and RosettaNet.

Benefit[a]	B2Bi[b]	EDI	RosettaNet	Respondents
2. Improves speed of business interactions	4.444 (0.691)	4.296 (0.823)	4.593 (0.501)	27
3. Reduces errors in business interactions	4.426 (0.633)	4.37 (0.688)	4.482 (0.58)	27
1. Reduces manual workload in data processing	4.278 (0.685)	4.222 (0.751)	4.333 (0.62)	27
12. Improves business relationships	4.115 (0.832)	3.962^{-} (0.871)	4.269^{+} (0.778)	26
10. Improves customer/supplier responsiveness	4.111 (0.664)	3.926^{-} (0.73)	4.296^{+} (0.542)	27
4. Reduces data transmission costs	3.963 (0.8)	3.852 (0.77)	4.074 (0.829)	27
6. Improves cash flow	3.944 (1.036)	3.852 (1.064)	4.037 (1.018)	27
9. Enables better control of supply/demand processes	3.926 (0.723)	3.741^{-} (0.712)	4.111^{+} (0.698)	27
11. Enables new business models	3.759 (0.751)	3.37^{---} (0.629)	4.148^{+++} (1.035)	27
7. Enables e-business with many potential business partners	3.667 (1.028)	3.407^{-} (0.971)	3.926^{+} (1.035)	27
8. Supports BPR	3.63 (1.033)	3.296^{--} (1.031)	3.963^{++} (0.94)	27
5. Reduces inventory costs	3.556 (1.058)	3.407 (1.047)	3.704 (1.068)	27

[a] Ordered by B2Bi.
[b] Average of *EDI* and *RosettaNet*.
$^{+}$/$^{-}$Statistically higher/lower at the 0.1 level, $^{++}$/$^{--}$at the 0.01 level, $^{+++}$/$^{---}$at the 0.001 level.

operators in requesting with technical problems and OEMs in responding with technical solutions. The first implementation was brought in use in 2007. By specifying public business processes, RosettaNet support BPR which in turn mitigates B2Bi. Since B2Bi with RosettaNet can be implemented with widespread technologies such as XML Schema and Extensible Stylesheet Language Transformations, RosettaNet enables e-business with more business partners than EDI. RosettaNet can also enable better control of processes and improve more responsiveness than EDI because of requirements for QoS. For example, an acknowledgement message and, if necessary, a response business document have to be sent within a certain period of time when a request business document has been received. With regard to improved business relationships, it is not clear why RosettaNet overperforms EDI in this benefit. One explanation might be that RosettaNet causes fewer conflicts between OEMs and operators during both implementation and use than EDI. How the standardization of RosettaNet [37] is carried out can reduce these conflicts. Although RosettaNet is more attractive, in particular for indirect benefits, it seems not be a completely superior to EDI as it has been suggested [18,28].

4.3. Barriers to EDI and RosettaNet

Table 6 includes means and standard deviations of barriers. Table 6 results in the following finding.

> Barriers to RosettaNet are higher than barriers to EDI but only a lack of knowledge on EDI or RosettaNet is a significantly higher barrier to RosettaNet.

The statistical analysis shows that a lack of EAI is ranked in the top. Without EAI, it is very difficult to adopt B2Bi if a company utilizes several information systems in its business processes. In addition, a lack of e-business expertise, a lack of knowledge on EDI or RosettaNet, and a lack of top management support are considered as serious barriers to B2Bi. Announcements and training on EDI and RosettaNet provides a way to tackle these barriers. Although implementation costs, and operating and maintenance costs are not among the most serious barriers, RosettaNet is working to reduce them [11]. RosettaNet Automated Enablement is an example of this work.

The only statistically significant difference in barriers between EDI and RosettaNet is a lack of knowledge on EDI or RosettaNet although RosettaNet has higher barriers. According to Lu et al. [26], critical success factors for RosettaNet are very similar to EDI. The same applies to barriers. Higher barriers to RosettaNet can result from its strict requirements for QoS such as confidentiality and integrity. The relative newness of RosettaNet compared to EDI can also explain higher barriers. Furthermore, EDIINT has become well-known and EDI has increasingly migrated from the VANs to the Internet. This may have cut differences in implementation costs as well as operating and maintenance costs between EDI and RosettaNet. Focusing on a lack of knowledge on EDI or RosettaNet, RosettaNet Telecommunications Council should be worried about this barrier which definitely prefers EDI. At the moment, it seems not to be realistic to say that RosettaNet fixes all the shortcomings of EDI and overcomes the challenges of B2Bi.

5. Discussion

The contribution of the paper is in creating an understanding of B2Bi in the telecommunications industry. The first objective of this paper was to analyze how coordination costs of the business process in terms of frequency and complexity of the business process, and timeliness and accuracy required in the business process explain applicability of B2Bi in terms of necessity. The second objective was to compare benefits and barriers between older EDI-based and newer XML-based e-business frameworks. In

Table 6
Statistical results of perceived barriers to EDI and RosettaNet.

Barrier[a]	B2Bi[b]	EDI	RosettaNet	Respondents
4. Lack of EAI	3.615 (0.953)	3.577 (0.945)	3.654 (0.977)	26
7. Lack of e-business expertise	3.596 (1.015)	3.423 (1.065)	3.769 (0.951)	26
6. Lack of knowledge on EDI or RosettaNet	3.519 (0.896)	3.308^{-} (0.788)	3.731^{+} (0.962)	26
8. Lack of top management support	3.404 (0.913)	3.308 (0.884)	3.5 (0.949)	26
1. High implementation costs	3.385 (0.911)	3.269 (0.974)	3.5 (0.949)	26
3. Low volume of business interactions	3.24 (0.981)	3.16 (0.987)	3.32 (0.988)	25
2. High operating and maintenance costs	2.904 (0.934)	2.885 (0.993)	2.923 (0.891)	26
5. Most of current business partners do not support EDI or RosettaNet	2.865 (1.067)	2.654 (0.977)	3.077 (1.129)	26

[a] Ordered by B2Bi.
[b] Average of EDI and RosettaNet.
$^{+}$/$^{-}$Statistically higher/lower at the 0.1 level.

the scientific contribution, this paper extends previous studies [8,48] by focusing on business processes, and taking into account frequency and complexity as well as timeliness and accuracy. According to the statistical tests, frequency, timeliness, and to some extent accuracy facilitate this applicability in the telecommunications industry. In addition, this paper extends studies [4,12,20,34] that have ranked benefits from and barriers to B2Bi, or compared them between different kinds of companies or between the VANs and the Internet. The statistical tests show that RosettaNet as a new XML-based e-business framework has advantages over EDI in the telecommunications industry although these advantages are not nearly as large as anticipated. The practical contribution is that companies, especially OEMs and operators in the telecommunications industry that would like to bring B2Bi in use or increase this use are able to make plans based on the findings from this paper.

Two limitations of this paper should be noted. Firstly, finding difficulties in gaining access to companies in the telecommunications industry, our data sample is very limited. It covers 25–29 responses from five major OEMs and five European operators. Moreover, the responses are weighted towards large companies. These can limit the generalizability of the findings. Secondly, the findings are based on subjective perceptions, not objective measures. A problem is that sample companies may be unwilling to supply exact data when they are competitors, or they may not even have such data. For these reasons, our findings must be interpreted with caution outside the telecommunications industry.

The differential value of newer XML-based e-business frameworks over older EDI-based e-business frameworks deserves attention in further research. Further research is needed to find appropriate objective measures of coordination costs. For a part of timeliness, accuracy, and especially complexity, this is a challenge. In addition, further research in other industries, with other e-business frameworks and with small companies would be useful to verify the findings presented in this paper.

6. Conclusions

After statistically analyzing applicability of B2Bi in nine business processes between major OEMs and European operators, and 12 benefits from and eight barriers to EDI, i.e. ASC X12, EDIFACT, EDIFICE, and EIDX, and RosettaNet in the telecommunications industry, this paper provides three findings. Firstly, B2Bi is more/less applicable in more/less frequent business processes requiring higher/lower timeliness and accuracy. However, accuracy required in the business process does not influence applicability as strongly as frequency of the business process and timeliness required in the business process. Like higher frequency of transactions [8], higher frequency of the business process facilitate B2Bi. For a part of timeliness and accuracy required in the business process, this paper presents completely new findings. We anticipated that complexity of the business process has a positive effect on applicability but we did not observe evidence for this. Unlike higher complexity of products [8], higher complexity of the business process does not facilitate B2Bi. In the telecommunications industry, B2Bi is most applicable in order creation and payment but least applicable in collaborative design. In addition, shipment and ticketing are more applicable business processes, while product configuration, collaborative forecasting, inventory reporting, and product information are not. As there exists a multi-criteria method for selection of an e-business framework [7], an approach to evaluation of B2Bi in different business processes seems to have been missing. The paper provides such an approach to the telecommunications industry. We suggest that the analysis of frequency, timeliness, and accuracy in business processes is also useful in other industries when business partners plan B2Bi.

Secondly, benefits from RosettaNet are higher than benefits from EDI as we expected. Improved speed, reduced errors, and reduced manual workload were regarded as the main benefits from B2Bi. Thirdly, we were surprised that barriers to RosettaNet are not lower than barriers to EDI. A lack of EAI and a lack of e-business expertise were perceived as the major barriers to B2Bi. The benefits from RosettaNet have to be much higher than the barriers to RosettaNet. Otherwise, RosettaNet would not have gained a footing in the telecommunications industry. We did not find statistically significant differences in benefits and barriers between EDI and RosettaNet, except for all indirect benefits such as enabling new business models and supporting BPR, and a lack of knowledge on EDI or RosettaNet. This reflects that RosettaNet might not be that superior to EDI as proposed in the literature [18,28]. Therefore, it should be no surprise that EDI is still alive and well [2].

Acknowledgements

The authors gratefully acknowledge funding from the Finnish Funding Agency for Technology and Innovation (TEKES) for the conduct of this research, and referees for their comments. Participation of the ten companies supplying data is also recognized.

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