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Christine Legner

Institute of Research on Information Systems, European Business School (EBS), christine.legner@ebs.edu

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European Business School (EBS), christine.legner@ebs.edu

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Christine Legner, European Business School (EBS), Rheingaustr. 1, 65375 Oestrich-Winkel, Germany, christine.legner@ebs.edu

Abstract

The need for collaboration within value chains is rapidly increasing and drives enterprise to align and electronically integrate their business processes with their business partners. As technologies evolve, manifold forms of B2B integration have emerged – from e-mail communication to customer or supplier portals, the exchange of EDIFACT- to XML documents, and Web Services. Although service-oriented architectures (SOA) are considered the future of inter-organizational linkages, no empirical studies have been found which surveyed the impact of SOA on B2B integration costs and benefits. From a research perspective, we still lack a systematic analysis that explains how a specific B2B integration technology impacts the effectiveness of B2B integration.

Building on transaction cost theory, this research analyzes the different forms of B2B integration with regard to their impact on connectivity and coordination costs. Based on a field study from the automotive industry, it demonstrates that there is economic rationale for preferring supplier portals to machine-to-machine integration based on EDIFACT or XML messages. Compared to prior technologies, SOA reduces the costs of external integration by eliminating separate B2B integration infrastructures and improving connectivity of internal applications. However, we find that prior literature tends to overestimate the impact of open Internet and Web service technologies on connectivity costs.

Keywords: B2B integration, e-business, electronic data interchange, inter-organizational systems, transaction costs, Service-oriented architecture (SOA)

1   INTRODUCTION

The need for collaboration within value chains is rapidly increasing in many industries and drives enterprise to align and electronically integrate their business processes with their business partners. A huge growth of inter-organizational process integration is projected in the coming years due to the following three factors. First, enterprises increasingly realize that they gain competitive advantage by intensifying their customer interactions, concentrating on core competencies and augmenting the level of external sourcing (Dyer and Singh 1998; Venkatraman and Henderson 1998). This is underpinned by prominent examples from the automotive industry (Dannenberg and Kleinhans 2004) and financial services (Sydow et al. 1998). Second, companies have significantly increased internal process and systems integration over the past decade which is considered a major enabler of external integration (Zhu et al. 2006; Zhu et al. 2004). Third, inter-organizational systems technology has been completely overhauled since the mid 1990s by the emergence of the Internet. Today, the Internet provides a widely accepted infrastructure for e-business. Web services and service-oriented architectures (SOA) have emerged as an enhanced concept for integration in heterogeneous environments and are expected to stimulate inter-organizational process integration (Daniel and White 2005; Hagel and Brown 2001).

Inter-organizational systems (IOS) have been intensively studied since the 1960s, when the online airline ticketing system SABRE and other early forms of IOS established electronic linkages between business partners. Despite the vast body of IOS research that analyzes characteristics and benefits of B2B integration (e.g. Choudhury 1997; Massetti and Zmud 1996; Mukhopadhyay and Kekre 2002; Saeed et al. 2005), little research has been conducted so far with regard to analyzing and comparing the different forms of B2B integration and their effectiveness. While there is consent that the use of electronic channels reduces transaction costs (Grover et al. 2002; Malone et al. 1987), it is not well understood how technology choices affect the savings. In collaborative B2B relationships, business partners negotiate mid- to long-term contractual agreements that govern a larger number of transactions (Christiaanse et al. 2004; Clemons and Row 1992; Grover et al. 2002). As they seek investments in electronic linkages in order to reduce high-perceived transaction costs, they have the choice between manifold B2B integration options, from e-mail communication to customer or supplier portals, the exchange of EDIFACT- to XML documents, and Web Services. This paper takes on these challenges and aims at answering the following research questions:

1. How do different forms of B2B integration impact transaction costs in B2B relationships?

2. Is there empirical evidence that Web services and SOA overcome the shortcomings of prior forms of B2B integration and thereby are more likely to experience broad adoption?

Building on transaction cost theory and prior IOS literature, the author suggests distinguishing connectivity costs and coordination costs when analyzing the effectiveness of different forms of B2B integration. The resulting model has been applied in the automotive industry in order to explore the costs and benefits of B2B integration. While the field study presents a first attempt towards measuring transaction costs of electronic B2B relationships, the main contribution of this paper is the conceptual model and the operationalization of transaction cost elements. Hence, this research is intended to further stimulate the academic discourse on the effectiveness of B2B integration and the measurement of transaction costs in electronic B2B relationships.

The remainder of this article is structured as follows: The next section outlines the research methodology. From the review of prior research on IOS and transaction cost theory, we subsequently derive a conceptual model for analyzing different forms of B2B integration and their effectiveness. By applying the model in a field study in the automotive industry, we were able to explore the impact of five different forms of B2B integration on transaction costs. The article concludes with a summary of the insights related to current forms of B2B integration and the impact of service-oriented concepts.

2 RESEARCH METHOD

In view of the research objectives, we adopted an exploratory research design. Using transaction cost economics as a framework of analysis, the aim was to explore how the different forms of B2B integration impact the transaction costs. In a first step, a literature review was performed in order to systemize the different forms of IOS and to identify different transaction cost elements that characterize B2B integration. Given the lacking measurement approaches employed in the transaction cost literature, we derived a refined model that comprises the main transaction cost elements in B2B integration. The second step in the research process involved the collection and analysis of data that are related to the different forms of B2B integration and their impact on transaction costs. Since many industries either have limited experience with electronic integration or strongly rely on a dominant form of B2B integration (European Commission 2007), we had to carefully select a scenario that would provide the possibilities of analyzing and comparing different forms of B2B integration. In addition, accessibility of data was an important factor. For the purpose of gathering data from different B2B integration variants, we decided to focus on the specific scenario of engineering change management in the automotive industry. The following criteria were decisive: (1) The automotive industry has broad experience in B2B integration due to its long history in EDI-based supplier relationships. In this regard, automotive manufacturers and suppliers are aware of the various issues involved in B2B integration and can also be considered "IT-savvy". (2) Engineering change management has been subject to a recent industry standardization initiative by the Association of German Automotive Manufacturers (VDA). This initiative resulted in VDA Recommendation 4965 which represents a well-documented and comprehensive industry standard. In view of the wide range of implementation variants, which range from manufacturer-neutral clients to EDI, automotive companies are pressing for solutions that have greater interoperability through SOA and Web services.

Over a period of 15 months, from October 2005 to February 2007, the author was heading a research team that conducted a field study in the automotive industry. As an active member of the VDA initiative on Engineering Change Management (VDA ECM), the research team participated in regular working meetings and contributed to the specification of XML messages. In addition, it supported a sub-group of the VDA initiative in designing a service-oriented architecture for the electronic integration of their engineering change management processes. This sub-group consisted of one automotive OEM and four suppliers, and was supported by several technology providers. This activity implied intensive collaboration between all participants. The results were a pilot implementation of the ECM scenarios based on SOA and an in-depth evaluation of the suggested approach compared to the more traditional forms of B2B integration. The evaluation was performed based on the conceptual model presented in this paper. It builds on the experiences from the pilot implementation and estimations that the automotive experts gained when realizing other B2B integration projects.

3 PRIOR RESEARCH

3.1 Inter-organizational Systems (IOS)

According to Johnston and Vitale (1988) and Hong (2002), inter-organizational systems (IOS) are network-based information systems that transcend organizational boundaries. The many different forms of IOS that exist currently reflect the evolution of B2B integration technologies. They range from the first EDI-based systems that were established in the 1960s to the Internet that gave raise to the concepts of e-business and e-commerce, and, more recently, Web services and Service-oriented Architectures. Many scholars argue that service-oriented concepts will provide a more cost-effective e-business platform than traditional EDI systems (Dorn et al. 2009; Legner and Vogel 2008). They are expected to cope better with the differences in semantics and pragmatics among the different actors,

and to replace the traditional document-centric approaches to B2B integration by a process-centric approach. IS researchers have proposed various categorization schemes and modes in order to systemize the different levels of external integration and their support for different types of supplier-buyer relationships (e.g. Choudhury 1997; Massetti and Zmud 1996; Mukhopadhyay and Kekre 2002; Saeed et al. 2005). IOS can be classified according to the type of electronic interaction that they support and the topology of the IT-supported inter-firm relationship (c.f. Table 1):

- The *interaction type* depends on the communication channel (Löwer 2005; McAfee 2005; Reimers 2001): Electronic human-human-interaction describes traditional forms of interaction between humans that are supported by electronic means, e.g. e-mail or video-conferencing. In the case of human-machine-interaction, external users are gaining direct access to shared data and applications. This is typically realized by Web front-ends or portals that bundle data and applications on the basis of users and roles. Machine-machine interaction finally describes the direct communication between two information systems which eliminates human intervention. It can be achieved by file transfer or by message exchange, which are both associated with asynchronous communication, as well as by service calls.

- The *topology of the IT-enabled inter-firm relationship* refers to the relationships between the business partners (Alt 2008). 1:1 connections represent dyadic relationships, e.g. between a customer and a supplier. Over time, they often evolve into 1:n or n:1 connections when a focal firm starts linking up with a larger number of (smaller) business partners. The shift to m:n relationships requires either the adherence to widely accepted standards (Damsgaard and Truex 2000) or the existence of an intermediary that facilitates multilateral electronic relationships (Giaglis et al. 2002).

		Topology of IT-enabled inter-firm relationship			
		1:1 (dyadic)	**1:n or n:1 (focal)**	**m:n (multilateral / exchange)**	**m:n (multilateral / standard-based)**
Interaction type (Löwer 2005; McAfee 2005; Reimers 2001)	*human-human-interaction:* interaction between humans supported by electronic means	E-mail communication Online chats, Instant messaging, etc.	E-mail communication Online chats, Instant messaging, etc.	E-mail communication Online chats, Instant messaging, etc.	E-mail communication Online chats, Instant messaging, etc.
	human-machine-interaction: external users are getting direct access to data and applications	(Onsite or Web-based) access to internal applications and data for individual external users	(Web-based) access to internal applications and data for external user groups: • Extranets • Customer / supplier portals	(Web-based) access to shared applications and data: • Electronic marketplace • Exchange • Shared service	N /A
	machine-machine-interaction: direct communication between two information systems without human intervention	Direct communication between information systems based on bilaterally agreed specifications: • File transfer • Message exchange • Web services	Direct communication between information systems based on specifications that are imposed by one partner: • File transfer • Message exchange • Web services	Multilateral communication between information systems mediated by an intermediary: • Electronic marketplace • Exchange • Shared service	Multilateral communication between information systems based on standards: • File transfer • Message exchange • Web services

Table 1. Categorization of Different Forms of IOS

3.2 Transaction Cost Theory

Transaction costs, originally developed by Coase (1937), are key in explaining the impact of electronic integration and assessing its benefits. According to transaction cost theory, the most efficient form of the inter- and intra-organizational structure minimizes transaction and production costs (Rindfleisch and Heide 1997). Although the use of IT is generally considered to reduce transaction costs (Malone et al. 1987), existing studies apply transaction cost theory rather at a conceptual rather than at a measurement level. Williamson (1985) initially proposed a division between ex-ante costs (costs prior to the execution of a transaction, i.e. partner search and contract negotiation) and ex-post costs (occurring during and after a transaction, i.e. policing and enforcement costs). With respect to the shortcomings of Williamson's approach, Milgrom and Roberts (1992) propose the categorization of transaction costs into motivation and coordination costs which encompass the cost of obtaining infor-mation, the cost of coordinating the production process as well as the cost of measurement. Clemons and Row (1992) and Clemons et al. (1993) distinguish between two components of transaction costs, namely costs of coordination and costs of transaction risks. They argue that IT investments are asset-specific since they are idiosyncratic to the relationship with the other firm.

While the transaction cost-standpoint has been widely adopted in studies related to supply chain integration, outsourcing, and electronic markets, most studies are focussing on the negotiation and transaction phase. The relational perspective in transaction cost research (Christiaanse et al. 2004; Clemons and Row 1992; Grover et al. 2002) argues that it is too narrow to restrict the unit of analysis to a pure sales transaction (instead of the exchange relationship). In B2B networks, firms negotiate mid- to long-term contractual agreements that govern a larger number of transactions. In such relational structures, they may seek bilateral investments for setting up electronic linkages in order to reduce high-perceived transaction costs (Grover et al. 2002). In terms of transaction cost theory, this translates into asset-specific (or relationship-specific) investments and high transaction frequency.

4 CONCEPTUAL MODEL

Based on the relational perspective in transaction cost theory and propositions from IOS research, we suggest that two main cost elements characterize electronic B2B integration, namely connectivity and coordination costs (c.f. Table 2).

Connectivity costs denote non-recurring costs to establish an electronic business relationship. Prior literature on transaction costs emphasizes partner finding and contractual negotiation, i.e. the time spent by both transacting sides on agreeing on contractual terms. In the context of B2B integration, significant costs are incurred for the design and implementation costs of electronic process integration. Prior literature on IOS adoption emphasizes the effort to establish inter-organizational agreements (Kubicek 1992; McAfee 2005; Reimers 2001) and the internal costs incurred for implementing external process integration (Zhu et al. 2006). Since early IOS have mostly been built as proprietary systems, relationship-specific or asset-specific investments in joint infrastructure are considered to be more important in the case of older communication technology applications such as EDI and other proprietary networks. The use of open technologies, such as Web service- or XML-based applications, is expected to reduce asset-specific investments for firms (Christiaanse et al. 2004). Hence, the following cost elements that make up the connectivity costs of enterprise i connecting with n business partners can be derived:

$$C_{connect_i} = \sum_{j=1}^{n}(C_{P.agr,ij} + C_{P.impl,ij} + C_{IS.agr,ij} + C_{IS.impl,ij})$$

Costs occur for establishing inter-organizational agreements between two business partners i and j and for their subsequent (internal) implementation. Since we have to consider the organizational and the

technical aspects in setting up electronic B2B relationships, we distinguish costs at the process and IS layer. With regard to the process layer, the efforts in establishing an inter-organizational agreement on the process interaction between enterprises i and j result in $c_{P.agr,ij}$. The costs for the internal implementation of the partner-specific process and organizational changes are denoted by $c_{P.impl,ij}$. On the IS layer, $c_{IS.agr,ij}$ are the costs for the inter-organizational agreement on the IS interface (or services) and communication infrastructure, whereas $c_{IS.impl,ij}$ are the costs incurred for their implementation.

Coordination costs are the recurring costs to enable and execute a transaction. Electronic integration reduces coordination costs (Grover et al. 2002; Malone et al. 1987). However, if an IOS is used to automate an existing process, its effects are limited to reducing manual data processing and improving the reliability as well as the timeliness of information (Hoogewegen and Wagenaar 1996). As the firms progress to using IOS for closely coupling business processes between firms, they are able to realize additional benefits of vertical integration (Mukhopadhyay and Kekre 2002; Saeed et al. 2005; Zhu et al. 2004). The use of IOS is considered most beneficial if applied in cooperative relationships (Chatfield and Yetton 2000; Johnston and Vitale 1988) and accompanied by process innovation such as vendor-managed inventory or continuous replenishment in the retail and consumer goods industries (Clark and Stoddard 1996; Riggins and Mukhopadhyay 1994). The effectiveness of B2B integration can be measured by reduced coordination costs, i.e. the savings realized in executing and monitoring transactions. These savings depend on the number of transactions t_n conducted with all n business partners and the savings in coordination costs per transaction.

$$\Delta c_{coord_i} = \sum_{j=1}^{n}\sum_{k=1}^{t_n}(\Delta c_{coord,ijk})$$

Transaction phase / costs	Description	Propositions from IOS literature
Ex-ante: Connectivity costs	Non-recurring costs to establish an electronic business relationship	B2B integration relies on inter-organizational agreements (public process and IS interface specifications), while the required level of inter-organizational agreements depends on the interaction type (Kubicek 1992; McAfee 2005; Reimers 2001). Collaborative relationships imply idiosyncratic (=asset-specific) investments (Clemons et al. 1993; Clemons and Row 1992; Grover et al. 2002). Open Internet technologies decrease asset-specific investments in electronic B2B relationships (Christiaanse et al. 2004; Zhu et al. 2006). Internal adoption costs of external integration are significant (Zhu et al. 2006), given the financial investments and the complexity associated with making process changes and organizational adjustments.
Ex-post: Coordination costs	Recurring costs to enable and execute a transaction	Electronic integration reduces coordination costs (Grover et al. 2002; Malone et al. 1987). IOS are most beneficial if applied in cooperative relationships (Chatfield and Yetton 2000; Johnston and Vitale 1988) and accompanied by process innovation (Clark and Stoddard 1996; Riggins and Mukhopadhyay 1994).

Table 2. Transaction Cost Breakdown for Assessing B2B Integration

5 FIELD STUDY IN THE AUTOMOTIVE INDUSTRY

For the purpose of exploring the impact of different forms of B2B integration on transaction costs, the conceptual model has been applied in a field study in the automotive industry. The following section presents the findings of the study.

5.1 Background: Engineering Change Management in the Automotive Industry

Although it has been intensively studied for a long time, the automotive value chain is currently undergoing significant changes (Dannenberg and Kleinhans 2004; Doran et al. 2007; Seidel et al. 2005): Manufacturers are concentrating on branding and downstream activities such as marketing and aftersales, while tier-1 suppliers are increasingly taking over engineering, production and assembly of major components and even entire vehicles (Coronado Mondragon et al. 2006). Today, more than 65% of the value is created within the supplier network with a projected increase to 77% over the next decade (Dannenberg and Kleinhans 2004). With the changing roles in the automotive industry, the need for inter-organizational coordination increases and encompasses not only supply chain management, but also the innovation and product development processes. As part of product life cycle management, engineering change management refers to evaluating and deciding ideas for change as well as the implementation of the changes in development and production. Possible triggers include changes in product design or the elimination of quality and/or safety defects. Currently, suppliers are directly affected by approximately 30% of the more than 10 000 engineering changes an OEM processes per year. Engineering change management is the subject of current standardization efforts which have resulted in VDA Recommendation 4965 of the German Association of the Automotive Industry (VDA 2005) and which are currently brought to the international level.

5.2 Forms of B2B Integration

As part of the field study, five different forms of B2B integration have been analyzed. Interestingly, the group of automotive companies has never used intermediaries to electronically support interactions between OEMs and tier-1 suppliers, despite the intensive discussions in practitioner and academic publications about the role of Covisint and its recent shutdown. The companies had gained experiences with the following five different forms of B2B integration:

- **E-mail communication:** While e-mail communication represents the most widespread form of electronic interaction in the engineering change management scenario, it is mostly used to notify external partners about engineering changes and to share documents with them. Since no structured information is exchanged, e-mail communication corresponds to an electronic human-human interaction in a dyadic OEM-supplier relationship (1:1).

- **Portals:** In order to further automate and streamline their B2B interactions, OEMs have established supplier portals. These portals support interactions with suppliers and provide them with front-end access to the OEM´s internal applications, including engineering change management systems. Supplier portals are to be classified as human-machine interaction and support 1:n relationships between one OEM and its suppliers.

- **Message exchange based on individual data format:** This form of B2B integration is used if two firms bilaterally agree on a data format for exchanging engineering change messages electronically. It represents a dyadic relationship with bilateral agreements between the OEM and supplier (1:1).

- **Message exchange based on industry standard:** This option corresponds to the situation when the message format specified by the VDA ECM standard is used to electronically exchange engineering changes between business partners. In this case, multi-lateral agreements on ECM messages are a prerequisite (m:n).

- **SOA-based process integration based on industry standard:** The SOA-based approach allows for external process integration based on Web service calls. For the engineering change management scenario, the reference architecture outlined by Legner and Vogel (2008) translates the VDA recommendation into a public process model and public service interface (m:n). It has been subject of a pilot implementation.

As part of the field study, data was gathered based on prior experiences with these five forms of B2B integration and complemented with data gathered by VDA (2005). In the case of SOA-based connections, results from the pilot implementation were used. Table 3 presents an overview of the findings which will be discussed in more details in the following two sections.

5.3   Findings Related to Coordination Costs

As discussed earlier, the effectiveness of B2B integration depends on its effect on coordination costs, i.e. the savings in executing and monitoring transactions. In the specific case of engineering change management, the benefits of electronic integration only materialize if engineering changes are exchanged as structured messages that can be processed and imported into the company-specific engineering change management systems. The exchange of electronic messages significantly reduces the manual efforts that are caused by business partners requesting to comment on engineering changes by using their company-specific templates and terminology. With regard to coordination costs, no difference has been identified between the three forms of electronic machine-to-machine integration. Since all of them realize electronic system integration, the reduction in coordination costs amounts to 0.75 person-days per engineering change request (for both parties). On average, three external inter-actions are required for processing an engineering change request, with an estimated effort of 0.25 person-days for collecting and organizing information. Compared to machine-to-machine integration, the drawbacks from portal-based human-to-machine integration are obvious. Given that suppliers are required to manually re-enter data and to adopt the OEM-specific business and process logic, the estimated savings of 0.75 person-days only apply for the OEM.

5.4   Findings Related to Connectivity Costs

Connectivity costs are incurred for establishing inter-organizational agreements between the different parties and their subsequent (internal) implementation. While connectivity costs are insignificant in the case of e-mail communication, they are also a minor factor in the case of supplier portals where the OEM incurred most of the costs. However, connectivity costs represent an "entry barrier" when it comes to the establishment of machine-to-machine linkages between manufacturers and their suppli-ers. Table 3 presents the connectivity costs which we identified from for the different forms of B2B integration in the engineering change management scenario. Estimations by the VDA ECM working group were used for quantifying the efforts related to inter-organizational agreements (here: $c_{P.agr,i}$ and $c_{IS.agr,i}$). It has proven impossible to further quantify the internal efforts for linking up $c_{P.impl,i}$ and $c_{IS.impl,i}$ since they largely depend on the internal processes and applications. However, Table 3 is quite informative in several ways: First, the inter-organizational agreements at the process level generate significantly more effort (15 days) than those at the IS level (5 days). Second, automotive companies experience that none of the approaches to B2B integration completely eliminates bilateral efforts. Even if public constructs are defined, some bilateral negotiations will be necessary to analyze and set up the collaboration (5 days). Third, Table 3 confirms that SOA-based process integration addresses the shortcomings of existing B2B integration approaches and significantly reduces the relationship-specific investments at process and IS level. Whereas the reduction of relation-specific investments compared to point-to-point connections is obvious, the comparison with the document-centric B2B standards is more interesting. The latter indicates significant relationship-specific costs for inter-organizational process alignment. In the case of SOA, these costs can be reduced if the vertical standard specifies public SOA constructs in the form of process and IS interface specifications. Finally, automotive experts stated that SOA will further reduce the IS-level implementation efforts although they have had difficulties to quantify these effects in the concrete case. They argue the following. (1) An SOA eliminates the need for maintaining a separate B2B integration infrastructure and is more scalable and flexible than existing adapters; (2) widely used Internet technologies will require less proprietary integration knowledge in the future; (3) strongly typed interfaces and process-centric integration allow for better testing and earlier error detection.

Form of B2B Integration	E-mail communication	Portal	Message exchange based on individual data format	Message exchange based on industry standard	SOA-based process integration based on industry standard
Interaction Type	Human-human	Human-machine	Machine-machine	Machine-machine	Machine-machine
Relationship	1:1 (Dyadic relationship with unstructured information exchange)	1:n (Focal relationship where OEMs provide suppliers with Web-based access to their information systems)	1:1 (Dyadic relationship with bilateral agreement on message format)	n:m (multi-lateral agreement on message formats, here: XML or EDI documents)	m:n (Multi-lateral agreement on public constructs covering process and IS layer)
Adoption in practice	High – used in all B2B interactions in engineering change management	Middle – OEMs have established around 30-50 different supplier portals, ECM scenario is partly implemented	Low – few implementations	Low – few implementations, e.g. BMW and Magna Steyr / EDI	Low – pilot implementation by BMW and suppliers
Coordination costs – savings in executing and monitoring transactions: Δ $c_{coord,i}$					
Savings through electronic processing	No difference	0.75 PD per engineering change (OEM only)	0.75 PD per engineering change (both parties)	0.75 PD per engineering change (both parties)	0.75 PD per engineering change (both parties)
Total	$\Delta c_{coord,i} = 0$	OEM: $\Delta c_{coord,i}=0.75*n*t_n$ Supplier: $\Delta c_{coord,i} = 0$	$\Delta c_{coord,i} = 0.75 * n * t_n$	$\Delta c_{coord,i} = 0.75 * n * t_n$	$\Delta c_{coord,i} = 0.75 * n * t_n$
Connectivity costs - inter-organizational agreement on the process interaction: $c_{P.agr,i}$					
Costs for analyzing engineering partnership	N/A	N/A	5 PD per partner	5 PD per partner	5 PD per partner
Costs for defining inter-organizational process interaction	N/A	N/A	10 PD per partner	10 PD per partner	0 PD (due to pre-defined public constructs)
Total	$c_{P.agr,i} = 0$	$c_{P.agr,i} = 0$	$c_{P.agr,i} = \sum_{j=1}^{n} 15 = n*15$	$c_{P.agr,i} = \sum_{j=1}^{n} 15 = n*15$	$c_{P,i} = \sum_{j=1}^{n} 5 = n*5$
Connectivity costs - internal implementation of the partner-specific process / organizational changes: $c_{P\,impl,i}$					
Costs for specifying internal changes	N/A	3 PD per OEM (suppliers only)	3 PD per partner	3 PD per partner	3 PD (partner-independent)

Partner-specific organizational changes	N/A	$c_{P.change,ij}$ depending on internal processes (suppliers only)	$c_{P.change,ij}$ depending on internal processes	$c_{P.change,ij}$ depending on internal processes	$c_{P.change,i}$ (partner-independent) depending on internal processes
Total	$c_{P.impl,i}=0$	OEM: $c_{P.impl,i}=0$ Supplier: $c_{P.impl,i}=\sum_{j=1}^{n}\left(3+c_{P.change,ij}\right)$	$c_{P.impl,i}=\sum_{j=1}^{n}\left(3+c_{P.change,ij}\right)$	$c_{P.impl,i}=\sum_{j=1}^{n}\left(3+c_{P.change,ij}\right)$	$c_{P.impl,i}=3+c_{P.change,i}$
Connectivity costs - inter-organizational agreement on the IS level: $c_{IS.agr,\,i}$					
Definition of the information that has to be exchanged	N/A	N/A	3 PD per partner	0 PD (due to pre-defined EDI/XML messages)	0 PD (due to pre-defined public constructs such as WSDL, …)
Decision on the data exchange format	N/A	N/A	1 PD per partner	0 PD (due to pre-defined EDI/XML messages)	0 PD (due to pre-defined public constructs such as WSDL, …)
Total	$c_{IS.agr,i}=0$	N/A	$c_{IS.agr,i}=\sum_{j=1}^{n}4=n*4$	$c_{IS.agr,i}=0$	$c_{IS.agr,i}=0$
Connectivity costs - internal implementation of the IS interface and communication infrastructure: $c_{IS.impl,\,i}$					
Field mapping	N/A	N/A	1 PD per partner	1 PD in total	1 PD in total
Interface realization + communication infrastructure and backend integration	N/A	Only OEM: $c_{IS.change,i}$ (setup of supplier portal, partner-independent, depending on internal application landscape)	10 PD per partner + $c_{P\,IS.change,ij}$ (depending on internal application landscape)	10 PD in total (adapter) + $c_{P\,IS.change,i}$ (partner-independent, but depending on internal application landscape)	10 PD in total (service) + $c_{P\,IS.change,i}$ (partner-independent, but depending on internal application landscape)
Total	$c_{IS.impl,i}=0$	OEM: $c_{IS.impl,i}=c_{IS.change,i}$ Supplier: $c_{IS.impl,i}=0$	$c_{IS.impl,i}=\sum_{j=1}^{n}\left(11+c_{IS.change,ij}\right)$	$c_{IS.impl,i}=11+c_{IS.change,i}$	$c_{IS.impl,i}=11+c_{IS.change,i}$
Legend: PD – person days					

Table 3. Assessment of Five Different Forms of B2B Integration From a Transaction Cost Perspective

6   CONCLUSION

The contribution of this research is two-fold: First, it derives a model for assessing different forms of B2B integration and their impact on transaction costs of collaborative B2B relationships. By distinguishing connectivity and coordination costs, it provides a systematic view on the cost and benefit structures of different forms of B2B integration. It thereby captures the inherent differences that exist between machine-to-machine and human-to-machine interaction. While existing IOS research focuses mostly on benefits, this paper draws the attention to the fact that different forms of B2B integration require different ex-ante investments in order to generate benefits. The second contribution of this research is the comparison of different forms of B2B integration. This study demonstrates that there is economic rationale for preferring e-mail communication and supplier portals to more complex forms of machine-to-machine integration. While machine-to-machine integration is associated with the highest savings in coordination costs, it comes with significant investments in electronic connectivity. This explains some of the phenomena revealed by current statistics on e-business adoption (European Commission 2007). Asymmetric investments and benefits may exist for the different parties in electronic B2B relationships, notably in the case of B2B portals. When comparing SOA and Web Services to prior forms of B2B integration, we find that service-oriented concepts potentially increase the interoperability and scalability of electronic B2B relationships. This is due to their (1) leveraging of open Internet standards, (2) elimination of the need for maintaining a separate B2B integration infrastructure and (3) ease of integrating with internal applications. However, IS implementation efforts only account for a smaller part of the overall investments in external process integration, and SOA does not alter the problem of implementing organizational changes. Another interesting finding relates to the role of standardization which has been extensively discussed by prior IOS literature (Damsgaard and Truex 2000; Reimers and Li 2005; Zhu et al. 2006). According to the automotive industry's experiences, vertical standards reduce connectivity costs and relationship-specific investments, but do not completely eliminate them. Besides the need for analyzing bilateral relationships prior to setting up electronic linkages, this is due to the costs incurred for implementing internal process and system changes in order to connect with external partners. On the other hand, the scope and quality of vertical standards significantly affect connectivity costs. If standardization goes beyond message definition and specifies process-level agreements, it further reduces connectivity costs.

There are several limitations to our research. The most important limitation lies in the explorative approach and the limited empirical base for assessing the alternative forms of B2B integration. Although we chose an industry and a scenario which provided rich data related to different forms of B2B integration, there is a risk that our findings are only applicable to this particular scenario. Another limitation of our research is due to the lacking availability of data on B2B integration costs. Our analysis relies on estimations from pilot and productive implementations. Future work is necessary to gather more empirical data and to validate our findings in other B2B scenarios and industry settings. While this study demonstrates that transactions cost theory provides a very valuable framework for analyzing the different forms of B2B integration, the suggested model only presents a first step towards measuring transaction costs. We hope that our findings stimulate further research and encourage further studies that elaborate on the distinction between connectivity and coordination costs. Since the different forms of B2B integration are still understudied, more conceptual and empirical research is needed to improve our understanding of B2B integration variants and their impact.

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