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Vertical electronic coordination in B2B relationships

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ABSTRACT

This paper examines how relation-specific information technology (IT) investments affect vertical electronic coordination between firms. Recent research has conceptualized that the levels of specificity in IT investments and adjacent business processes lead the parties to increased vertical electronic integration. In this paper we make a deliberate distinction between vertical electronic coordination (VEC) for collaborative purposes, which involves a high degree of interdependence between firms, and VEC for transactional purposes, characterized by a low degree of interdependence and asset specificity between firms. Through a cross-industrial survey of 198 firms we found that the effect of specific IT investments on VEC for collaborative purposes is contingent upon the level of other specific assets deployed in the buyer-seller relationship. No such effects were found for VEC for transactional purposes. Our study suggests that substantial specific investments increase the need for customized information systems that can facilitate efficient coordination where assets are at risk.

1. Introduction

Vertical coordination as a governance form serves as foundation for executing transactions and managing inter-dependence between firms. The influence of information technology (IT) on governance forms was initially introduced by Malone, Yates and Benjamin (1987, 1989), who claim a relationship between information technology, coordination costs and the formation of electronic markets. The researchers propose that the use of IT will facilitate a move from single supplier arrangements to multiple supplier relationships, due to the lowered costs of acquiring

information, specifically related to searching costs and evaluating and monitoring suppliers. Although this theoretical view has received wide scholarly recognition, empirical evidence is mixed. The reasons for varying evidence may be multiple, but there is a growing acknowledgement among IS researchers that there is an important distinction between standardized, general inter-firm information system (IOS), and IOS that are highly specific to the contractual parties in order to coordinate electronic business activities (Zaheer and Venkatraman, 1994; Holland and Lockett, 1997; Kim and Mahoney, 2006). Recent research suggests that increasing levels of specificity in IT investments and adjacent business processes lead the parties towards increased vertical electronic integration (Zhu and Kraemer, 2005; Kim and Mahoney, 2006; Dedrick et al., 2008). This may serve as a substitute for managerial hierarchy because relation-specific IT systems provide alternative governance without residing to organizational integration (Zaheer and Venkatraman, 1994). It is further argued that organizations that strive for increased competitiveness through IT, will commit resources to create relation-specific IT assets, and letting access to strategic business information be privileged for chosen business partners. For instance, Holland and Lockett's (1997) case studies indicate that when IOS are used to manage inter-dependencies, information systems becomes more specific, to the degree that it cannot be easily replicated to new suppliers without substantial costs. This results in increasing levels of organizational and technological integration across firm boundaries (Holland and Lockett, 1997; Kim and Mahoney, 2006), and may be part of an explicit strategy to lock in partners or to facilitate 'deeper integration' of processes and systems in order to meet coordination needs within a specific supplier relationship (Amit and Zott, 2001; Dedrick et al., 2008). The central issue is that

closer integration of information system is expected to improve responsiveness to market changes, shorten product development cycles, and enhance product quality. Evidence of this is seen by the emerging integration of supply chains and closer collaboration forms between firms by the means of IOS (Holland and Lockett, 1997; Petersen et al., 2005).

In order to capture the range of multiple coordination needs, it is necessary to differentiate the concept of vertical electronic coordination. Systems integration across firms for the purpose of close, strategic collaboration usually involves substantial tailoring of technical and organizational resources (Holland and Lockett, 1997; Sanders and Premus, 2002; Saeed et al., 2005), and calls for more adaptation between the parties (Bensaou, 1997; Lee et al., 2003). Implicitly these investments involve inter-organizational systems (IOS) that cannot be easily replicated or transferred to new relationships without substantial re-investments in training, inter-operability of systems and organizational adaptations. To the contrary, systems integration for transactional purposes are usually based on industry standard software where the degree of specificity in technology is low (Clemons and Row, 1992; Holland and Lockett, 1994), and focus is on automation of standard transaction processes, such as purchase orders, billing, shipment notes, etc. (Grieger, 2003). Increasing levels of specificity in IT investments for inter-firm coordination purposes imply increasing costs and deployment of resources. The customization levels of IOS is therefore a central aspect to any buyer-seller relationship that engage in electronic business.

This paper focuses on vertical electronic coordination (VEC) for collaborative purposes, and examines the effect of specific IT investments and other specific investments on collaborative electronic coordination between firms. In particular, we will argue that the association between IT specific investments and vertical electronic coordination for collaborative purposes will be highly contingent on other specific investments which foster interdependence between the firms. In contrast, such type of relationship is not expected to be found when using VEC for transactional purposes as a dependent variable.

The paper is organized as follows: First, we describe the concept of vertical electronic coordination (VEC), with a deliberate focus on the distinction between VEC for collaborative and transactional purposes. Next we draw upon transaction cost economics to derive our conceptual framework on the relationship between the dependent variable VEC for collaborative purposes and the independent variables; IT specific investments and other specific investments. We develop three hypotheses, with a particular focus on how specific investments that are not related to IT serve as a moderating variable, because its presence increases inter-firm dependence and coordination needs. The methodology section describes how the conceptual constructs are operationalized and measured in a cross-industrial survey of 198 Norwegian buyer-seller relationships. The final section includes a discussion of the key findings, as well as implications of the study and suggestions for future research.

2. Vertical electronic coordination (VEC): The transactional and collaborative approach

Vertical coordination concerns the flow of information, and cooperation on strategic issues and operational performance, as well as ongoing negotiations and adjustments to terms of trade (Buvik and John, 2000). From the theoretical framework of TCE, coordination processes form the basis for monitoring, controlling and adapting to change in a relationship. TCE is often used to understand the influence of IT on organizational structures, because the use of inter-firm information system (IOS) is closely connected to the form and structure of inter-firm relationships (Srinivasan et al., 1994). Vertical electronic coordination can be defined as a mechanism for *electronic governance forms* (EGF) between firms. The electronic governance form is based on the scope of vertical electronic coordination conducted in a B2B relationship, as well as the characteristics of the IOS. In our model vertical electronic coordination is the central construct that entails the specific activities, tasks, processes and information that are shared and exchanged in a buyer–seller relationship by the means of information technology. In order to capture the differences of activities and processes that are exchanged in an electronic form, we make a deliberate distinction between vertical electronic coordination for *collaborative* purposes and vertical electronic coordination for *transactional* purposes. This is a taxonomy of e-business commonly seen within the supply chain management and logistics literature (see e.g. Lee et al., 2003; Harrison and Hoek, 2005; Laudon and Traver, 2007), and encompasses the typology of IOS as proposed by e.g. Chatterjee et al (2004a), Holland et al. (1997), and Chae et al. (2005).

The *transactional* approach is associated with coordination of administrative activities between firms, where the focus lays on automation of transaction processes, such as purchase orders, billing, shipment notes, financial transactions and tendering processes. The transactional approach is generally associated with low value products that generate high volumes of orders and billings (see i.e. Weele, 2002; Presutti, 2003; Bartezzaghi and Ronchi, 2004), and electronic transactions of this kind are often characterized by a fixed format with predefined data and information fields (Zhu and Kraemer, 2005; Laudon and Traver, 2007). Extant attention has been paid to the transactional approach of VEC, because it has been viewed as an effective tool for reducing administrative and transaction processing costs, and enhancing performance, in particular with respect to purchasing (Essig and Ulli, 2001; Boyler and Olson, 2002; Peleg et al., 2002). Furthermore, the transactional approach focuses on increasing the efficiency of internal purchasing routines and concentrating contracts to fewer suppliers (Bakos and Brynjolfsson, 1993a; Stump and Sriram, 1997). With high volumes of trade, the potential for administrative economies of scale by electronic transactions is considered to be high. These transactions are often based on standardized IT solutions, where the degree of specificity in technology is low. Furthermore, these electronic activities do not require high levels of information sharing between the firms, when the terms of trade are set. Another important aspect is that VEC for transactional purposes is performed independently of whether the buyer and seller have made specific adaptations in the relationship and are unaffected by the nature of the relationship. That is, the need to coordinate transactional activities exists in any relationship as necessary transactional processes.

The *collaborative* approach of VEC encompasses coordination of a broader scope of business activities. This form extend the standardized processes and information exchange, and entails coordination processes that requires specific system facilitation and compatibility between firms, for instance sharing data regarding production plans, demand forecasting, product development and design, engineering drawings, bills of materials, pricing structures, as well as advanced logistics information about the products and services that are exchanged in the relationship (Lee et al., 2003; Laudon and Traver, 2007). Integration of business processes across firm boundaries is often associated with relation-specific investments which is turn creates more inter-dependence between the firms (Kim and Mahoney, 2006). Hence, when a buyer and seller engage in closer integration of processes, more extensive IT integration would be expected to facilitate efficient coordination (Zaheer and Venkatraman, 1994; Dedrick et al., 2008). Furthermore, collaborative e-business is typically characterized by a 'rich communication environment' (Laudon and Traver, 2007) and unstructured information sharing (Bensaou, 1997) to enable a broad scope of coordination and sharing of sensitive information between the firms. This demands a strategic approach to how information is shared with whom, and in what ways, as well as the explicit monitoring of coordination in order to govern against opportunistic behaviour. Therefore, the reasoning for close electronic coordination is more of an inter-organizational issue rather than technological infrastructure, and implies a move from transactional to more relational governance in the buyer-seller relationship (Kim and Mahoney, 2006).

Table 1 presents the basic differences between VEC for collaborative purpose and VEC for transactional purposes in terms of different characteristics of exchange. The

main difference between 'VEC transaction' and 'VEC collaboration' lies in the strategic nature of coordinated activities and information shared. Electronic cooperation that tightly couples inter-firm operations, increases bilateral dependence and is thus reflected by a collaborative governance approach. Low degree of electronic coordination, however, is characterised by a transactional focus in the relationship.

Table 1: Differences in characteristics between VEC for transactional purpose and VEC for collaborative purposes

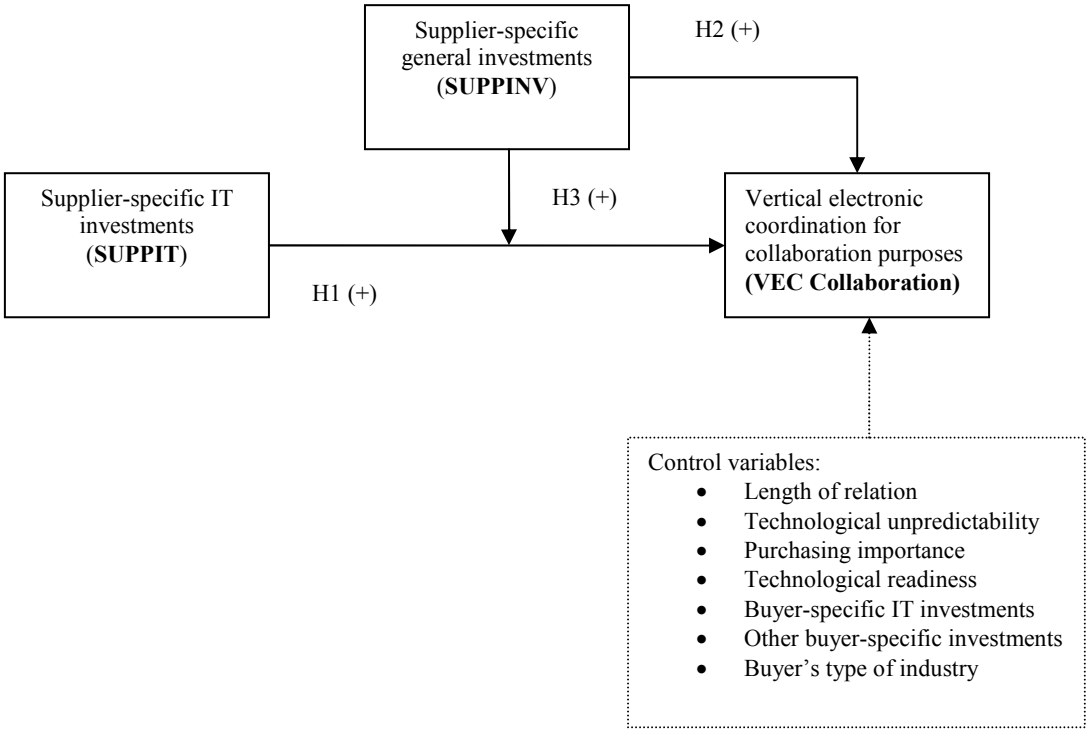
Characteristics	VEC transactional	VEC collaboration
Types of business process coordinated	• Documentation exchange • Order processing • Payment and invoicing processes • Shipment notices • Tendering processes	• Demand, forecasting and replenishment of inventory levels • Production planning • Delivery schedules • Joint development programs • Product and design modifications • Point of sales data
Business level	• Administrative	• Strategic and operational
Degree of inter-dependence between firms	• Low	• High
Need for information sharing	• Low	• High
Degree of specificity in IOS	• Low	• High

The relationship between IT and inter-firm coordination may become more evident in the presence of specific assets, because they attenuate inter-firm dependence and the needs for inter-firm coordination. Thus the effect of IT investments on inter-firm collaboration should become more evident when other forms of specific investments are high. VEC for collaborative purposes is a prime candidate for illustrating this proposition, because it is the most advanced electronic coordination form between firms, as it facilitates electronic coordination of operational and strategic activities.

3. Conceptual framework and hypotheses

According to the theoretical frameworks of Williamson (1975, 1985) and empirical research within TCE (Rindfleisch and Heide, 1997), the presence of specific assets is the most important determinant of relational governance forms. In this research we explicitly attend the contingency effect between different forms of specific assets on vertical electronic coordination (VEC) for collaborative purposes. We include however, the main effects of both kinds of specific investments, in order to control for the theoretical relationship between specific investments and hybrid governance forms (Joshi and Stump, 1999; Andersen and Buvik, 2001). The conceptual framework is presented in Figure 1.

Figure 1: The conceptual framework of the VEC collaboration model



Supplier-specific IT investments (SUPPIT)

Conducting inter-firm coordination through digital channels and media is logically impossible without some level of investments in IT infrastructure. Our focus is particularly on how the level of *idiosyncratic* investments between the parties, as compared to general IT investments – may determine the level of vertical electronic coordination between them. On the grounds that there is a stronger economic incentive for a supplier to customize IT assets on behalf of a customer (Williamson, 1985; Bakos and Brynjolfsson, 1993b; Buvik and Reve, 2001) than vice versa, we expect the degree of electronic coordination to be more affected by the supplier's customization of information systems and associated processes than the opposite. This coordination aspect is empirically demonstrated by CPFR systems (collaborative planning, forecasting and replenishment) in for instance the case of Wal-Mart, where the suppliers are required to integrate their IT systems with the buyer's system, to coordinate information and prognoses about planning, forecasting, replenishment data (Cooke, 1998). We predict that situations in which the supplier has made specific IT investments for trading with a specific buyer, the parties are inclined to coordinate activities through the specific IOS. Therefore, we propose that there is a positive association between supplier-specific investments and the degree of vertical coordination for collaborative purposes. The following first main effect on VEC is hypothesized:

H1: *Vertical electronic coordination for collaborative purposes is positively associated with specific IT investments made by the supplier.*

Other supplier-specific investments (SUPPINV)

The central axiom of TCE is that there is a positive association between specific assets and hybrid governance forms (Williamson, 1991a). This relationship is empirically well grounded (Geyskens, Steenkamp, & Kumar, 2006.) Furthermore, research also demonstrates that the need for coordination is increasing as the level of specific investments in the relationship increases, specifically when the assets are deployed by the supplier (Buvik and Reve, 2001). We propose that the presence of supplier-specific investments increases vertical electronic coordination for collaborative purposes, because the deployment of specialized resources will be a positive source for coordinating business activities electronically, both for efficiency and competitive purposes. Hence, we assume:

H2: *Vertical electronic coordination for collaborative purposes is positively associated with other specific assets made by the supplier*.

The interaction hypothesis

Chae et al (2005) demonstrate that the effect of IT investments on inter-firm collaboration is moderated by dimensions such as trust, dependence, long term commitment and information sharing. Their case study illustrates a central point, namely that the effect of IT on inter-firm coordination may be moderated by other organizational factors. In another survey Dedrick et al (2008) found the association between e-procurement systems and number of suppliers to be negatively moderated by system integration. That is, buyers with e-commerce systems use fewer suppliers when IT integration is strong.

Arguably it is the level of specific assets deployed in the relationship that serve as a moderator on VEC, because in line with the TCE perspective, it is the level of

deployed assets that creates inter-firm dependency and coordination needs. Furthermore, when specific assets are deployed, the relationship is expected to operate under relational governance which is often associated with long term commitment, high degree of information sharing as well as trust (Heide and John, 1990). If the firms have not deployed any specific assets, there will be no need for coordination due to low inter-dependence between them, and thus no reason for the buyer and seller to invest further in collaborative forms of e-business. On the other hand, in the presence of substantial specific assets deployed in the relationship, the parties will have a continuous need for high levels of coordination, and a specific IOS will attend these coordination needs in a more customized way. Thus, we postulate that there is a positive interaction effect between supplier-specific IT investments and other supplier-specific investments on VEC for collaborative purposes. That is, the effect of IT investments on VEC collaboration will be attenuated by increasing levels of other supplier-specific investments. Hence the following interaction effect is proposed:

H3: *The positive association between supplier-specific IT investments and vertical electronic coordination for collaborative purposes will be enhanced by increasing levels of other specific investments made by the supplier*.

As previously argued the *transactional* approach to electronic coordination entails the transmission of non-strategic information which requires low degree of coordination. We will therefore postulate that if we test the same hypotheses on transactional forms of electronic coordination, we will not see any interaction effects nor main effect, as the need for transactional information is the same independent of

specific assets deployed. For instance, information about price, order frequency, dates of delivery etc. does not require high degrees of vertical coordination.

Control variables

In order to control for possible effects of other central variables on VEC, we include seven control variables, which impact are represented by dotted lines in Figure 1. *Length* of relation has been used as a positive predictor of cooperative relationships (Heide and John, 1990). *Technological unpredictability* is a proxy for external uncertainty which is theoretically associated with hybrid governance. External uncertainty as a determinant of governance forms has been researched in many dimensions, including market/volume uncertainty (Anderson, 1985; Heide and John, 1990), technological unpredictability (obsolescence) with respect to production specific technology (Heide and John, 1990), as well as pace of change in technology (Klein, 1989). This study uses the unpredictability aspect of technology as a control variable, because it captures the aspect of unpredictability and pace of change in the general realm of technology. *Purchasing importance* is the percentage of buyer's annual sales accounted for by the purchasing value from this supplier. It is a proxy for the buyer's relative purchasing concentration for this specific supplier, as well as the buyer's procurement and sourcing strategy (Stump, 1995). The variable has been used in previous research as various scales, and demonstrated positive association with vertical cooperation forms (Heide and John, 1990). *Technological readiness* is a proxy for organizational readiness for using inter-organizational systems. This construct is commonly seen as an explanatory factor on IOS adoption issues (Iacovou et al., 1995; Grewal et al., 2001; Pei-Fang et al., 2006), and may thus be an

explanatory factor for high levels of electronic coordination between firms. *Buyer's specific IT investments* and *buyer's other specific investments* are included to control for possible reciprocity effects on vertical electronic coordination (Anderson and Weitz, 1992). Finally, we test for any spuriosity between the VEC and the independent variables with respect to the type of *industry* in which the buying firm operates.

4. Methodology

Research context and data collection

The unit of analysis in this investigation is buyer-seller relationships in which the partners use an inter-firm information system (IOS) to coordinate their economic exchange. The population frame for this is principally large, but in order to obtain a relevant population from which to draw a sample, the main criteria for selecting the empirical context have been 1) a population of businesses in which the dependent variable must manifest itself to varying degrees 2) a population with sufficient variation of industries, to avoid bias towards one specific industry group 3) a population of firms with an explicit orientation towards their upstream activities with suppliers, so that they are able to pick a suitable supplier-relationship on which to base their response 4) key informants at the purchasing management level, who are familiar with the issues that represent the major research problem.

The questions in our survey focus on electronic coordination with one specific supplier. Hence, the key informants were instructed to choose a supplier relationship through which they collaborate electronically by some form of IOS. The various forms of IOS were exemplified for guidance purposes. No further directions were

given, for instance with respect to type of relationship or coordination activities performed electronically with the supplier so as to empirically capture as much variance as possible of vertical electronic coordination. The one-sided, key informant approach is the common methodological approach to acquire information about both sides of the relationship, despite the inability to control for reliability from the reciprocal partner (John and Reve, 1982; Cannon and Perreault Jr., 1999). In buyer-seller relationships, where the focus is on supply and upstream activities, the key informant will be employed in the buying firm, often within the purchasing or logistics function, because this function is assumed to have specific knowledge of supplier and upstream related activities.

The sampling frame consist of firms and organizations with membership in NIMA (Norwegian Association of Purchasing and Logistics) and public administration entities registered to be potential adopters of e-procurement by the e-Procurement Secretariat[1] in 2006. NIMA represent multiple SIC codes and has (of 2006) 724 unique corporate memberships, whereas the roster from the e-Procurement Secretariat consists of 641 public entities. We identified the respondents' industry by differentiating between businesses within manufacturing, service, retail, public sector and "other". The final questionnaire was mailed out in 2006 to a census of 1365 qualified firms in the sampling frame. After two follow up by mail and phone call to non-respondents, a total of 198 firms responded, all of which were usable for analysis purposes.

[1] The eProcurement Secretariat is established by the Norwegian Ministry of Government Administration and Reform and serves to advocate the use of e-commerce in the Norwegian public sector entities.

This corresponds to a total response rate of 16.1%[2] .

A non response bias was tested between the first and the final set of completed surveys by using t-tests (Armstrong and Overton, 1977). Tests were performed on the respondents' annual sales volume, number of employees and purchasing volume (Heide and John, 1990). The tests revealed that non-response bias do not seem to be a significant issue for the respective variables (for annual sale volume t=0.63; p=0.53, for purchasing volume t = -.98; p=0.33, for number of employees t=0.45; p=0.65). We also performed a chi square test for the early and late responders with respect to the most important IT system used in this relationship. The test revealed no significant differences between the late and early respondents regarding the most important IT system in use with the supplier (χ^2=6.0, df=4; p=0.20).

Measurements

In order to develop good measures of items that capture the research domain and problem (Churchill Jr, 1979), we first conducted in-depth interviews with 12 key informants, within purchasing, logistics or supply chain management across several industries, with the purpose of testing the proposed theoretical relationships through a qualitative approach. Based on these interviews and a review of previous empirical research on inter-firm coordination and IOS, we developed a preliminary survey instrument that was pilot tested through a convenience sample of 20 firms across industries.

[2] The total number of mail delivery failures (meaning that the unit could not be reached, and thereby is a non-eligible member of the initial sampling frame) was 135. Within the qualified sampling frame of NIMA members, the response rate was 22.9 %, and within the qualified sampling frame of the eProcurement Secretariat's roster, the response rate corresponded to 8.4%

Within the IS field, TCE is commonly used as theoretical framework for investigating IOS and performance in inter-firm relationships. The concept of specificity in IOS (see e.g. Christiaanse et al., 2004; Kim and Mahoney, 2006) as well as vertical electronic integration (Zaheer and Venkatraman, 1994; Mukhopadhyay and Kekre, 2002) are addressed within the IS field in particular. However, the concepts of *vertical electronic coordination* and *specific IT investments* are not explicitly discussed nor operationalized based on the classic measures of specific assets (Walker and Weber, 1984; Heide and John, 1990; Anderson and Weitz, 1992). The operationalizing of the central measures in this study is therefore founded on the classic TCE measures, with the addition of an IT dimension, for which the IOS literature has been central. The development of measures was further built on results from our pilot investigation. In this study, a Likert scale from 1 to 7 with endpoints "highly agree" and "highly disagree" was used to measure the main constructs. The control variables are measured as categorical, ordinal and continuous variables.

Vertical electronic coordination (VEC). Operationalization of vertical coordination in general entails inter-firm activities and information sharing pertaining to purchasing, operations management and logistical issues (Reve and Stern, 1986; Buvik and John, 2000). As previously discussed, electronic coordination may be categorized into at least two main groups; the *collaborative* form and the *transactional* form. In order to capture the different dimensions of VEC, we have deliberately used several indicators that measure various electronic coordination processes between firms. In this respect the measures have been developed on the basis of existing literature on coordination by Buvik and John (2000), and Joshi and

Stump (1999), and the use of IOS to support inter-firm business processes (Zaheer and Venkatraman, 1995; Bensaou, 1997; Powell and Dent-Micallef, 1997; Mukhopadhyay and Kekre, 2002; Subramani, 2004; Chatterjee and Ravichandran, 2004a). The measures have been modified to our specific context.

Supplier specific IT investments (SUPPIT) are assets that are both tangible and intangible, and customized for a specific purpose and/or a specific relationship. Recent research postulate that it is not merely the specificity of technology per se that characterizes the asset specificity of IT, but also the particular human skills and business processes connected to the use of a particular system in a particular relationship (Zaheer and Venkatraman, 1994; Mukhopadhyay and Kekre, 2002). For instance, specific IT investments entail intangible organizational assets, such as specific operating procedures, skills and specific training, development time as well as relation-specific organizational knowledge (Argyres, 1995). Furthermore, efficient use of IOS may depend on learning specific business processes and domain knowledge specifically upon request of another firm, and pertains to expertise developed for a specific exchange context (Subramani and Venkatraman, 2003). Common for all these intangible assets is that the routines, processes and knowledge created to enact a particular relation, have little value outside the exchange relationship. Our measurement of supplier specific IT investments are based on empirical studies by Heide and John (1990), Joshi and Stump (1999), and Buvik and John (2000), as well as theoretical frameworks of IOS investments by Cash & Kosynski (1985), Zaheer and Venkatraman (1994), Claycomb, Iver and Germain (2005), Subramani (2004), and Powell and Dent-Micallef (1997). The measures have been modified to reflect our specific context.

Specific assets (SUPPINV). This construct reflects the magnitude of resources devoted to a particular relationship (Williamson, 1991a). It pertains to specific tailoring of production processes, adapting products and design on behalf of the partner, relation-specific development projects, and skills and particular know-how used in the particular relationship. In this study we deliberately differentiate between specific IT investments and 'other specific investments' not related to IT, in order to test the relationship between these two constructs in our model. The items are drawn from previous empirical research by Buvik (1995), Heide and John (1990), Joshi and Stump (1999) and Bensaou and Anderson (1999).

The measures for specific investments (including IT) are measured from both sides of the relationship to control for reciprocity or credible commitment acts (Bensaou and Anderson, 1999; Joshi and Stump, 1999; Buvik and Reve, 2001). The measures on asset specificity from the buyer's side (BUYINV and BUYIT) are used as control variables in the VEC model.

Control variables

Ratio of buyer's annual purchasing volume from this supplier to buyer's annual sale (STAKE) is a single item measured as a continuous variable. *Type of business industry* (*BUYIND*) is measured as a categorical variable where we have asked the respondents to categorize their core business according to our taxonomy (manufacturing, service, retail, public sector and "other")[3]. Different types of manufacturing industries are commonly used as control variables (Stump, 1995; Joshi and Stump, 1999). In order to capture a possible effect between the

[3] Large corporations, for instance within the oil and gas industry, operate in both upstream and downstream business activities. I.e. StatoilHydro are involved in oil drilling activities as well as selling fuel from gas stations. Thus we have asked for the core business of the unit(s) for which the respondent is responsible.

manufacturing type of industries and other sectors with respect to VEC, the variable is measured as a dichotomous variable where manufacturing is coded as 1 and the other three as one group equal to 0. *Historical length of relationship* (LENGTH) is measured by the number of years the buyer has been trading with the supplier (Heide and John, 1990). *Technological unpredictability (TECHUNCERT)* is a multi-item measure that captures the buyer's perception of technological pace of change in the procured product from the supplier. We include the construct to test for possible effects on VEC. The measure is adapted from Stump and Heide (1996), and modified to our context. *Technological readiness* (*TECHRED*) has previously been identified as an important determinant of e-commerce adoption (Gibbs and Kraemer, 2004), and refers to the level of financial and technological resources and know-how of the firm (Iacovou et al., 1995). As the firms' level of IT sophistication and resources has shown to be of significance, we include the variable as a control, to test for possible effect in the VEC model. The scale is formative in that it comprises three different aspects that impact the perception of technological readiness.

Measure validation

No serious violations against assumption of normality were detected, and the levels of missing data were low (less than 5%). We first assessed the reliability and consistency dimensions by an exploratory factor analysis (EFA), and then applied confirmatory factor analysis (CFA) to our measurement scales, to confirm the unidimensionality in a stricter sense (Gerbing and Anderson, 1988). To extract an optimal structure of underlying factors from our measured items, rigorous testing were performed by using Principal Component Analysis (PCA), Principal Analysis

Factoring (PAF), as well as the Maximum Likelihood (ML) method. Variables which cross-loaded, or had low loadings were discarded unless theoretically justified.

For all the constructs, the results of EFA have converged in one factor per construct, with the notable exception of vertical electronic coordination (VEC) with 12 items (see table 2). The final EFA measure of each construct was subjected to a reliability test by Cronbach's alpha and item to total measure. Considering the wide range of items that were developed to test VEC, we were also investigating the possibilities that the construct could be multidimensional and formative in nature. However, as demonstrated by the CFA results the VEC construct converged into three constructs. This was also the case in the explorative factor analysis of the construct.

Maximum Likelihood (ML) estimation method in LISREL (8.72) (Jöreskog and Sörbom, 1995) was used for assessment of the measurement model, by first estimating for each construct separately, and subsequently for all the main constructs in the model without constraining the covariance matrix of the construct. Although there is a possibility of a second-order factor solution, the explorative nature of the items as well as the theoretical reasoning behind the VEC factors do not support a higher order solution. Based on the factor loadings and fit statistics, the model converged in a three factor solution. The CFA results of the VEC variable are presented in Table 2 (see table A2 in the Appendix for details and measurements of all the constructs in the model). As demonstrated by the fit indices, the single measurement model has acceptable values.

Table 2: Results from the confirmatory factor analysis for the VEC construct.

Construct and model statistics	**Item description** (Standardized factor loading in parenthesis)
Vertical electronic coordination ***(VEC)*** *(8 items converging in 3 factors) $\chi 2$ (16)=27.50, p=0.036; CFI=0.985;GFI=0.966 RMSEA=0.060; NFI=0.967*	*"Our firm performs extensive electronic coordination through this IT system with this supplier with respect to":*
VEC collaboration [4]	1. Coordination of production plans (.82) 2. Product and design modifications (.75) 3. Development and testing of new products (.69)
VEC transaction	1. Order processing (.70) 2. Invoicing and payments (.62)
VEC "documentation"	1. Tender processing (.71) 2. Document exchange (.76) 3. Product specifications (.74)

The convergent factors of "VEC collaboration" and "VEC transaction" subscribe to our theoretical framework. The third factor, VEC "documentation", entails items that are less discriminant to the others, and the indicators that form the third construct, seem to lie in between the two more distinct forms of electronic coordination. Based on the results of explorative and confirmatory analysis as well as the theoretical reasoning behind the factors, we use indicators that reflect the construct "VEC collaboration" as our main dependent variable. Secondly, we will use the construct of VEC transaction, reflected by two indicators, to test how the main dependent variable, "VEC collaboration", can be explained discriminatingly different from VEC transaction. This will be provided for under the test of hypotheses.

A confirmatory factor analysis was run simultaneously on all the main variables. The fit statistics are reported in Table 3 (the interaction term of the two constructs and the control variables are not included in the measurement model). No modification

[4] One error term was allowed to co-vary between item 5 and 6 (.21) in the single measurement model. However the error term is not allowed to vary in the full measurement model.

indices were estimated in the error terms, and the model fit demonstrates acceptable fit indices.

Table 3: Measurement model results for the VEC model

Item	SUPPINV	SUPPIT	VEC collaboration
SUPPINV 1	0.803 [a]		
SUPPINV 2	0.860 (13.06)		
SUPPINV 3	0.866 (13.13)		
SUPPIT 1		0.847 [a]	
SUPPIT 2		0.943 (16.83)	
SUPPIT 3		0.783 (13.19)	
SUPPIT 4		0.697 (11.12)	
VEC coll 1			0.697 [a]
VEC coll 2			0.896 (10.41)
VEC coll 3			0.816 (10.16)

Standardized estimated factor loadings (t-values in parentheses).
[a] Item fixed for scaling purposes.
Model fit indices:
Chi-square $\chi^2(32)= 52.45$, p=0.0127; RMSEA=0.057; CFI=0.99; GFI=0.95; NFI=0.97

In addition to the individual items' factor loadings in CFA, we have calculated a "composite reliability" score for each latent variable, often referred as "construct reliability" (PC), and a complimentary measure known as "average variance extracted" (AVE or PV) (Fornell and Larcker, 1981). Discriminant validity of each construct was investigated by assessing the variance extracted percentages (PV) of the constructs with the square of the correlation estimate (standardized) between the constructs (Fornell and Larcker, 1981). As can be seen from Table 4, all PV measures are well beyond 0.50 indicating adequate convergence. For any two constructs, the PV measures are greater than the squared inter construct correlation which provides evidence of discriminant validity.

Table 4: Discriminant validity for the VEC model: Squared inter construct correlation (R^2) matrix and variance extracted estimates (PV) and composite reliability (PC).

Factor	Suppinv	SuppIT	VEC
Suppinv	1.00		
SuppIT	0.16	1.00	
VEC	0.29	0.06	1.00
PV measures (>0.5)	0.71	0.68	0.74
PC measures (>0.7)	0.88	0.89	0.89

5. Results

In order to test our hypotheses, an ordinary least square (OLS) regression model was estimated. Our model was as follows (control variables in parentheses):

$$\mathbf{VEC_{col} = a_0 + (b_1 STAKE + b_2\ BUYIND + b_3 ITKNOW + b_4 TEHCNUNC + + b_5\ LENGTH + b_6 BUYIT + b_7 BUYINV) + b_8 SUPPIT + b_9 SUPPINV + b_{10} SUPPITxSUPPINV + e}$$

where:

VEC_{col} = collaborative vertical electronic coordination

SUPPIT = Supplier-specific IT investments (focal independent variable)

SUPPINV= Other supplier-specific investments (moderating variable)

SUPPITxSUPPINV = Interaction term

The use of an interaction term in regression models increases the likelihood of multicollinearity problems (Cronbach, 1987). To cope with such problems, the scales of the variables entering the interaction term were mean-centred (Aiken and West, 1991; Jaccard and Turrisi, 2003). Table A1 in the Appendix shows the correlation matrix and descriptive statistics for the variables in the VEC model.

Hierarchical regression procedures were used to estimate the VEC equation. The first block of variables entered was the control variables. We have deliberately controlled

for these variables, in order to test how robust the model is with respect to control variables that are likely to influence VEC, or to explain some of the variance in the main variables. The explained variance of the control variables as a block is significant at $p< 0.01$. ($R^2=0.19$, $F=4.74$). The next block entered consisted of the focal independent variable and the moderator variable, which demonstrated that the explained variance of the main effects is significant (change in $R^2= 0.104$, change in $F=10.43$, $p<0.01$). Finally the interaction term was entered as a block, which demonstrated a significant additional contribution to the explained variance of the dependent variable (change in $R^2=0.029$, change in $F=6.094$, $p<0.05$). The total variance explained (adjusted R^2) in the model is 0.27 (see Table 5). This compares favourably with comparable, prior studies on electronic integration (Zaheer and Venkatraman, 1994; Bensaou, 1997).

Table 5: Estimated total model. Dependent variable: Vertical Electronic coordination for collaborative purposes (VEC collaboration)

Regression model	**Independent variables**	**Un-standardized coefficients**	*t-values*
Control variables	Constant	2.49	4.650***
	Purchasing importance (STAKE)	.00	.283
	Buyer's type of industry (BUYIND)[a]	.38	1.554*
	Buyer's know-how of IT (ITKNOW)	-.02	-.298
	Technological uncertainty (TECHUNCERT)	.16	1.938**
	Length of relationship w/supplier (LENGTH)	-.15	-1.201
	Buyer specific IT investments (BUYIT)	-.13	-1.239
	Other buyer-specific investments (BUYINV)	.17	1.380*
Main effects	**Supplier-specific IT investments (SUPPIT)[b]**	.04	.474
	Other supplier-specific investments (SUPPINV)[b]	.36	4.253***
Interaction term	**SUPPINV x SUPPIT[b]**	.12	2.469***
R2 adj = .27 F (10;198) =6.66* **			

a. BUYIND is represented by a dummy variable (1=manufacturing, 0= all other industries)
b. Mean centered scores
* Significant at p<.10 (one tailed)
** Significant at p<.05 (one tailed)
***Significant at p<.01 (one tailed)

Test of hypotheses

The findings of the individual hypotheses were as follows:

H1: We predicted a positive main effect between the specific IT investments made by the supplier (SUPPIT) and VEC for collaborative purposes. Although in the expected direction, the result was non-significant and thus did not support our proposition as hypothesized. (b=.04, t=.47, p>.10)

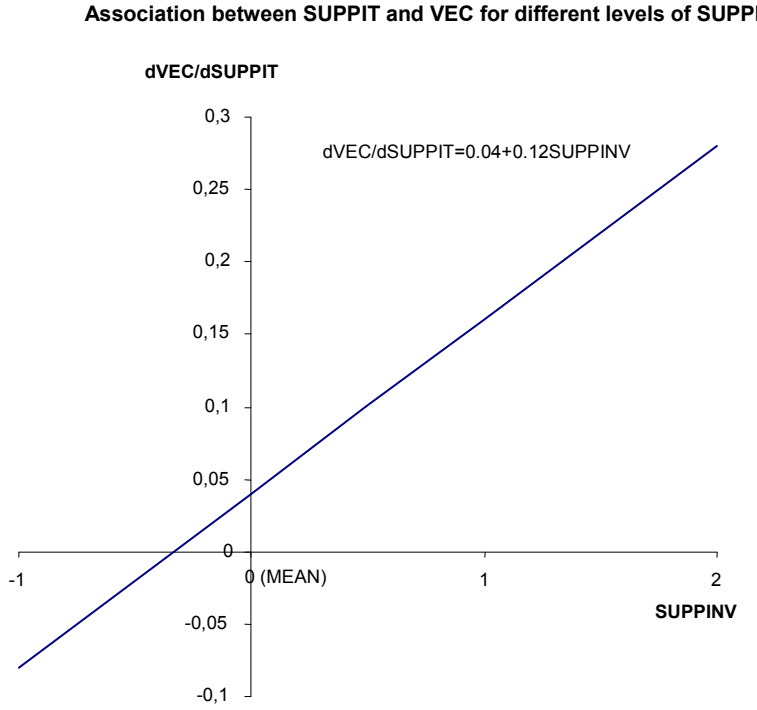
H2: We find that there is a significant and positive relationship between the level of other supplier-specific investments (SUPPINV) and VEC for collaborative purposes which provides support for hypothesis (b=.36, t=4.25, p<.01).

H3: The interaction effect provides the test of the VEC hypothesis; that there is a positive association between VEC and supplier-specific IT investments (SUPPIT) for

increasing levels of supplier-specific other investments (SUPPINV). The result is consistent with our proposition. (b=.12, t=2.47, p<.01).

Following the recommendations of Cohen (2003) and Schoonhoven (1981), the contingent effect on VEC can be depicted by graphing the partial derivative of vertical electronic coordination with respect to supplier specific IT investments, over the range of other supplier-specific investments (Figure 2). By inserting estimates from the regression analysis (Table 5), this can be expressed as: δVEC/δSUPPIT=0.04 + 0.12(SUPPINV)

Figure 2: Association between supplier–specific IT investments and VEC for different levels of SUPPINV (mean centered scores)



As can be seen from Figure 2, supplier-specific IT investments (SUPPIT) have a positive effect on VEC when other supplier-specific investments (SUPPINV) are high. On the other hand, when other supplier-specific assets are low, the association between supplier-specific IT investments and vertical electronic coordination will be

weakened. This is depicted by the graph as a non monotonic effect since the plotted line crosses the horizontal axis, and thereby changes signs (Schoonhoven, 1981).

Results for the control variables

With respect to the control variables, three are significant at the $p<0.05$ and $p<0.10$ level. The effect of technological unpredictability, as perceived by the buyer, has a significant positive effect ($b=.16$, $t=1.938$, $p<0.05$) on vertical electronic coordination in a buyer–supplier relationship. This result is contradictory to the findings of Heide and John (1990) who found that technological unpredictability reduces a firm's expectations of continuity. It does, however, support the findings of Bensaou (1997) who found that technological unpredictability is positively associated with cooperation in supplier relationships, as it may act as a form of uncertainty absorption. A weaker statistical significance is found for two other control variables. At $p<0.10$ there is a significant positive difference between manufacturing buying firms relative to other types of industry with respect to vertical electronic coordination with suppliers ($b=0.38$, $t=1.554$). This may demonstrate that the collaborative nature of electronic coordination is reflected in the manufacturing industry's needs for closer collaboration with suppliers regarding information exchange on product design, modifications and development processes. Finally, the model shows that the other buyer-specific investments have a positive effect on VEC ($b=0.17$, $t=1.380$, $p<0.10$). This is consistent with the TCE argument that specific assets in the relationship enhances the need for relational governance, and gives an indirect support to the model, in that the deployment of specific assets has a positive effect on vertical electronic coordination, also when applied from the buyer's side. Notable though, and residing with our propositions, the supplier-specific investments

in the relationships have a much larger effect on VEC (b=0.36, t=4.253) than does the buyer's deployment of specific assets (b=0.17, t=1.380).

Supplementary testing: "Transactional VEC" as the dependent variable

Although we have not made any explicit hypothesis, we have proposed that we do not expect a significant interaction effect of SUPPIT and SUPPINV on VEC for transactional purposes. In our conceptual framework, we propose that VEC transaction is conducted among firms, regardless of specific assets deployed in the relationship.. An additional statistical model was estimated to test whether the conceptual framework of vertical electronic coordination between firms is supported by regressing VEC transactional[5] on the same interaction terms as VEC collaboration. The results were all together non significant.

6. Discussion and implications

Based on the theoretical framework of TCE and characteristics of IOS, we have tested the contingent relationship between vertical electronic coordination for collaborative purposes and the level of supplier-specific IT investments. The empirical results demonstrated support for our main hypothesis (H3), which concerned the interaction effect between the level of IT specific investments and the level of other specific investment made by the supplier. Controlling for asset reciprocity from the buyer's side, technological unpredictability, IT know-how,

[5] The VEC transactional construct consists of two items. In an EFA analysis with principal component analysis and varimax rotation, the two items converge in a one factor solution with Eigenvalue = .014, and communalities of .730 and .618 respectively. Although low reliability measure (.60), the CFA measurement demonstrated acceptable fit measures for a three factor model, with VEC transaction consisting of these two items.

length of relation, buyer's type of industry, and purchasing importance, the results demonstrated that:

> *Supplier-specific IT investments have a statistically significant and positive effect on vertical electronic coordination for collaboration purposes, for increasing levels of other specific investments made by the supplier.*

Theoretical implications

Conceptual frameworks, empirical studies and anecdotal evidence point out the importance of implementing e-business systems in business to business settings. However, the focus of this literature has commonly been on e-business systems for transactional purposes. Recent research presents a more differentiated approach, and calls for more attention on electronic coordination for collaborative purposes (Zaheer and Venkatraman, 1994; Chatterjee and Ravichandran, 2004a; Kim and Mahoney, 2006). Even though the TCE framework is commonly enfolded in IOS research as claimed by Malone et al (1987), limited research is available with respect to conceptualizing and measuring the *specificity* of IOS, and how customized IT assets effect vertical electronic coordination in business relationships. Notable exceptions to this are Clemons and Row (1992), Zaheer and Venkatraman (1994), Bensaou (1997) Holland and Lockett (1997), as well as, Kim and Mahoney (2006).

Our results extend the theoretical framework of how investments in information technology affect electronic coordination between firms. Increasing levels of asset specificity in a relationship may increase the need for IT specific investments, in order to obtain more efficient communication and to obtain better "fit" for customized requirements in B2B relationships (Dedrick et al., 2008). In this sense

our findings support differentiating the concept of electronic coordination into collaborative purposes e-business and e-business for transactional purposes, as there is a long range of activities and clear distinction between the characteristics entailed in each category of e-business.

Coordination strategies are designed to manage complex transactions and inter-dependences between firms who are involved in the development, design and production of a product or service, as well as increasing market responsiveness. Our model and empirical findings are in line with Holland and Lockett (1997) who, on the basis of empirical case studies, propose that investments in specific IT systems are results of a particular coordination approach. The inter-dependence makes firms invest in IOS that increases rather than decreases transaction specificity, which may be part of a deliberate 'lock-in' strategy with trading partners or to improve the operational efficiency in vertical business relationships. Furthermore, vertical electronic coordination for collaborative purpose induces a need for flexibility in the IOS to manage adaptation and inter-dependency more effectively. This will result in customizing the information system and business processes according to the partners' specific needs (Subramani, 2004; Rai et al., 2006). This is evident from the collaboration forms in supply chains and the use of IOS to resolve coordination challenges such as increased responsiveness to market, improved product quality and shorter development time.

We proposed and found support that the vertical electronic collaboration is facilitated by supplier-specific IT investments, but that the effects of these investments are contingent upon the level of other supplier-specific investments. On the other hand,

we argued that because the need to process order and payments are independent of the level of specific asset deployed, we would not expect a similar interaction effect. To demonstrate this, we tested the VEC model by substituting VEC collaboration with VEC transaction as the dependent variable. The outcome of this analysis demonstrates that there is no interaction between specific IT investments and other specific investments, which supports that there is a distinct difference between the nature of vertical electronic coordination for collaborative purposes and vertical electronic coordination for transaction purpose.

Managerial implications

Increasing competition between firms and value chains reinforces the importance of streamlined coordination of updated and accurate information in real time. Moreover, the increasing focus on how IT can facilitate competitive advantages will drive the most competitive industries to align IT investments according to their strategic dependence outside the boundaries of the firm. Hence, business importance and the management of interdependencies should be a driver for how the firm differentiates their level of IT investments and adjacent customization. The crucial question for management is: What is the optimal level of IOS customization that will generate the most value for the firm? Clearly, to protect other specific assets at risk, firms ought to assess e-business systems that allow for flexibility, and should not succumb to systems that are not tailored well enough to maximize efficient communication and coordination with partners that have a high strategic value to the firm.

With respect to investments in e-business systems for transactional purposes, the picture is somewhat different. We have seen that there is no significant coherence

between the effects of IT systems and how firms coordinate their transactional activities electronically. This means that there is no evidence that electronic transactions should be supported by large investments in highly customized IT systems, because there are no assets at risk. Complex e-business systems and investments therein, should instead be based on strategic relationships to capture competitive advantages through sophisticated collaboration. As demonstrated by several industries, it enables faster response to market, as well as streamlined production processes across firm boundaries. Williamson (1979) posit that simple governance should be used for simple relations and complex governance for complex relations. This may be transferable to investments in electronic governance forms as well.

7. Limitations and future research

Our research results are subject to some limitations. The VEC and SUPPIT constructs are somewhat explorative in character. Despite acceptable reliability measures, caution must be taken for potential bias or measurement errors that may taint the results of the analysis. Although using a heterogeneous group of units was a deliberate design to avoid bias towards one specific industry group heterogeneity can be a threat to internal validity. It was *ex ante* difficult to identify firms that use IOS to coordinate activities with suppliers. Despite a deliberate choice of sampling frame, the units do not necessarily cover firms that have extensively adopted IOS. We also acknowledge limitations with respect to generalizing the results outside Norway. For validity reasons, it would be favorable to have the buyer's perceptions validated by data from the supplier's side. Finally, caution must be taken with respect to

longitudinal validity, because electronic coordination between firms is still under-developed, which may create biased results pertaining to the proposed theoretical relationships. Despite robust testing of the empirical evidence, the sampling frame may simply not have enough variance as reflected by low average values of electronic coordination for collaborative purposes.

Future research should remedy these limitations by providing more empirical evidence on the economic transformations of vertical electronic coordination in B2B relationships, and the developments of electronic governance forms over time.

Appendix

Table A1: Correlation matrix, descriptive statistics and reliability estimates for the VEC collaboration model (n=198)

	1	2	3	4	5	6	7	8	9	10	11
1. Vertical electronic coordination, collaborative form (VECcol)	1										
2. Supplier specific other investments (SUPPINV) [a]	.48(**)	1									
3. Supplier-specific IT investments (SUPPIT)[a]	.24(**)	.37(**)	1								
4. SUPPINV x SUPPIT)[a]	.12(*)	-.04	.17(*)	1							
5. Purchasing importance (STAKE)	-.04	-.03	.04	.03	1						
6. Buyer's type of industry (BUYIND)	.18(**)	.22(**)	-.13(*)	-.10	-.11	1					
7. Buyer's know-how of IT (ITKNOW)	-.02	.01	.20(**)	.17(*)	.12	-.15(*)	1				
8. Technological uncertainty (TECHUNCERT)	.13(*)	.12	.16(*)	.09	.07	-.15(*)	.20(**)	1			
9. Prior length of relationship with supplier (LENGTH)	-.01	.14(*)	.13(*)	-.05	.18(*)	.08	.17(**)	-.01	1		
10. Buyer-specific IT investments (BUYIT)	.10	.23(**)	.46(**)	.02	.17(*)	.23(**)	.28(**)	.25(**)	.02	1	
11. Other buyer-specific investments (BUYINV)	.36(**)	.56(**)	.40(**)	-.10	.04	.05	.12	.23(**)	.04	.63(**)	1
Mean	2.89	0.00	0.00	0.80	6.39	0.38	5.11	2.83	2.19	2.66	2.92
SD	1.50	1.57	1.36	2.16	12.24	0.49	1.43	1.37	0.91	1.44	1.30
Alpha	.85	.88	.90					.75		.91	.81

a. Mean centered scores

***Significant at p<.05 (one tailed); ** Significant at p<.01 (one tailed)**

Table A2: Results of CFA measures of the individual constructs

Construct and model statistics	Item description (Standardized factor loadings pr single construct in parentheses)
VEC collaboration (3 items) (Loadings reported from three factor solution)	*"Our firm performs extensive electronic coordination through this IT system with this supplier with respect to:"* 1. Coordination of production plans (.82) 2. Product and design modifications (.75) 3. Development and testing of new products (.69)
VEC transaction (2 items) (Loadings reported from three factor solution)	*"Our firm perform extensive electronic coordination through this IT system with this supplier with respect to:"* 1. Order processing (.70) 2. Invoicing and payments (.62)
SUPPINV (3 items) Just-identified yielding perfect fit in a single measurement model	*"The extent of other supplier-specific adaptations for your firm:"* 1. Made extensive product- and design modifications specifically tailored to us (.79) 2. Made extensive modifications in their production processes in order to handle their deliveries to us (.85) 3. Made extensive investments in joint development projects with our firm (.89)
SUPPIT (4 items) $\chi 2$ (2)=0.053, p=0.974; CFI=1.00;GFI=1.00 RMSEA=0.000; NFI=1.00	*"The extent of supplier-specific adaptations in the supplier's IOS, in order to adapt to your firm:"* 1. Invested extensively in their own IT know-how and skills (competence) (.84) 2. Invested extensively in IT systems by our standards and requirements (.95) 3. Made extensive reorganizing of their internal processes and routines (.78) 4. Made extensive investment to integrate their IT systems with our IT system (.70)
BUYINV (4 items) $\chi 2$ (2)=3.736, p=0.154; CFI=0.995;GFI=0.991 RMSEA=0.066; NFI=0.989 *Control variable*	*"The extent of other buyer-specific adaptations for cooperating with this supplier:"* 1. Spent substantial amount of time and money to provide this supplier with information about our needs and requirements (.72) 2. Made extensive tailoring in machinery and tools in order to make use of products from this supplier (.68) 3. Made extensive reorganizing in our firm (of our production processes) to collaborate more efficiently with this supplier (.67) 4. Made extensive investments in joint development projects with this supplier (.82)
BUYIT (4 items)[6] $\chi 2$ (1)=0.00 ,p=0.952; CFI=1.00;GFI=1.00 RMSEA=0.000, NFI=1.00 *Control variable*	*"The extent of buyer-specific IT investments to enable electronic collaboration with this supplier:"* 1. Made our personnel go through extensive training of the IT system in use with this supplier (.80) 2. Made extensive adjustments in our IT system (.93) 3. Made extensive investments to integrate our IT system with this supplier's IT systems (.85) 4. Invested in extensive technical know how to service and operate IT system in use with this supplier (.79)
TECHUNCERT (3 items) Just identified yielding perfect fit In a single measurement model *Control variable*	*"The extent of technological unpredictability as perceived by the buyer:"* 1. There is rapid technological changes and development for the product we source from this supplier (.70) 2. There is a high level of unpredictability concerning the life cycle time of this procured product (.77) 3. The supplier often changes the specification of this product (.66)
TECHRED Formative scale For regression purposes, one item is used *Control variable**	*"Technological readiness of buyer":* 1. Our firm has very good expertise within IT

* Technological readiness – is measured as a formative scale of technological readiness. One item is used in the regression analysis. The item is labeled IT KNOWHOW as it describes the buyers' response to IT expertise.

[6] One error term was allowed to co-vary between item 4 and 5 (.15) in the single measurement model. However the error term is not allowed to vary in the full measurement model.

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