Investigating the impact of e-business applications on supply chain collaboration in the German automotive industry

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Abstract

Purpose – The internet and web-based technologies have enabled the integration of information systems across organisational boundaries in ways that were hitherto impossible. The measurement of e-business (EB) value has been traditionally considered as a single construct. However, the desire to develop a comprehensive understanding of the impact of EB applications from a theoretical perspective has resulted in the modelling of multiple EB constructs. The impact of EB enabled collaboration on operational performance was also investigated. The purpose of this paper is to explore the enabling role of multiple dimensions of EB investigating if all EB applications impact directly and positively on supply chain collaboration.

Design/methodology/approach – A web-based survey was carried out to collect data within the German automotive industry. Structural equation modelling was conducted to test the measurement and structural model.

Findings – The results provide justification for the modelling of EB in multiple dimensions. Furthermore, some EB applications impacted positively on supply chain collaboration whilst some did not. The results also proved that EB enabled collaboration impacted directly and positively on the multiple dimensions of operational performance tested.

Practical implications – EB applications cannot be viewed by practising managers as being universally beneficial in improving collaboration across a buyer-supplier boundary. However, the results reveal that, by carefully selecting the most appropriate EB applications, operations improvement benefits can be realised across a range of operational metrics due to enhanced supply chain collaboration.

Originality/value – The deconstruction of EB into multiple constructs will enable the measurement of EB value to be more accurately assessed. Furthermore, the direct impact of EB-enabled collaboration to facilitate interaction and integration and its impact on operational performance adds to the body of knowledge within the larger research field of supply chain collaboration.

Keywords E-business technologies, E-business value, Supply chain management, Collaboration, Operational performance, Innovation, Germany

Paper type Research paper

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1. Introduction

IT in general and E-business (EB) in particular have been widely used to transform business processes and to create entirely new business models. The arrival of internet business-to-business applications has provided new and innovative opportunities for supply chain management (Da Silveira and Cagliano, 2006). Companies are increasingly using EB applications such as electronic auctions, electronic catalogues, and customer relationship management applications to streamline their business processes along the entire supply chain (Da Silveira and Cagliano, 2006; Bakker *et al.*, 2008). EB can be defined as information systems to acquire, process, and transmit information for more effective decision-making, relative to competitive standards (Powell and Dent-Micallef, 1997; Zhu and Kraemer, 2002; Zhu, 2004; Ray *et al.*, 2005; Sanders, 2007; Jeffers *et al.*, 2008). The internet and related technologies have enabled organisations to conduct business across firm boundaries almost as efficiently and effectively as they do within the firm (Boone and Ganeshan, 2007). However, this proliferation of EB adoption by organisations has created a perception that wider and deeper use of EB applications must always be beneficial.

The advent of EB has been viewed as a keystone of supply chain collaboration. A collaborative supply chain has been described as two or more organisations working together to jointly plan and implement supply chain operations more successfully than working independently (Simatupang and Sridharan, 2002; Arshinder and Deshmukh, 2008). Simatupang and Sridharan (2002) proposed that integrative policies of information sharing, joint decision-making and incentive alignment would be present in a collaborative supply chain. Supply chain collaboration is a concept that is affected by many factors, with EB being one of them. Despite the critical role of EB in SCM, research pertaining to digitally enabled supply chain integration has been limited and piecemeal (Rai *et al.*, 2006). Moreover, it has been repeatedly reported that EB is an important enabler for information sharing; however, its impact on complex collaborative practices including joint decision-making and incentive alignment has not been established yet. In addition, very little is known about how EB-enabled collaboration affects performance (Sanders, 2007).

Consequently, the objectives of this paper are twofold; first, to explore the enabling role of multiple dimensions of EB investigating if all EB applications impact directly and positively on supply chain collaboration in terms of information sharing, incentive alignment, and joint decision-making; and second, to test a model where buyer-supplier collaboration is modeled as the mediating variable between EB applications and operational performance measured through cost, quality, flexibility and innovativeness.

2. Literature review

2.1 Supply chain collaboration

Collaboration has received increased attention in both the operations and supply chain literature (Matopoulos *et al.*, 2007; Nyaga *et al.*, 2010). In the supply chain literature, the terms collaboration, integration and buyer-suppler relationships are often used synonymously (Cannon and Perreault, 1999; Das *et al.*, 2006). Collaboration may be conceptualised as a component of integration (Kahn and Mentzer, 1996; Stank *et al.*, 2001; Pagell, 2004; Sanders, 2007; Wiengarten *et al.*, 2010). Integration can be defined as the process of interdepartmental interaction and collaboration, bringing together departments to form a cohesive organisation (Kahn and Mentzer, 1996). Buyer-supplier relationships on the other hand can be viewed as the overarching supply chain concept

(Cannon and Perreault, 1999). Collaboration can also be conceptualised as external between organisations and internal between people and departments. Pagell (2004), for example, carried out a series of case studies to explore factors that enable and inhibit internal integration between operations, purchasing and logistics.

Whilst focusing on external supply chain collaboration some common themes can be identified from previous literature. In its basic form, collaboration seems to include some form of information sharing, which may result in inter-organisational communication (Paulraj *et al.*, 2008). Paulraj *et al.* (2008) identified that communication is enabled through long-term relationship orientation, network governance and information technology. Other studies have also proposed additional dimensions to represent collaboration in the supply chain context (Simatupang and Sridharan, 2005; Nyaga *et al.*, 2010). These studies refer to the complexity of collaboration, which entails more than just the information sharing and inter-organisational communication components. Nyaga *et al.* (2010) conceptualised collaboration through collaborative activities such as information sharing, joint relationship efforts and dedicated investments. Joint relationship efforts can be defined as collaborative working structures in terms of planning, goal setting, performance measurement and problem solving while dedicated investments were those committed to a specific supply chain relationship. Similarly, Stank *et al.* (2001) identified three perspectives of integration: a series of interactions, collaborative behavior, or a composite of the two. In a study of supply chain collaboration based on performance improvements, Vereecke and Muylle (2006) conceptualised collaboration through information exchange and structural collaboration. They define collaboration in terms of those characteristics that embrace both conflict and partnership, implying some form of mutuality without an apparent need for longtime commitment or total openness and trust. In addition, they define a collaborative relationship as one where more than one organisation works together for a mutual objective.

Simatupang and Sridharan (2002) proposed that integrative policies of information sharing, joint decision-making and incentive alignment would be present in a collaborative supply chain. The factors of information sharing, decision synchronisation, and incentive alignment were developed into a collaboration index (Simatupang and Sridharan, 2005). This index enables the measurement of the extent of collaboration in a buyer-supplier relationship. Simatupang and Sridharan (2005) conceptualised information sharing as the act of capturing and disseminating timely and relevant information for decision makers to plan and control supply chain operations; decision synchronisation was conceptualised as joint decision-making in planning and operational contexts and incentive alignment was conceptualised as the degree to which supply chain members share costs, risks, and benefits.

In conclusion, practitioners and researchers have equally highlighted the phenomenon of supply chain collaboration. However, there is considerable diversity in its conceptualisation and measurement (Simatupang and Sridharan, 2005). As such, in order to fully appreciate the complexity of supply chain collaboration, a more congruent and sophisticated approach to its measurement is required (Sanders, 2007).

2.2 EB applications and buyer-supplier collaboration

With the adoption of web-based technologies, supply chain collaboration is practiced across a wide range of industry sectors (Sanders, 2007). Various studies have underlined the importance of EB in order to enable and/or support supply chain integration and collaboration (Devaraj *et al.*, 2007; Ordanini and Rubera, 2008). Previous research has extensively tested the performance impact of IT in general and EB in particular under the realm of IT business value research (Melville *et al.*, 2004). The general consent has been that EB resources, on their own, do not necessarily improve performance (Nevo and Wade, 2010). However, an important role of EB is to enable various performance enhancing factors and practices such as knowledge sharing, process integration and supply chain coordination (Zhu and Kraemer, 2002; Ray *et al.*, 2005; Sanders, 2007). There is a considerable body of research, which has used a resource-based view (RBV) lens to examine the direct effect of EB applications on firm performance (Melville *et al.*, 2004; Wade and Hulland, 2004). The results of this research are mixed. Accordingly, some researchers have used the RBV to investigate the indirect effect of EB. In other words EB applications might be enabling and supporting tools. However, they may not be able to significantly improve firm performance on their own and directly.

The development of sophisticated web-based EB applications has enabled organisations to consider putting collaboration into practice throughout their supply chain (Devaraj *et al.*, 2007; Sanders, 2007; Ordanini and Rubera, 2008). They have enabled organisations to share large amounts of information between supply chain partners (Boone and Ganeshan, 2007). Sanders (2008) highlighted that EB applications enable real-time collaboration and integration between supply chain partners, which improves production planning, inventory management, and distribution. Subramani (2004) for example studied the indirect effects of IT use in interorganisational networks through relationship-specific intangible investments. Results supported the hypothesis that IT use in interfirm relationships leads to the creation of closer cooperative interfirm relationships, as evidenced by investments in these intangible assets by suppliers (Subramani, 2004).

The argument that EB increases collaboration has been supported by various researchers through transaction cost economics (TCE) theory (Sanders, 2007). Web-based EB technologies have been shown to decrease transaction costs, in the form of coordination costs and transaction risks (Kent and Mentzer, 2003; Saeed *et al.*, 2005; Sanders, 2007). Sanders (2007) highlighted that IT promotes collaboration by reducing transaction costs. Based on TCE, Saeed *et al.* (2005) examined the impact of inter-organisational systems (IOS) on process efficiency and sourcing leverage using buyer-supplier dyads as the level of analysis in a supply chain setting. Their conceptual model assessed the impact of IOS measured by IOS breadth and initiation on process efficiency and sourcing leverage. Results indicated that only higher levels of external integration that went beyond simple procurement systems, alongside who initiates the IOS (buyer or supplier), allowed manufacturing firms to enhance process efficiency. In contrast, it has been argued that IOS breadth and IOS initiation enable manufacturing firms to enhance sourcing leverage over their suppliers (Saeed *et al.*, 2005).

Overall, research on the impact of EB on collaboration is still underexplored (Sanders, 2007). Whilst it is apparent that the subject of EB value is an area of growing research interest in the field of supply chain management and collaboration, the measurement of EB value appears not to be consistent and there is a lack of clarity with regard to what specific EB applications contribute to EB value in general and supply chain collaboration in particular. In fact, the impression created from the extant literature is that EB is universally beneficial. The rate of development of web-based applications and of adoption suggests that an investigation of EB value at the level of the EB applications is required to add to the body of research knowledge.

2.3 Buyer-supplier collaboration and operational performance

Increasingly, having closer buyer-supplier relationships is being proclaimed as a means to achieve superior performance (Handley and Benton, 2009). Previous research has consistently found that collaboration, coordination and integration through the means of information sharing between firms, improves firm performance (Lee *et al.*, 1997; Chen *et al.*, 2004; Vereecke and Muylle, 2006). Devaraj *et al.* (2007) identified that supplier integration does significantly contribute to operational firm performance in terms of cost, quality, flexibility, and delivery performance, whereas customer integration does not. Another study by Vickery *et al.* (2003) tested the effects of an integrative supply chain strategy on customer service and financial performance. An integrative supply chain strategy was conceptualised through IT and supply chain integration.

Some researchers have linked the performance benefits of supply chain collaboration through the theoretical foundations of the relational view (Dyer and Singh, 1998; Chen *et al.*, 2004). Dyer and Singh (1998) argue that organisations engaging in alliances can gain supernormal profit (relational rents) through the following four sources:

(1) relation-specific assets;

(2) knowledge-sharing routines;

(3) complementary resources/capabilities; and

(4) effective governance.

In a case study of Japanese automakers, Dyer and Singh (1998) empirically verified that close supplier relationships lead to more relationship specific assets (investments), lower transaction costs, and ultimately superior operational performance.

While a relatively small number of studies have established and confirmed the link between collaboration and operational performance, the results tend to be at an aggregate level; only recently has collaboration been conceptualised using multiple dimensions and their effect on operational performance examined. However, the impact of EB-enabled supply chain collaboration on operational performance is a riper area for research investigation. Previous research in this area has tended to focus on assessing EB-enabled collaboration and its impact on performance largely from an information sharing perspective. The impact of the more complex social constructs of collaboration on performance have not been the focus of much extant research yet (Simatupang and Sridharan, 2002). This perspective is amplified when integrating the link between supply chain collaboration and EB-applications.

3. Conceptual model and research hypotheses

Figure 1 shows the conceptual model highlighting the relationships between EB, collaboration and operational performance.

EB applications are defined as the information systems that the focal organisation has implemented to support and/or enable electronic processes and activities with its

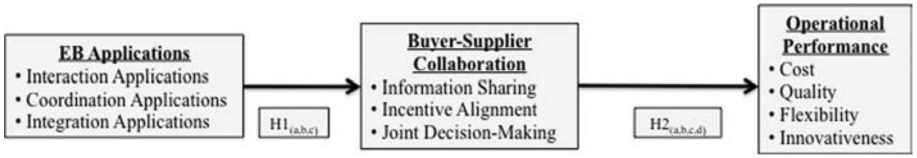

Figure 1.
Conceptual model

key suppliers (Powell and Dent-Micallef, 1997; Zhu and Kraemer, 2002; Zhu, 2004; Ray *et al.*, 2005; Jeffers *et al.*, 2008). Key suppliers are distinguished from ordinary suppliers in terms of the volume and/or value of the items that they supply. Earlier research in the area of EB has largely ignored the role of an organisation's supply chain partners' EB system in the value creation process (Barua *et al.*, 2004). A firm's EB system needs to interact with the EB systems of its partnering firms where subsequent value may be created at least in part from the collaborative working that EB has enabled.

Specifically, we analyse the interplay of a company's EB applications such as EB interaction applications (i.e. applications that enable the exchange and sharing of data and information); EB coordination applications (i.e. applications that support and/or enable the planning and evaluation of an organisation's supply chain processes) and EB integration applications (i.e. applications to support and enable the integration of processes and the seamless flow of data throughout the supply chain) with its key suppliers' EB applications.

The link between EB applications and organisational collaboration has been made by several authors (Devaraj *et al.*, 2007; Sanders, 2007; Saraf *et al.*, 2007). This research supports the development of our first set of hypotheses. Sanders (2007) identified that the firm's use of EB technologies has a direct and positive impact on intra and inter-organisational collaboration. In another study, Devaraj *et al.* (2007) tested the impact of EB capabilities on collaboration in the form of production information integration. They identified that EB capabilities in the form of customer, purchasing and collaboration applications support customer and supplier integration. More recently, Power *et al.* (2010) examined the effects of EB on operational performance and found that EB on its own had no significant impact. However, they identified that EB linked to trading partner collaboration led to enhanced operational performance.

The first objective of this paper is to test whether, by deconstructing EB into interaction applications, coordination applications and integration applications, independently impacts upon collaboration. Consequently, our first set of hypotheses is presented as follows:

H1$_{(a,b,c)}$. Higher levels of EB implementation with regard to (a) interaction, (b) coordination and (c) integration applications are associated with higher degrees of buyer-supplier collaboration.

Buyer-supplier collaboration, the mediating variable, is defined as the extent to which an organisation shares information, costs, risks, benefits, and makes joint decisions with them (Stank *et al.*, 2001; Simatupang and Sridharan, 2005; Nyaga *et al.*, 2010). A limited number of empirical studies have tested the effect of supply chain collaboration on performance (Sriram and Stump, 2004; Vereecke and Muylle, 2006). For example, using Frohlich and Westbrook's (2001) concept of arcs of integration, Devaraj *et al.* (2007) identified that supplier integration has a significant positive contribution on firm performance, while customer integration does not. Simatupang and Sridharan (2005) in their collaboration construct tested the effect of information sharing, incentive alignment and joint decision-making (decision synchronisation) on fulfilment, inventory and responsiveness. They identified that all three collaborative dimensions influenced these operational metrics.

Turning to EB applications, most research on EB value has tended to ignore the role of collaboration in the value creation process (Barua *et al.*, 2004). It has been argued that in order for a firm's EB system to maximise its potential impact on performance it needs to be supported by the EB systems of the suppliers with whom it collaborates. For example, e-procurement typically requires compatible electronic data and exchange interfaces across businesses, substantial systems redesign and integration within those businesses, joint personnel training, and significant commitment from top management. Kohli and Grover (2008) argued that such an approach creates improved performance through IT value being realised through multiple parties and the value thus emerges from establishing collaborative relationships. In terms of EB technologies facilitating collaboration, Sanders (2007) supported this view when he found a positive relationship between collaboration and both inter- and intra-organisational performance reflected in cost, quality, flexibility and innovation metrics.

The second objective of this paper is to test whether supply chain collaboration impacts upon operational performance. Consequently, our second set of hypotheses is presented as follows:

$H2_{(a,b,c,d)}$. A higher degree of buyer-supplier collaboration is associated with improved performance with regard to (a) cost, (b) quality, (c) flexibility and (d) innovativeness.

4. Methodology

In order to test the proposed hypotheses this study employs the commonly used two-stage structural equation modelling (SEM) approach (Anderson and Gerbing, 1988). In the first stage the measurement properties in terms of reliability and validity will be assessed through confirmatory factor analysis (CFA). The second stage tests the hypothesised relationships through the structural model.

4.1 Questionnaire

The survey was developed in several stages. First, a paper-based version of the questionnaire draft was discussed with colleagues from academia. After some minor changes, the questionnaire was given to senior consultants from well established automotive consultancy agencies and discussed with six German purchasing directors' from various automotive companies along the supply chain. Based on their valuable comments, the questionnaire was further refined with changes made to questions about the technologies that have been implemented to support and/or enable supply chain processes in buyer-supplier relationships. Additionally, some questions such as those regarding the performance indicators were reworded.

Subsequently, we undertook a pilot test of the survey to seek final suggestions for improvement and clarification and the questionnaire was tested with 18 German purchasing directors from various companies reflecting the population of the German automotive supply industry (Dillman, 2000).

In order to collect data efficiently, the questionnaire has been further developed into a web-based survey. Its usability was tested by colleagues and ten managers from the German automotive industry, who also participated in the paper-based pilot test. After some minor changes made to the design, the web-based survey has been successfully developed and used to collect data for this research (see the Appendix). The aforementioned pilot phases were particularly necessary due to the constant and rapid developments of EB applications (Zhu and Kraemer, 2002; Froehle and Roth, 2004).

4.2 Data collection

Data for this study was obtained from German manufacturing suppliers within the automotive industry. The German automotive industry is the biggest and most important industry in Germany with 708,585 employees and revenue of 317,054 million Euros in the year 2010 (VDA, 2011). Based on production statistics collected by the "International Organization of Motor Vehicle Manufacturers", Germany is also the biggest car manufacturer in Europe with a total of 6,195,661 cars produced in 2007, compared with 11,610,000 cars made by the biggest worldwide car manufacturer based in Japan. Furthermore, in the vehicle supplier market, which is the main focus of this research, 11 of the 50 largest global automotive suppliers are located in Germany (VDA, 2008).

There are several reasons for collecting data from the German automotive supplier industry. First, manufacturing industry in general and the automotive industry in particular have always been early adopters of new information technologies and systems (Deloitte Research, 2002). Second, this industry has always had closely linked supply chains that require collaboration between the supply chain partners (Zirpoli and Caputo, 2002). Third, the automotive industry is highly competitive, making EB applications an important resource for companies to streamline their supply chains. Fourth, this industry has a great number of companies, making it suitable for survey research that requires a large sample size. Finally, concentrating on a single industry assists in controlling for extraneous industry factors that could confound the analysis (Zhu, 2004).

Invitation letters were e-mailed to 867 companies. The sample was selected through the two most widely used and most recognised databases for German automotive suppliers by DEKRA (Kroll and Kroll, 2005/2006) and Wilden (2005/2006). Because of the nature of the questions the head of the purchasing department was identified as being the single most appropriate person to complete the questionnaire. Participants were targeted up to five times via telephone and e-mail between June and October 2007 (Dillman, 2000). A total of 173 questionnaires were returned out of which 152 were usable resulting in an effective response rate of 17.5 per cent. The majority of the respondents hold the title of vice president of procurement and purchasing (43.4 per cent), followed by vice president of materials management (25.0 per cent), CEO (6.6 per cent), director of procurement and purchasing (6.6 per cent), procurement and purchasing manager (5.3 per cent) and others (13.1 per cent). In addition Table I lists the respondents' company size in terms of employees.

Number of employees in Germany	Frequency (%)
1-250	58 (38.1)
251-500	27 (17.8)
501-750	11 (7.2)
751-1,000	15 (9.9)
1,001-	41 (27.0)
Total	152

Table I.
Company size of survey respondents

4.3 Measures

With reference to Figure 1 and EB applications, interaction applications are defined as the extent to which organisations have implemented EB applications to support and/or enable communication and data transfer with key suppliers (Johnson *et al.*, 1992; MacKay, 1993; Chidambaram, 1996; Massetti and Zmud, 1996; Rubart *et al.*, 2001; Banker *et al.*, 2006; Bakos and Katsamakas, 2008; Johnson *et al.*, 2007). This category includes applications such as web-based EDI, private and public supplier portals shared workspaces, audio conferencing and unified messaging (Table I, see the Appendix). Coordination applications are defined as the extent to which organisations have implemented EB applications to support and/or enable the planning and evaluation of an organisation's processes and activities with its key suppliers (Wu *et al.*, 2003). These applications allow organisations to electronically monitor and analyse their spending and their supplier's performance (Wu *et al.*, 2003). This category includes applications that allow organisations to monitor and analyse their procurement activities and processes such as order tracking or quality management. Integration applications are defined as the extent to which organisations have integrated their interaction and coordination applications with their internal and key suppliers systems (Barua *et al.*, 2004; Rai *et al.*, 2006). These applications enable organisations to seamlessly communicate their suppliers through process and technology integration.

Buyer-supplier collaboration is conceptualised as a multidimensional construct, which reflects its complexity (Simatupang and Sridharan, 2005; Nyaga *et al.*, 2010). In addition, the latent variables are further developed and treated as a second-order factor model, which will have certain advantages for the data analysis process. Information sharing is conceptualised as the breadth of information exchanged in a buyer-supplier relationship. Items have been adapted to fit the purpose of this study, and six items have been used to measure the breadth of information sharing within buyer-supplier relationships (Li *et al.*, 2005; Zhou and Benton, 2007). Incentive alignment is conceptualised as the extent to which the buyer organisation shares costs, risks, and benefits with its key suppliers (Paulraj *et al.*, 2008, Cao and Zhang, 2011). Again, as a result of the pilot conducted with industry experts, some items have been amended for clarification purposes. The final dimension joint decision-making (called decision synchronisation in Simatupang and Sridharan (2005)) is conceptualised as the degree to which the buyer and its key suppliers jointly make key decisions at the planning and operations level (Das *et al.*, 2006; Cao and Zhang, 2011).

The final set of measures relates to operational performance, which is defined as an organisation's performance in cost, quality, flexibility and innovativeness (Vickery *et al.*, 1993; Miller and Roth, 1994; De Toni and Tonchia, 2001; Chen and Paulraj, 2004). The first three of these reflect the operational performance dimensions a company uses to generally express its manufacturing strategy (Ward *et al.*, 1995; De Toni and Tonchia, 2001). With regard to the fourth performance indicator, inter-organisational collaboration has been proposed to be beneficial for a firm's innovative performance (Faems *et al.*, 2005). This is likely to be particularly important in the automotive industry, where suppliers play a key role in the development process of new technologies. Bosch AG, for example, is responsible for the development and supply of the electronic systems of Daimler's E-class. A high degree of collaboration with such an important supplier and partner is expected to not only reduce research and development costs, but also provides Daimler the opportunity to use the latest innovations for their cars. This involves e-enabled collaboration, through EB applications, such as shared workspaces and web-based conferencing tools. The difference of this study in comparison to others is that these four dimensions will be assessed individually through multiple items. All items including the abbreviated questions, the mean and standard deviation can be found in Table I and the Appendix (measured through seven-point Likert scales).

4.4 Non-response bias and common methods variance

Before any further analysis was undertaken, non-response bias, which is the difference in the estimate between the respondents and non-respondents, has to be analysed (Pearl and Fairley, 1985). For this purpose, the significant differences in the responses of early and late returned questionnaires have been analysed (Lambert and Harrington, 1990). Six of the survey items used in the analysis were randomly selected, and χ^2 tests were performed on the initial and last set of twenty responses from the total of 152 responses received. Results indicate that no statistically significant difference in the estimate between earlier and later respondents have been detected, that is, no bias for non-response (Armstrong and Overton, 1977).

As data was collected from a single informant (purchasing director), before testing the hypotheses, it is necessary to test for common methods variance. The approach developed and recommended by Podsakoff *et al.* (2003) was followed. In their approach an additional unmeasured methods factor is introduced into the measurement model. Following this method the results indicate that all items continued to load significantly on their intended latent variables which suggests that common methods variance is not of significance in this model.

5. Measurement model

5.1 Confirmatory factor analysis

According to Handley and Benton (2009, p. 10), "second-order factors are latent constructs used to explain the covariance between two or more first-order factors". Based on previous research this study conceptualises buyer-supplier collaboration as a second-order factor because of the expected correlations among information sharing, joint decision-making and incentive alignment (Simatupang and Sridharan, 2005). Apart from conceptual advantages, another important benefit of using second-order factors is that the individual first-order factors can capture more homogeneous, narrowly defined content domains (Gerbing *et al.*, 1994; Handley and Benton, 2009).

The relationships between the items and their latent variables are based on the previously discussed literature (Table II). The maximum likelihood method in Lisrel 8.8 was used to carry out the CFA. Multiple incremental and absolute fit indices (χ^2/d.f. $= 1.43$; RMSEA $= 0.041$; NNFI $= 0.91$; CFI $= 0.96$; NFI $= 0.96$; IFI $= 0.96$) reflect a good measurement model fit (Bollen, 1989; Gerbing and Anderson, 1992).

Statistical justifications for conceptualising buyer-supplier collaboration as a second-order construct can be made through comparing the fit of the first-order model with that of the more restricted second-order model (Handley and Benton, 2009). Recently, researchers have begun to use the target coefficient (T), which is the χ^2 ratio (divide χ^2 of first-order model by second-order model) as an indicator for the degree to which the second-order CFA model accounts for the relations among the first-order factors (Tanriverdi and Venkatraman, 2005; Handley and Benton, 2009). With a (T) coefficient

Table II. CFA factor loadings and descriptives

Scale/Cronbach's α	Variable	Mean	SD	Factor loading	t-value	SE
EB interaction applications $\alpha = 0.745$	Web-based EDI	2.52	2.02	0.77	10.71	0.16
	Private supplier portals	1.77	1.95	0.60	7.71	0.16
	Public B2B markets	1.46	1.82	0.84	12.16	0.13
	Shared workspaces	1.44	1.85	0.70	9.45	0.14
	Audio conferencing	3.02	2.24	0.76	10.56	0.17
	Unified messaging	1.51	1.84	0.59	7.62	0.14
EB coordination application $\alpha = 0.915$	*Applications that allows you to ...*					
	Monitor and analyse your spending	1.86	1.84	0.85	13.96	0.12
	Monitor and analyse your suppliers' performance electronically	2.14	1.77	0.89	11.28	0.12
	Monitor and analyse the quality of the procured items and materials electronically	2.24	1.91	0.89	11.35	0.13
	To electronically track order and order status	2.01	1.89	0.71	10.50	0.14
	To electronically manage your supplier contracts	1.87	1.72	0.78	12.10	0.12
EB integration applications $\alpha = 0.875$	Our systems can easily transmit, integrate and process data from our suppliers among various internal systems	3.79	1.92	0.71	9.03	0.15
	Order changes are automatically reflected in downstream processes and our e-procurement system	3.48	2.09	0.64	7.74	0.16
	Our EB applications for the supply-side work seamlessly with the applications of our buyer-side	3.17	1.79	0.77	10.93	0.13
	Applications of our e-business system work seamlessly with the system of our key suppliers	3.17	1.80	0.83	12.22	0.12
	Applications of our EB system have been successfully integrated to most of our internal information systems	3.36	1.80	0.87	13.92	0.12
Information sharing $\alpha = 0.880$	*Sharing information about ...*					
	Inventory levels with your key supplier	3.72	1.87	0.70	9.36	0.14
	Production planning decisions and demand forecast with your key supplier	4.41	1.59	0.68	8.37	0.12
	Production and delivery schedules with your key suppliers	4.68	1.61	0.60	7.06	0.13
	New product developments or changes in existing products with your key suppliers	4.30	1.50	0.83	12.36	0.10

(*continued*)

Table II.

Scale/Cronbach's α	Variable	Mean	SD	Factor loading	t-value	SE
	Long-term strategic plans and events, e.g. entering new markets, or acquiring a new customer base with your key suppliers	3.67	1.56	0.86	13.46	0.10
	Market and economic situations and forecasts with your key suppliers	4.01	1.54	0.77	11.47	0.11
Incentive alignment $\alpha = 0.653$	Shared long-term benefits of joint product developments and joint problem solving	2.77	1.61	0.62	5.92	0.14
	Shared savings on reduced inventory costs	2.43	1.61	0.59	5.32	0.14
	Delivery guarantee for a peak demand	4.12	1.50	0.49	6.37	0.13
	Allowance for product defects	5.08	1.55	0.33	4.30	0.13
	Long-term incentive schemes for a high standard in product quality	3.63	1.67	0.63	8.53	0.13
	Agreements on order changes	4.25	1.50	0.56	7.40	0.12
Joint decision-making	*Decisions on …*					
$\alpha = 0.777$	Inventory requirements	3.25	1.73	0.56	7.06	0.13
	Optimal order quantity	4.33	1.60	0.68	9.21	0.12
	Implementation of supply chain software	2.81	1.71	0.58	4.59	0.14
	New product developments or modifications	4.03	1.69	0.75	10.95	0.12
	Long-range planning	4.13	1.63	0.83	12.16	0.11
	Forecasting	4.36	1.71	0.91	14.34	0.11
Cost	Ordering costs	4.87	1.14	0.81	10.89	0.085
$\alpha = 0.772$	Order cycle time	4.48	1.26	0.63	7.90	0.10
	Inventory turnover	4.36	1.28	0.60	7.50	0.10
	Costs of procured products/materials	5.12	1.09	0.69	8.89	0.085
Quality	Quality and reliability of produced products/components	5.33	0.92	0.77	13.77	0.065
$\alpha = 0.847$	Quality and reliability of procured items	5.59	.98	0.95	10.45	0.072
Flexibility	Ability to sense and respond to poor supplier performance	5.30	1.15	0.87	11.30	0.089
$\alpha = 0.726$	Ability to respond to demand changes in changing volume and mix of procured items	4.72	1.13	0.65	8.35	0.089
Innovativeness	Number of new product developments	4.63	1.43	0.58	8.11	0.11
$\alpha = 0.809$	Knowledge about key suppliers' production program	5.16	1.09	0.90	10.10	0.085
	Knowledge about suppliers' strength and weaknesses	5.28	1.15	0.82	8.59	0.093
	Time to market of new products	4.32	1.28	0.57	6.89	0.065

of 0.0871 results confirm that the second-order model explains the majority of the relations between information sharing, joint decision-making and incentive alignment. For the paths from buyer-supplier collaboration to its three dimensions are all were found to be significant at $p < 0.01$. Therefore, the second-order model is theoretically and statistically justified.

A commonly used test for convergent validity is to evaluate whether an item's standardised coefficient in the measurement model is greater than twice its standard error (Anderson and Gerbing, 1988). Results listed in Table II reveal that coefficients for all items exceed twice their standard error.

Discriminant validity was tested through inter-factor correlations (Anderson and Gerbing, 1988). Very high inter-factor correlations (1.00) indicate that the factors are measuring the same concept, although some correlation is expected since a second-order CFA is included in the model. An analysis of Table III reveals that inter-factor correlations are still acceptable. As expected, correlations between the second-order factors are reasonable high, however none of the correlations are significant.

Finally, reliability was tested through calculating the Cronbach's α values of the proposed latent variables. The values in Table II are all above the commonly used cut-off value of 0.60 indicating reasonably reliable measures (Nunnally, 1978).

6. Analysis and results

Composite scores were calculated for information sharing, incentive alignment and joint decision-making to simplify the conceptualisation of the second-order factor buyer-supplier collaboration. Figure 2 shows the results of the structure model tested (R^2 in cost, innovativeness, quality and flexibility: 0.37, 0.54, 0.27 and 0.30). Overall, model fit indices are as follows: RMSEA = 0.05, RMR = 0.073, NNFI = 0.96, CFI = 0.97. A comparison of these values against those in Hu and Bentler (1999) indicates that this model is satisfactory. In addition, with a ratio of χ^2 to degrees of freedom of 1.43 it is well below the commonly desired threshold of 3 (MacCallum *et al.*, 1996; Byrne, 1998).

EB applications in terms of interaction-, coordination-, and integration applications were hypothesised to increase buyer-supplier collaboration, which was measured by information sharing, joint decision-making and incentive alignment ($H1_a$, $H1_b$, $H1_c$). In other words, EB applications are expected to facilitate and enhance the sharing of information, the making of joint decisions and an increase in incentive alignment. These hypotheses were directly tested by assessing the statistical significances

Latent variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Interaction applications	1									
(2) Coordination applications	0.42	1								
(3) Integration applications	0.32	0.54	1							
(4) Information sharing	0.34	0.38	0.32	1						
(5) Incentive alignment	0.33	0.29	0.41	0.72	1					
(6) Joint decision-making	0.24	0.33	0.32	0.76	0.77	1				
(7) Cost	0.22	0.24	0.28	0.46	0.42	0.27	1			
(8) Quality	0.10	0.09	0.08	0.36	0.31	0.20	0.58	1		
(9) Innovativeness	0.31	0.27	0.31	0.64	0.67	0.56	0.69	0.63	1	
(10) Flexibility	0.10	0.16	0.11	0.40	0.43	0.23	0.58	0.71	0.74	1

Table III.
Correlations results

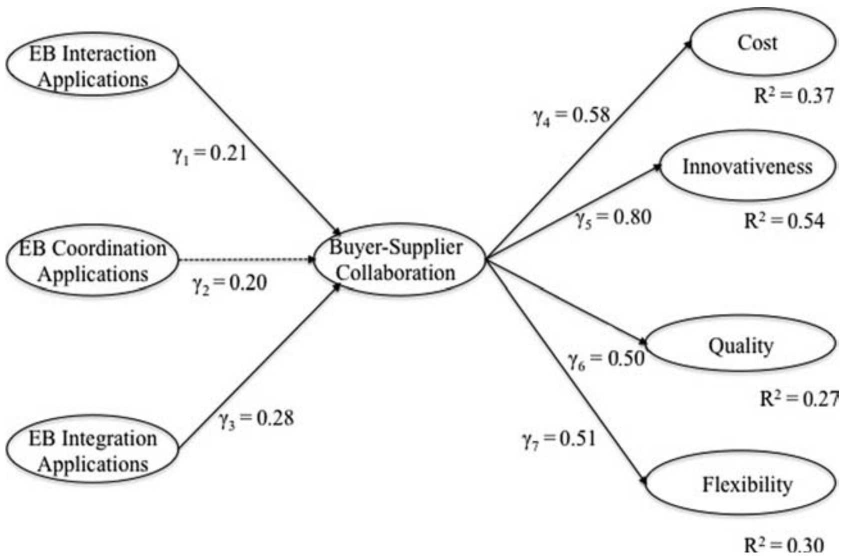

Figure 2.
Structural model results

of paths γ_1, γ_2 and γ_3. The standard path coefficient from EB interaction applications to buyer-supplier collaboration ($\gamma_1 = 0.21$; *t*-value $= 2.04$) was statistically significant and therefore $H1_a$ is supported. The standard path coefficient from EB coordination applications to buyer-supplier collaboration ($\gamma_1 = 0.20$; *t*-value $= 1.48$) was not statistically significant and therefore $H1_b$ is not supported. The standard path coefficient from EB integration applications to buyer-supplier collaboration ($\gamma_1 = 0.28$; *t*-value $= 2.77$) was statistically significant therefore $H1_c$ is supported.

Buyer-supplier collaboration on the other hand was hypothesised to increase an organisation's operational performance in terms of cost-, innovativeness-, quality-, and flexibility-related performance indicators ($H2_a$, $H2_b$, $H2_c$, $H2_d$). These hypotheses were also tested through assessing the statistical significances of paths γ_4, γ_5, γ_6 and γ_7. The standard path coefficient from buyer-supplier collaboration to cost related performance ($\gamma_1 = 0.58$; *t*-value $= 5.99$) was statistically significant and therefore $H2_a$ is supported. The standard path coefficient from buyer-supplier collaboration to innovativeness related performance ($\gamma_1 = 0.80$; *t*-value $= 5.94$) was statistically significant and therefore $H2_b$ is supported. The standard path coefficient from buyer-supplier collaboration to quality related performance ($\gamma_1 = 0.50$; *t*-value $= 5.67$) was statistically significant and therefore $H2_c$ is supported. Finally, the standard path coefficient from buyer-supplier collaboration to flexibility related performance ($\gamma_1 = 0.51$; *t*-value $= 6.10$) was statistically significant and therefore $H2_d$ is supported. In conclusion, apart from the path between EB coordination applications and buyer-supplier collaboration ($H1_b$) all other hypotheses have been confirmed.

7. Discussion, implications and future research

This study deconstructed EB value to test the importance of specific EB applications for complex buyer-supplier collaboration. It also tested the impact of EB-enabled collaboration on operational performance in terms of quality, cost, flexibility and innovativeness related performance indicators. Buyer-supplier collaboration has been conceptualised as a combination of information-sharing, joint decision-making and incentive alignment. This study makes a significant contribution through empirically testing the assumptions in the extant literature that EB applications enable buyer-supplier collaboration and subsequently improve operational performance. EB applications have been categorised and conceptualised into interaction, coordination, and integration applications. This research has identified that interaction and integration applications have a significant positive effect on buyer-supplier collaboration whereas coordination applications have not. Additionally, we found that complex collaboration significantly improves operational performance in terms of cost, quality, flexibility and innovativeness. Overall, a number of important findings emerge from this study that has both theoretical and managerial implications.

An important theoretical contribution of this research is the deconstruction of EB to enable the measurement of EB value to be more accurately in future research. We believe that our findings contribute to a better understanding of how to measure EB value from a theoretical perspective. The importance of interorganisational collaboration is well established in the literature. However, the use of EB applications to support collaboration is not well documented.

By carrying out a second-order CFA, this study makes a further contribution by confirming the multidimensional nature of the concept of supply chain collaboration. The construct is based on the Simatupang and Sridharan (2005) collaboration index and measures collaboration through information sharing, joint decision-making and incentive alignment. In applying and testing the Simatupang and Sridharan collaboration constructs in this research setting the original proposed dimensions have been confirmed. Through carrying out a second-order CFA, collaboration can now be modelled as one higher order latent variable consisting of three first-order latent variables representing the three dimensions of collaboration. This measurement construct can be adopted and further developed and refined in the future by researchers interested in the critical domain of supply chain collaboration. Furthermore, the direct impact of EB enabled collaboration to facilitate interaction and integration and its impact on operational performance adds to the body of knowledge within the larger research field of supply chain collaboration.

Another important finding is with regards to the impact of buyer-supplier collaboration on operational performance. The structural model explained 37 per cent of the variance in cost performance, 54 per cent of variance in innovativeness performance, 27 per cent of variance in quality performance and 30 per cent of variance in flexibility performance. These results indicate strongly that collaboration is the single most important factor that influences performance with regard to innovativeness. Likewise, collaboration has a very significant impact on improving cost performance. When promoting or evaluating a firm's collaborative efforts, companies should note that collaboration is a multidimensional concept, which is the result of several relationship building interacting activities and processes such as information sharing, joint decision-making and incentive alignment in the form of sharing costs, risks and rewards. As such in order to promote collaboration practitioners need to consider all three dimensions in order to generate operational performance benefits.

From a managerial perspective, the results indicate that EB applications cannot be viewed by practising managers as being universally beneficial in improving collaboration across a buyer-supplier boundary. Results inform management who want to promote collaboration through EB applications on what type of technologies to focus. By carefully and purposefully selecting the most appropriate EB applications, operations improvement benefits can be realised across a range of operational metrics due to enhanced supply chain collaboration. According to our results EB interaction applications such as web-based EDI, portals, shared workspaces, audio conferencing and unifying messaging tools are very influential. However, interaction applications may be very expensive to implement. Whilst messaging and conferencing tools are cost-effective methods to enable or support communication and data transfer with key suppliers, more sophisticated applications such as private supplier platforms are customised to order and are costly and time-consuming to develop. The benefits of such EB interaction tools are mostly present to large companies with a large supplier base at this stage. In addition, integration applications are also found to be of vital importance. In accordance with our results, management needs to ensure that their systems can transmit, integrate and process data internally and externally and that their EB applications are successfully integrated with their suppliers EB systems. On the other hand we have identified that EB coordination applications to support and/or enable the planning and evaluation of an organisation's processes and activities with its key suppliers do not significantly impact on buyer-supplier collaboration. This does not suggest that monitoring, controlling and evaluating various purchasing processes necessarily have a negative impact on collaboration. However, it does suggest that in the co-presence of interaction and integration applications it is of non-significance. Consequently, managers need to prioritise and consider the extent of using coordination applications in order to support buyer-supplier collaboration. In other words higher levels of control have to be weighed against higher levels of collaboration. From a theoretical viewpoint this suggests taking a more detailed view on which EB applications (i.e. EB interaction and integration applications) to choose to support and enable buyer-supplier collaboration.

No research can claim for itself that it is without limitations. One limitation of this study is in terms of the type of implemented EB technologies. Although the present study includes a wide range of technologies to support the buyer-supplier relationship there is always a limit to the level of detail that can be incorporated. Second, in terms of the actual performance measurement process, this study relies on perceptual and therefore subjective information from the respondents. Although it has been highlighted in previous research that perceptual measures give a fairly accurate picture of their actual performance it is still subjective (Tallon and Kraemer, 2007). Thirdly, a response rate of 17.5 per cent can certainly be viewed as relatively low. The ever-increasing number of surveys and the related survey fatigue may contribute to lower response rates. Nevertheless, the results of this study should be interpreted in the light of this response rate. Additionally, the degree of buyer-supplier collaboration is only measured through data collected from the buyer's perspective. In other words, the degree to which the focal firm (buyer) collaborates with its key suppliers is only assessed through data collected from one side of the supply-chain. Results could be potentially biased, as collaboration is a concept including at least two supply chain partners. As such, in order to get a comprehensive perspective of this dyadic relationship it would be more comprehensive if information from both parties were collected. Finally, the nature of the data is cross-sectional and can only provide a snapshot of what is currently happening within the sampled firms. It might as well be that performance improvements in some dimensions may be triggered by collaboration at earlier or different stages than others. This may result in causal relationships, which we could not truly test within this research.

This study provides several directions for potential future research in terms of construct development and theory development. The measurement constructs for collaboration can be further developed and refined through applying the concept to different supply chain relationships in different research settings. Furthermore, the retesting will purify the dimensions and items used to measure supply chain collaboration. In addition, the construct for collaboration has only been developed for the supplier side. Future research might adapt this concept for the buyer side. Another opportunity for future research is to include different performance indicator such as financial performance. It would also be interesting to identify whether collaboration can be a source of competitive or even sustainable competitive advantage to further underpin the importance of the concept. However, in order to test whether these performance developments are sustainable longitudinal data needs to be collected.

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Appendix. Survey items

EB applications (Powell and Dent-Micallef, 1997; Zhu and Kraemer, 2002; Barua et al.*, 2004)*

EB interaction applications (Johnson et al.*, 1992; MacKay, 1993; Chidambaram, 1996; Massetti and Zmud, 1996; Rubart* et al.*, 2001; Banker* et al.*, 2006; Johnson* et al.*, 2007; Bakos and Katsamakas, 2008)*. (Likert scale: 1-7; 1 – do not intent to implement, 2 – not yet begun, 4 – standard/common implementation, 7 – highly advanced implementation).

Please indicate the extent to which your organisation has implemented the following EB applications that support and/or enable the electronic communication with your key suppliers:

- Web-based EDI.
- Private supplier portals.
- Public B2B markets.
- Shared workspaces.
- Audio conferencing.
- Unified messaging.

Coordination applications (Wu et al.*, 2003)*. (Likert scale: 1-7; 1 – do not intent to implement, 2 – not yet begun, 4 – standard/common implementation, 7 – highly advanced implementation).

Please indicate the extent to which your organisation has implemented the following EB applications to plan, monitor, and evaluate your organisations processes and activities with your key suppliers.

Applications that allows you to ...

- Monitor and analyse your spending.
- Monitor and analyse your suppliers' performance electronically.
- Monitor and analyse the quality of the procured items and materials electronically.
- To electronically track order and order status.
- To electronically manage your supplier contracts.

Integration applications (Barua et al.*, 2004; Rai* et al.*, 2006)*. (Likert scale: 1-7; 1 – strongly disagree, 4 – neither agree nor disagree, 7 – strongly agree).

Please indicate the extent to which you agree or disagree that your EB system and data are integrated within your key suppliers systems and data:

- Our systems can easily transmit, integrate and process data from our suppliers among various internal systems.
- Order changes are automatically reflected in downstream processes and our e-procurement system.
- Our EB applications for the supply-side work seamlessly with the applications of our buyer-side.
- Applications of our e-business system work seamlessly with the system of our key suppliers.
- Applications of our EB system have been successfully integrated to most of our internal information systems.

Buyer-supplier collaboration (Simatupang and Sridharan, 2005)

Information sharing (Li et al.*, 2005; Zhou and Benton, 2007)*. (Likert scale: 1-7; 1 – not at all, 7 – very frequently).

Please indicate the extent to which you share the following information with your key suppliers:

- Information about inventory levels with your key suppliers.
- Information about production planning decisions and demand forecast with your key supplier.
- Information about new product developments or changes in existing products with your key suppliers.
- Information about long-term strategic plans and events, e.g. entering new markets, or acquiring a new customer base with your key suppliers.
- Information about market and economic situations and forecasts with your key suppliers.

Incentive alignment (Paulraj et al.*, 2008; Cao and Zhang, 2011)*. (Likert scale: 1-7; 1 – minimum level of practice; 7 – maximum level of practice).

Please indicate the extent to which your organisation shares costs, risks, and benefits with your key suppliers:

- Shared long-term benefits of joint product developments and joint problem solving.
- Shared savings on reduced inventory costs.
- Delivery guarantee for a peak demand.
- Allowance for product defects.
- Long-term incentive schemes for a high standard in product quality.
- Agreements on order changes.

Joint decision-making (Das et al.*, 2006; Cao and Zhang, 2011)*. (Likert scale: 1-7; 1 – no joint decisions, 7 – extensive joint decisions).

Please indicate the extent to which your organisation makes joint decision with your key suppliers:

- Inventory requirements.
- Optimal order quantity.
- Implementation of supply chain software.
- New product developments or modifications.
- Long-range planning.
- Decisions on forecasting.

Operational performance (Vickery et al.*, 1993; Miller and Roth, 1994; De Toni and Tonchia, 2001; Chen and Paulraj, 2004)*
(Likert scale: 1-7; 1 – not very good, 4 – average, 7 – very good).

Please rate the performance of your organisation in comparison with your competitors regarding the following operational indicators:

(1) Cost:
  - Ordering costs.
  - Order cycle time.
  - Inventory turnover.
  - Costs of procured products/materials.

(2) Quality:
- Quality and reliability of produced products/components.
- Quality and reliability of procured items.

(3) Flexibility:
- Ability to sense and respond to poor supplier performance.
- Ability to respond to demand changes in changing volume and mix of procured items.

(4) Innovativeness:
- Number of new product developments.
- Knowledge about key suppliers' production program.
- Knowledge about suppliers' strength and weaknesses.
- Time to market of new products.

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