ANGLES OF INTEGRATION: AN EMPIRICAL ANALYSIS OF THE ALIGNMENT OF INTERNET-BASED INFORMATION TECHNOLOGY AND GLOBAL SUPPLY CHAIN INTEGRATION

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This paper investigates the relationship between the focus and implementation degree of Internet-based information technology (IT) applications and the scope and orientation of process-oriented integration in global supply chains. Using data from 205 plants, which were collected in conjunction with the High Performance Manufacturing project, the degree of supplier and customer integration and its match with the implemented IT instruments supporting interorganizational collaboration are investigated empirically. Different types of integration are differentiated from each other with the help of factor, percentile and cluster analyses. The focus and degree of IT integration is measured for each of the resulting groups and the alignment of both aspects is analyzed with the help of an approach referred to as the angles of integration. With respect to supply chain integration and IT implementation, the analysis of different integration strategies shows that most of the plants do not align their IT implementation with their supply chain strategy. The paper helps companies to evaluate the alignment of their use of IT techniques with their global supply chain management emphases. Additionally, possible reasons for a potential missmatch of functional strategies are discussed giving managers insights for dealing more effectively with a strategic alignment. Furthermore, it refines an existing framework for the comparison of different supply chain integration strategies and applies it with IT. Based on the angles of integration, the match of supply chain integration and IT is investigated by statistical analyses.

Keywords: *supply chain management; B2B markets; e-business; survey research*

INTRODUCTION

In the past decades, supply chain management has evolved as a major discipline in operations management, and today it plays a significant role in the competitiveness of industrial companies. Great potential, including benefits like lower stocks and shorter cycle times, can be realized by implementing supply chain management practices (Fisher 1997; Lee, Padmanabhan and Whang 1997). In the production and operations management literature, Information Technology (IT) is often mentioned as a key driver for successful supply chain management implementation (e.g., Cachon and Fisher 2000; Bowersox, Closs and Drayer 2005; Sanders 2005; Devaraj, Krajewski and Wei 2007). Furthermore, the importance of the connection between supply chain management and IT is stressed in the statement by Byrd and Davidson (2003, p. 243): "Supply chain management has come to the forefront of organizational practice over the last decade as companies link to their suppliers electronically, to form interfunctional operations within their organizations and to forge electronic connections with key customers."

In a dynamic environment, many companies have to struggle with uncertainty. Often, companies respond with high inventories to buffer themselves against demand volatility. Furthermore, they try to cope with uncertainty by improving the accuracy of forecasts. The critical point is that inventories raise costs and forecasts are almost always wrong anyway (Stalk and Hout 1990; Suri 1998). Accordingly, uncertainty can be characterized as "the mother of inventory" (Christopher 2004, p. 263). Hence, information can be regarded as an effective remedy for the bullwhip effect (Lee et al. 1997) since it makes supply chains more responsive and efficient by getting uncertainty under control.

IT helps to cope with uncertainty by transferring information quickly through the supply chain, improving the availability and accuracy of information for better decision making. The development of Internet-based applications allows a higher degree of interorganizational communication, thus improving the flow of information and creating a seamless integration of entities in a supply chain (Devaraj et al. 2007; Sanders 2007). Internet-based applications foster supply chain integration by enhancing the efficiency of information transfer, the timeliness of information availability and the openness and transparency of relevant business information (Cagliano, Caniato and Spina 2003). In turn, Handfield and Nichols (1999) point out that, without a foundation of effective supply chain relationships, any efforts to manage the flow of information across the supply chain are likely to be unsuccessful.

Yet, despite the fact that supply chain management and IT are commonly accepted as critical enablers of successful production and operations management, there is still a lack of empirical work concerning the use of IT in supply chains, especially in terms of the adoption of Internet-based applications — or e-business — in a broad international context (Cagliano et al. 2003; Auramo, Kauremaa and Tanskanen 2005; Croom 2005). It seems that, with the importance of IT to supply chain relationships, the alignment of supply chain strategy and IT strategy — referred to as strategic fit — is a critical issue for successful supply chain development (in this paper, strategic fit is defined as the match of the respective functional strategies with each other in order to support an overall corporate strategy and thereby generating competitive advantage). The purpose of this paper is to empirically investigate the mutual alignment of supply chain strategy and IT. After discussing supply chain integration and the role of IT in supply chains, we investigate these issues with respect to their degrees of implementation. This is done by using an approach called the angles of integration, which can be regarded as a refinement of the arcs of integration framework (Frohlich and Westbrook 2001). In a second step, we compare the angles of integration in terms of supply chain integration and IT integration to analyze the alignment of both integration strategies, whereby the degree of IT integration is measured with respect to e-business in terms of Internet technologies.

GLOBAL SUPPLY CHAIN INTEGRATION

In order to cope with the challenging requirements of a demanding environment, companies frequently have to work together. Cooperative relationships between the firms within a supply chain can be regarded as the foundation for every effort in supply chain management (Handfield and Nichols 1999). A firm can realize cooperation by integrating and collaborating with its supply chain interfaces, that is those with its own suppliers and customers. In line with Salvador, Forza, Rungtusanatham and Choi (2001), we differentiate supply chain interactions according to the parties involved in the interaction, and thus distinguish between supplier integration and customer integration.

Supplier Integration

Supplier integration implies working together closely with key suppliers in a cooperative manner in order to generate advantages, such as a reduction of inventory or a decrease of the supplier lead time (see Kraljic's (1983) purchasing portfolio model as basis for identifying key suppliers). This means striving for long-term relationships with key suppliers, to share problems with them and conjointly finding more effective solutions, especially concerning the exchange of goods, funds and information. Furthermore, openness of communication should be emphasized when collaborating with suppliers in order to adopt strategies that can help foster improvement, including greater information sharing between parties and the visible presence of "co-destiny" relationships (Handfield and Nichols 1999, p. 10).

Customer Integration

Customer integration deals with a better understanding of key customers' needs and with their considerations in the company's business processes. It is the logical counterpart of supplier integration when looking at the interface from the supplier's perspective. In the context of mass customization, Piller, Moeslein and Stotko (2004) define customer integration as a form of company–customer interaction, in which the customer becomes a coproducer by taking part in activities and processes that used to be seen as the exclusive domain of the manufacturing company. Suppliers should recognize that some of their customers may reduce their supplier bases and strive for longer-term relationships with their suppliers, and therefore have to establish closer relationships with key accounts (Christopher 2004) by maintaining frequent contacts with them and being highly responsive to their needs.

Global Supply Chain Integration

Campbell and Sankaran (2005) understand supply chain integration as the process of developing linkages between an organization and its trading partners. Cagliano, Caniato and Spina (2006) stress that supply chain integration is strictly related to coordination mechanisms and, in particular, imply that business processes should be streamlined and interconnected both within and outside the company boundaries. Since we regard customer integration and supplier integration as the building blocks of supply chain integration, in this paper, supply chain integration is defined as the improvement of cooperative relationships with customers and suppliers.

The importance of integration is stressed in an approach presented by Frohlich and Westbrook (2001). They investigate the degree of supply chain integration according to the two factors of supplier integration and customer integration. In this paper, we correspond to their concept in a first step and distinguish between plants with five different approaches to supply chain integration accordingly: supplier integrators, customer integrators, simultaneous integrators, moderate plants and plants with an internal focus. In a second step, we investigate the current match between the focus and degree of supply chain integration and the current usage of collaborative IT, the cornerstone of effective supply chain management (Sanders and Premus 2002). Hence, the approach of Frohlich and Westbrook (2001) is extended since it does not capture both the focus and the degree.

INFORMATION TECHNOLOGIES IN GLOBAL SUPPLY CHAINS

IT

An important aspect of supply chain cooperation is the communication between partners along a supply chain. An efficient exchange of information is a key requirement for effective supply chain management. Handfield and Nichols (1999) and Grant (1996) stress that certain developments in technology have brought information to the forefront of resources from which companies can generate competitive advantage. Information can be seen as the "glue" that holds together the structures of all businesses (Evans and Wurster 1997). The relevance of information for supply chain management becomes obvious when the Bullwhip effect is considered (Forrester 1958; Lee et al. 1997). One important reason for this effect is a lack of information or a delay in the receipt of information. By visualizing a value chain as a linear flow of materials, people tend to neglect all the information flowing within a company and between a company and its suppliers, its distributors and its end customers (Evans and Wurster 1997). The flow of information is a pivotal point in the relationships within supply chains. New information and communication technologies enable innovative approaches to the management and exchange of information and therefore force managers to rethink and reshape their business strategies, their use of technology and their relations with suppliers and customers (Cross 2000).

The more integrated the flow of information between customers and suppliers, the easier it becomes to balance supply and demand across the entire network. This defeats the bullwhip effect and contributes to higher performance (Frohlich and Westbrook 2002). Accordingly, information, in particular visibility of demand and transparency of orders, can provide an important remedy for problems created by a lack of informational transparency (van Hoek 2001). Chopra and Meindl (2001) identify three characteristics information must show. Information must be accurate, it must be accessible in a timely manner, and it must be of the right kind. Accordingly, IT plays a dominant role in providing the necessary information in supply chains since it has the potential to improve communication between the chain actors, particularly in collaborative/co-operative conditions where information exchanges require greater frequency, significance and timeliness (Forza 1996).

Van Hoek states "... that information and communication technologies (ICT) will be for the economy what steam and machine power were to the industrial revolution" (2001, p. 21). Sanders and Premus (2002) see IT as the backbone of the supply chain business structure as it enables an improved acquiring, processing and transmitting of information among supply chain partners for more effective decision making. As a link between the suppliers and the manufacturer, the use of IT systems makes it possible to achieve greater precision and speed of the necessary information for the control of the supply process, as well as continuous evaluation of the supply relationship (Forza, Tuerk and Sato 2001).

E-business

E-business has become a centerpiece in the discussion of the use of IT in the context of supply chain management. Swaminathan and Tayur (2003, p. 1389) define e-business loosely as a "... business process that uses the Internet or other electronic medium as a channel to complete business transactions." This includes standardized electronic transactions between two companies, like Electronic Data Interchange (EDI), as well as transactions executed via the Internet. Contrary to this wide definition, some authors use a more narrow definition focusing explicitly on the Internet. According to Chopra and Meindl (2001), e-business is the execution of business transactions over the Internet. The main difference between EDI and Internet transactions is the possibility of interaction with multiple suppliers and customers when using the Internet, rather than focusing on the dyadic relationships of EDI (Hill and Scudder 2002; da Silveira and Cagliano 2006). In this paper, e-business is understood to be all business activities done via the Internet involving procurement and sales. E-procurement, in turn, is regarded as all purchasing and supply activities for which the Internet is used and e-sales are all marketing and sales activities using the Internet.

The importance of e-business for the efficiency of supply chain management is mentioned by several authors (e.g., Chopra and Meindl 2001; Kehoe and Boughton 2001). Johnson and Whang (2002, p. 414) even claim that "... nothing has rocked the young field of supply chain management like the emergence of the Internet." According to Christopher (2004), the Internet has perhaps provided one of the biggest breakthroughs when its potential impact on supply chain management is considered. Companies conducting e-business can perform such supply chain transactions as allowing customers to place and track orders or negotiating prices and contracts with suppliers over the Internet (Chopra and Meindl 2001). Companies using the Internet can access a broader range of trading partners and exchange detailed information more quickly and more cheaply than ever before (Cross 2000).

According to Chopra and Meindl (2001), IT systems play a significant role in every stage of the supply chain by enabling companies to gather and analyze information. But it is important to choose and to actually use IT in a better way, since just spending money on IT does not assure improvements and results (Forza et al. 2001). Hence, the strategic alignment of an IT system to the overall approach followed in supply chain management is relevant for the efficiency of a supply chain.

As theoretical foundation for this strategic alignment, contingency theory (Andrews 1971) can be used as starting point. Accordingly, companies should strive for achieving a strategic fit between their strengths/weaknesses and the environment's opportunities/threats. Furthermore, following Bourgeois and Astley (1979), a fit between strategy and internal structure should exist besides the strategic fit so that respective functions must be reorganized. The strategic focus of manufacturing plants in terms of a manufacturing strategy supporting the competitive strategy is introduced by Skinner (1969) and further developed by other authors (e.g., Wheelwright and Hayes 1985; Hill 1987; Slack 1994). In this context, Wheelwright and Hayes (1985), Hill (1987) and Hum and Leow (1996) mention the importance of a coordination of functional strategies in order to support a company's competitive strategy. Even Wheelwright and Hayes stress the meaning of consistency and contribution of functional strategies no matter if IT is considered an merely a supporting function or a major strategic topic of its own. Accordingly, the alignment of a manufacturing strategy and the IT system is a critical issue for competitiveness. Hayes, Pisano, Upton and Wheelwright (2005, p. 175) discuss the role of IT in terms of the concept of fit and focus and highlight the meaning for a company: "IT today has become all-pervasive. Its tentacles now stretch to embrace not only the whole firm, but the firm's suppliers, partners and customers as well. IT's role for many years was simply to support operations; today it is at the heart of operations. When combined with superior physical processes, it can be forged into a powerful weapon — providing firms with new abilities to compete through operations." Rathnam, Johnsenand and Wen (2005, p. 1) state that "... the alignment of business strategy and IT strategy has emerged as a critical issue for organizations." In this paper, we focus on IT in terms of Internet applications that are used to provide the desired information for suppliers and customers in a supply chain.

REVIEW OF EMPIRICAL LITERATURE

In the academic literature, only a few papers give empirical evidence for the impact of IT, especially of e-business, on supply chain management. Holland (1995) describes results of a case study in the textile industry from a managerial perspective. He concludes that companies are moving toward cooperative relationships in an effort to make the supply chain as a whole more competitive using interorganizational information systems. Croom (2001) conducted semistructured interviews in order to evaluate the impact of e-commerce on the structure of supply chains. Li and Lin (2006) examine empirically the impact of factors such as interorganizational relationships on information sharing and information quality in supply chains based on the data collected from 196 organizations without focusing on IT per se. Byrd and Davidson (2003) showed that IT's impact on the supply chain leads to better overall performance, based on a study with 225 respondents. They did not explicitly examine e-business. Frohlich and Westbrook (2002) investigated the relationship between Internet-enabled supply chain integration strategies and performance for manufacturing and service companies. Furthermore, they empirically investigated the drivers of web-based supply chain integration, but did not consider the alignment of supply chain strategy and IT.

Cagliano et al. (2003) conducted an investigation of e-business strategies, exploring the actual adoption of Internet technologies in supply chain processes. They review their primary results in a second article focusing on the Internet as a tool for reducing purchasing costs (Cagliano, Caniato and Spina 2005) instead of using it as a tool for integration and collaboration. Croom (2005) investigated the impact of e-business on supply chain management, based on a sample of 92 plants and interviews with six more organizations. Nguyen and Harrison (2004) developed a taxonomy illustrating a firm's positioning in terms of its electronic supply-chain orientation and investigated it based on the data of 102 respondents. They grouped the companies into four clusters according to their e-business capabilities and their integrated supply chain management capabilities. Auramo et al. (2005) conducted 48 telephone interviews and 18 in-depth interviews in order to analyze the benefits of IT in supply chain management.

Da Silveira and Cagliano (2006) investigated the difference between dyadic and multilateral interorganizational information systems in stable and dynamic supply chains, compared with performance and based on the IMSS data set. They did not consider the difference between supplier integration and customer integration, but rather distinguished between different types of entire supply chains. Forza et al. (2001) distinguish between suppliers and customers, but investigated only EDI in general, without focusing on Internet applications. Paulraj and Chen (2007) test the connection between strategic buy–supplier relationships and logistics integration with regard to performance. The impact of the strategic alignment of the purchasing function with the overall strategic orientation on performance is investigated empirically by Baier, Hartmann and Moser (2008). Based on the High Performance Manufacturing Project that is also used in this paper, Huang, Gattiker and Schroeder (2008) examine the relationship between TQM orientation and the adoption of eight supplier-facing e-commerce applications. Also based on the data set of this project McKone-Sweet and Lee (2009) analyze different supply chain strategies.

Altogether, it can be stated that none of the empirical research papers distinguish between supplier integration and customer integration explicitly, when investigating the fit between supply chain integration and IT. The reviewed studies treat several aspects related to the use of IT in the context of supply chain management, but none of them actually examine whether or not the chosen IT approach fits the degree and focus of the overall supply chain integration strategy. In this paper, we consider the difference between customer integration and supplier integration in supply chains and analyze the strategic alignment of supply chain integration and IT. It is assumed that an alignment of the IT strategy corresponding to the focus of supply chain integration is reasonable in order to support the pursued supply chain strategy by equivalent Internet technologies and improve the collaboration with supply chain partners. In the empirical analysis of the study conducted in this paper, the research question is investigated accordingly, whether there exists a strategic fit between the degree and focus of supply chain integration and IT integration. This question will be answered by an empirical analysis based on data collected within the High Performance Manufacturing Project. The analysis is done in two steps. First, we create factors for customer integration and supplier integration as well as measurements for customer-oriented IT integration and supplier-oriented IT integration. These we represent graphically as angles of integration. Second, we identify different groups of firms, distinguished according to supply chain integration, and investigate their strategic fits of supply chain integration and IT integration.

DATA ANALYSIS AND RESULTS

Research Methodology

The High Performance Manufacturing Project is an international research project, jointly conducted by researchers from eight countries. As successor of the World Class Manufacturing Project (Flynn, Schroeder, Flynn, Sakakibara and Bates 1997), its primary aim is the identification of management practices pursued by plants in three industries and the investigation of their linkage to performance. The comprehensive data set can also be used to investigate many other research questions in the field of operations management (for the basics of the project see Schroeder and Flynn (2001)). The data set is composed of contributions from 238 plants of the automotive supply, electronics and machinery industries, defined by the three-digit Standard Industrial Classification (SIC) code level, collected in the years 2004 and 2005. Each plant has more than 100 employees. Table I gives an overview of the structure of the complete database.

The database includes answers to 12 questionnaires that address domains of manufacturing companies, such as Human Resource Management, Quality Management, and Manufacturing Strategy. The questionnaires contain multiple items dealing with supply chain management and IT, and especially questions about the use of e-business instruments.

In order to identify plants with a high degree of customer integration and supplier integration, the plants were grouped by means of two percentile analyses on those two respective factors. These factors were created by using eight items about supply chain integration.

Analysis of Supplier Integration and Customer Integration

In the following section, two factors representing supplier integration and customer integration are described, having been built from eight items presented in Table II using a factor analysis with varimax rotation. Table II also shows the corresponding criteria for validity and reliability.

The validity of the factors was tested by assessing their eigenvalues and the explained variance. The eigenvalue of each factor must exceed the minimum threshold of 1.0 (Kim and Mueller 1978). This is fulfilled for both factors. Additionally, all factor loadings for each factor are greater than 0.4 (Hair, Anderson and Tatham 1987). Discriminant validity was tested by means of the bivariate correlations of the two factors and other potentially

TABLE I

Structure of the Database

	Electronic	Machinery	Automotive	Total
Austria	10	7	4	21
Finland	14	6	10	30
Germany	9	13	19	41
Italy	10	10	7	27
Japan	10	12	13	35
Korea	10	10	11	31
Sweden	7	10	7	24
USA	9	11	9	29
Total	79	79	80	238

TABLE II

Validity and Reliability of Factors

Factors	Loading	Cross-Loading	Eigenvalue	Alpha
Customer integration (CI)			2.411	0.826
We frequently are in close contact with our customers	0.805	0.120		
Our customers give us feedback on our quality and delivery performance	0.804	0.188		
We strive to be highly responsive to our customers' needs	0.815	0.161		
Our customers seem happy with our responsiveness to their problems	0.784	0.206		
Supplier integration (SI)			2.723	0.764
We are comfortable sharing problems with our suppliers	0.759	0.294		
In dealing with our suppliers, we are willing to change assumptions in order to find more effective solutions	0.625	0.099		
We believe that cooperating with our suppliers is beneficial	0.813	0.213		
We emphasize openness of communications in collaborating with our suppliers	0.816	0.080		
KMO	0.816			

influential variables such as industry, plant age, product complexity and plant size (Flynn et al. 1997). No significant correlations were observed between the individual factors and other variables of the model, so that no unintended constructs were measured.

The reliability of the factors was tested by Cronbach's α values whereby a value of 0.7 is regarded as acceptable (Nunnally 1978). The alpha values of each factor are greater than 0.7. A test of Cronbach's α in the respective countries shows whether the underlying questions of the factors have been understood in each country correctly. Only for plants from Finland is Cronbach's α below the threshold so that plants from this country must have been eliminated from the analysis leaving 205 plants for the subsequent analysis (see Appendix A for the country-specific alpha values). Considering the Kaiser–Meyer–Olkin (KMO) criterion of sampling adequacy, a minimum score of 0.5 is exceeded by both factors. Additionally, the chi-squares of Bartlett's test of nonsphericity for both factors are on a very high significance level. Accordingly, both factors fulfill all well-established criteria for validity and reliability and can be used for further analyses.

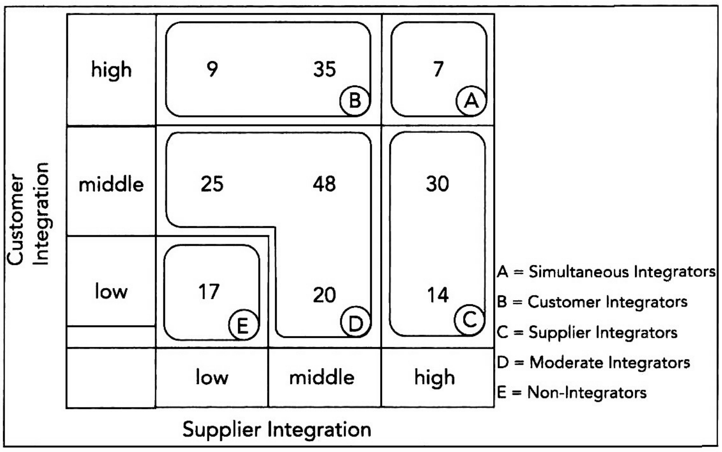
Identification of Groups of Integration

Based on two percentile analyses using the quartiles of the created factors, the plants are differentiated into the groups of high (top 25 percent), middle (medium 50 percent) and low (low 25 percent) degrees of integration on both dimensions, leading to nine possible approaches to integration (McClave and Benson 1985; Frohlich and Westbrook 2001). In accordance with the approach of Frohlich and Westbrook (2001), the combinations are separated into five groups. If a plant has a high degree of customer integration as well as a high degree of supplier integration, it is regarded as a *simultaneous integrator*.[1] Those plants do not focus on one form of integration, but seek to realize the potential of customer integration and supplier integration simultaneously. Some plants focus either on their suppliers or on their customers. These plants are called *customer integrators* and *supplier integrators*, respectively. The plants with no high degree of integration but at least a middle degree in one form of integration are referred to as *moderate integrators*. Finally, plants with a low integration degree in both integration dimensions have an internal focus and are characterized as *nonintegrators*. Figure 1 depicts the resulting numbers of plants for each combination.

The validity of the grouping was tested using cluster analysis. The result of the cluster analysis was then compared with the original grouping. More than 79 percent of the plants were classified by the cluster analysis

[1]Frohlich and Westbrook (2001) use the expression *outward facing* concerning this group. Since the aspect of a simultaneous integration of suppliers as well as customers is a key issue for this analysis, the term *simultaneous integrator* is used in this paper.

FIGURE 1
Cluster of Integration

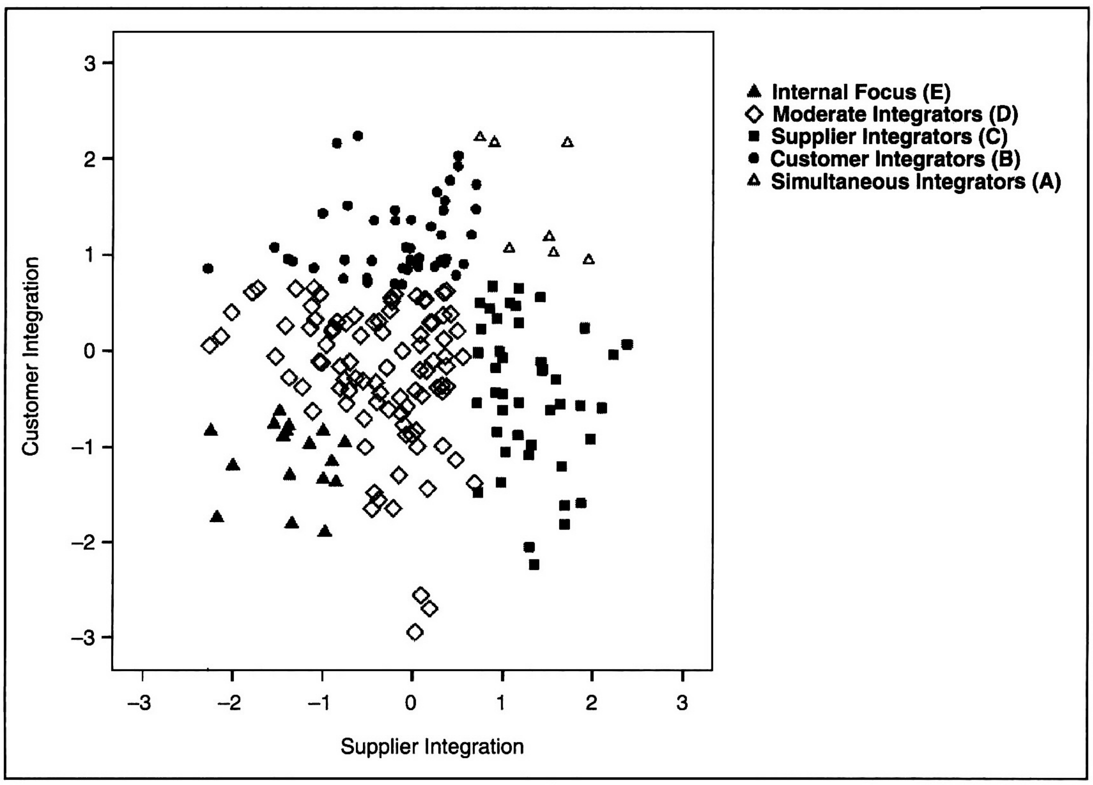


in the identical groups associated with the original grouping. Although this value is slightly lower than the one in the analysis of Frohlich and Westbrook (2001), the groups can be used for further analysis. Figure 2 depicts the positioning of the five groups in terms of customer integration and supplier integration. The groups are marked in a way that corresponds to Figure 1.

Analysis of the Degree and Focus of Global Supply Chain Integration

In the following section, the five groups are examined in order to show differences in their strategic supply chain focus and to allow a comparison with regard to the IT integration of the groups. For this, an approach is needed which allows a simultaneous analysis of supply chain integration and IT integration. Therefore, we take

FIGURE 2
Plant Positioning



up the conceptualization of Frohlich and Westbrook (2001), who use the circular arc between customer integration and supplier integration to investigate supply chain integration. In our case, the approach of Frohlich and Westbrook (2001) is refined in the following part: Instead of simply using the circular arc — as segment of a curve — to show the degree of customer integration and supplier integration, the underlying angle for customer integration and supplier integration will be examined. For each group, the mean factor value of both integration categories is calculated. The particular value is normalized with:

$$n_{factor} = \frac{x_{factor} - x_{min}}{x_{max} - x_{min}}, \quad (1)$$

whereby x_{factor} is the primary value resulting from the factor analysis, x_{min} and x_{max} are the corresponding minimum value and maximum value, and n_{factor} equals the normalized value according to the formula that is multiplied by 90. This is done in order to transfer the factor value X_{factor} to a scale ranging from 0° to 90°. Hence the highest factor value corresponds to a value of 1, which is equal to 90°, and the lowest factor value is 0, equaling 0°. Accordingly, the degree of the angle represents the value of the underlying factor. Conjointly, the two resulting degrees create a conjoint angle of integration illustrating the two categories of supply chain integration simultaneously.

The total angle of integration consists of the two angles that are created by the neutral line of zero integration (0°) and the line indicating the degree of integration, which can range from 0° to 90° for each factor. The variation of Frohlich and Westbrooks's original concept is done since it allows the analysis of two aspects, the scope of integration and the focus of integration, simultaneously. Figure 3 gives two examples of how factors for supplier integration and customer integration can be represented graphically with the concept of the *angles of integration*.

A wider angle stands for a higher degree of overall integration; a narrow angle means a lower degree of overall integration. Furthermore, the positioning of the angle bracket also illustrates the focus of integration: if a plant is more customer oriented or supplier oriented. The positioning of an angle bracket is represented by its bisecting line. For instance, the bisecting line of the dashed angle indicates a plant whose average overall degree of integration has a strong customer focus. The dotted angle shows a plant with a high overall degree of integration — indicated by a wide angle — but neither a strong focus on customers nor on suppliers. This approach of using angle brackets is used to graphically illustrate the results of the empirical analysis. It facilitates the identification of possible mismatches between the focus and the degree of supply chain integration and the IT integration in the same plant. Figure 4 shows the angles of integration and the corresponding bisecting line for each of the five groups. Each angle indicates the degree of customer integration and supplier integration for the respective group.

The widths of the resulting angles represent the degree of overall integration, while the directions of the angle brackets (which could also be illustrated by their bisecting lines) indicate the focus of the plants in each group.

The figure shows that the group of *simultaneous integrators* has the largest scope of integration which is indicated by the widest angle (143.9°). On the other hand, the *nonintegrators* group has the smallest scope of integration (40.3°) followed by the group of *moderate integrators* (75.2°). These three groups have no specific focuses on supplier integration or customer integration since the position of their bisecting lines is close to or exactly on the neutral axis (∼ 0°). The group of *customer integrators* has the strongest focus on customer integration (10.7°), as might be expected. Analogously, the *supplier integration* group has the strongest focus on supplier integration (6.6°). Table III shows the mean values for each group and the average value of all plants.

FIGURE 3
Angles of Integration

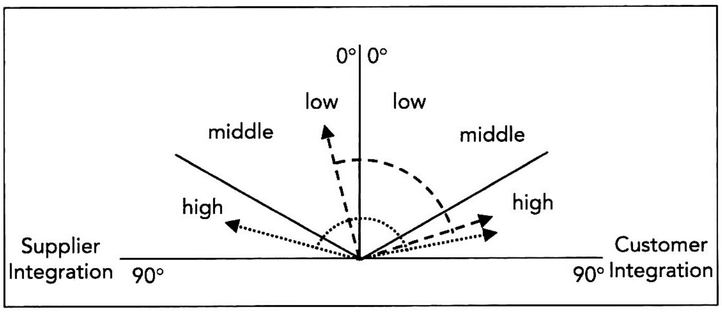
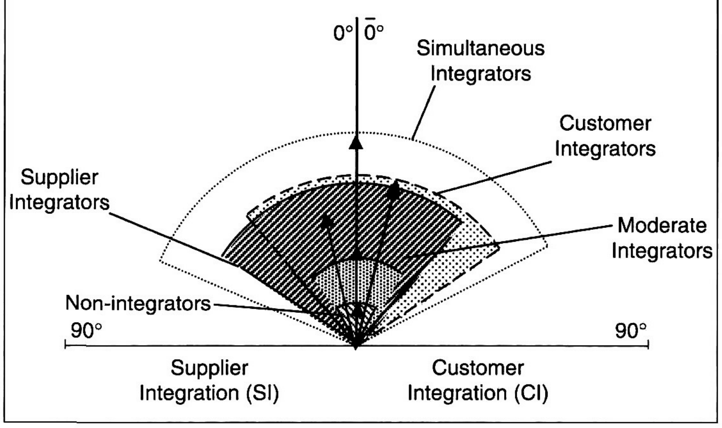


FIGURE 4
Angles of Supply Chain Integration



Analysis of IT Integration

In this section, the IT side of supply chain integration is investigated for the firms of this study. As stated earlier, this involves the use of Internet-based technologies to collaborate with suppliers or customers. We seek to show how far these technologies have been implemented in these firms. The technologies examined in this paper are the use of the Internet for *receiving and comparing suppliers' offers, providing dynamic pricing (negotiations and sellers' bids) for purchased items, transmitting orders to suppliers* and *tracking/tracing supply orders* on the supplier side and *providing online customized customer service* (where customers can configure the product within the constraints stated by the plant), *providing dynamic pricing offers to potential buyers, online order entry,* and the possibility to *check delivery status of their orders* on the customer side.[2] Since the data concerning the application of each particular technique are binary, the normalized number of techniques used is taken as the measure for the implementation of e-business on the supply and customer sides.

The degree of implementation is investigated for the five groups of supply chain integration identified earlier in order to discover differences between them. Figure 5 gives an overview of the Internet applications used for customer integration.

The figure shows that the customer-oriented Internet applications are applied only sporadically. Even the *simultaneous integrators* and *customer integrators* groups, which might be expected to use Internet applications to a great extent in order to support their strategic focus on customers, are far away from being outstanding in terms of IT-integration. This result is confirmed by an ANOVA showing no significant result for $p < 0.05$ (the mean values are represented in Appendix A).

If the Internet is used for the integration of customers, it is done most frequently by offering customers the opportunity to enter their orders online (41 plants). The possibility for customers to check the delivery status of their orders on the Internet is offered by 31 plants. Twenty-seven plants provide a customized online customer service. Using the Internet for dynamic pricing offers is implemented even less. Only 16 plants of the entire sample use this Internet application, presumably because this technology is not regarded as relevant for customer orientation, or it is too difficult to implement in the eyes of the IT managers. Only the simultaneous integrators show at least average values in this category. A reason for this observation might be that companies in this group might follow a "one size fits all" strategy for supply chain integration and for IT integration.

All in all, the majority of the plants from this study (almost two out of three) have applied none of the Internet applications at all (52 percent). Ten percent of the plants use only one of the mentioned Internet applications; fewer than 16 percent use two or more of them. On average, only 0.69 Internet applications are implemented.

For the supplier-oriented Internet applications, our data give a different picture. Here, some of the plants use the Internet for IT integration. One hundred two plants make use of the Internet to transmit orders to suppliers. In order to track and trace supply orders, the Internet is applied by 64 plants. The Internet is also used to receive and compare suppliers' offers (86 plants). Only 38 plants

[2]Some of the items describe collaboration rather than true integration, and could therefore lead to slight distortion. Nevertheless, they obviously represent the idea of fostering supply chain integration through the targeted implementation of Internet-based applications. Accordingly, basic insights from this study should still remain valid.

TABLE III

Angles of Supply Chain Integration

	Customer Angle	Supplier Angle	Width	Focus
Non-integrators	20.0°	20.3°	40.3°	0.1°
Moderate Integrators	37.2°	38.0°	75.2°	0.4°
Supplier Integrators	46.3°	59.6°	105.9°	6.6°
Customer Integrators	62.5°	41.1°	103.6°	10.7°
Simultaneous Integrators	71.2°	72.7°	143.9°	0.7°
All Plants	44.1°	43.3°	87.4°	0.4°

use the Internet for dynamic pricing. Surprisingly, the group *supplier integrators* shows low or only average values for the Internet applications. In terms of supplier-oriented IT integration, even this group would have been expected to support their supply chain integration strategies by supplier-based Internet technologies. This result is confirmed by an ANOVA showing no significant result for $p < 0.05$ (the mean values are represented in Appendix A). This fosters the supposition that there indeed exists a strategic mismatch of supply chain integration and IT integration. Figure 6 gives an overview of the Internet applications for IT integration in the five groups.

A look at the overall implementation shows that less than a fifth of the plants (18.4 percent) have implemented none of the Internet applications. 21.7 percent use at least one of the applications. Almost every second plant (43.5 percent) makes use of more than one Internet application, whereby 14 plants have implemented all of them. On average, 1.62 Internet applications are implemented.

As with the visualization of the degree and focus of supply chain integration, the IT integration can be illustrated with the concept of angles of integration. This will be done in a conjoint analysis in the following section, comparing supply chain integration and IT integration simultaneously in order to examine the alignment of both strategies.

Alignment of Supply Chain Integration and IT Integration

As it can be seen in Figure 7, the plants' main focus on IT integration is on the supply side. We assume it is reasonable to align the IT strategy corresponding to strategic supply chain focus in order to support the pursued supply chain strategy by the corresponding IT strategy. Accordingly, it would be expected that the focus in terms of supply chain integration is supported by equivalent Internet technologies, that is, plants of the customer integrators group focus on customer-oriented Internet technologies, for example, in order to improve the collaboration with customers. The strong focus on supplier-oriented Internet applications leads to the supposition that there exists a strategic mismatch between supply chain integration and IT integration in the majority of the plants of the study, since a dominant focus on the supply side cannot be observed in terms of supply

FIGURE 5
Customer-Oriented IT Integration

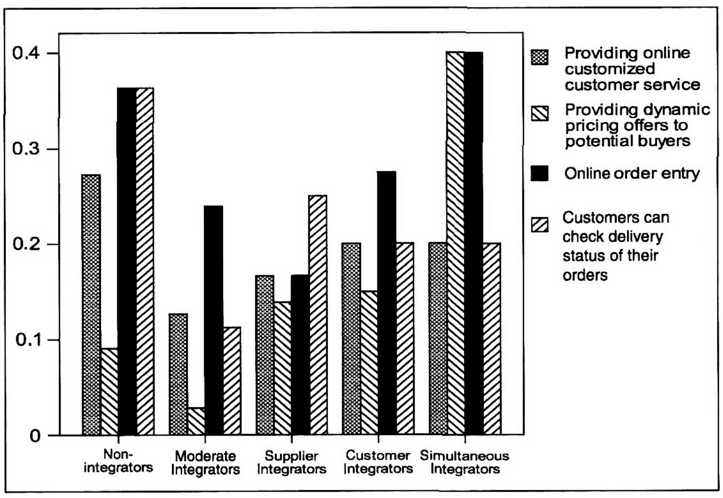
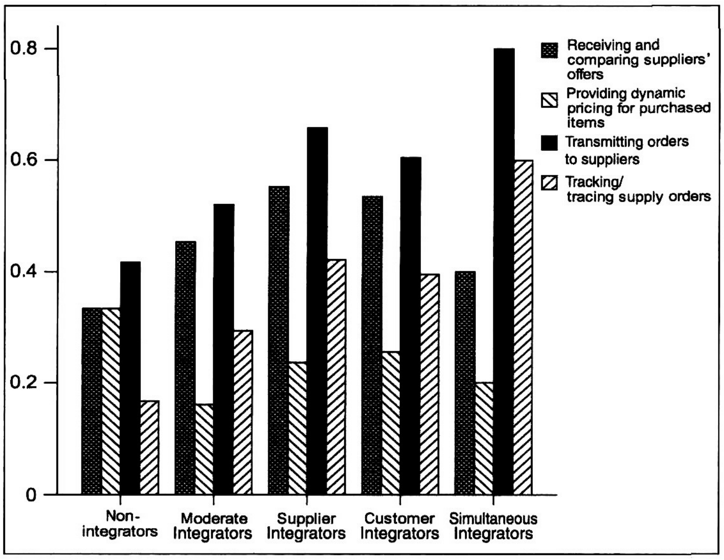


FIGURE 6
Supplier-Oriented IT Integration



chain integration. In order to consider this mismatch, supply chain integration and IT Integration are examined simultaneously. For a matching strategy, the bisecting lines for supply chain integration and IT Integration should point in the same direction, indicating that, for instance, supplier integration is supported by the corresponding supplier-related Internet application and customer integration is aided by the equivalent customer-oriented Internet application.

Figure 7b shows that most of the corresponding bisecting lines in each of the groups do not point in the same direction. For example, the bisecting line representing the IT strategy of the customer integrators shows a focus on the supply side. This would have been the case if the supply chain integration strategy and the IT strategy had been aligned properly to one another. Furthermore, the widths of the angles in each field are predominantly different. The simultaneous integrators group, for instance, has an angle representing the implementation degree of IT applications, whose width is smaller than the corresponding angle of supply chain integration. This indicates that the scope of integration in terms of supply chain integration and IT Integration is also not aligned for the majority of the plants in this study. Hence, the analysis indicates that the majority of the investigated companies surprisingly do not align their IT activities with their supply chain strategies.

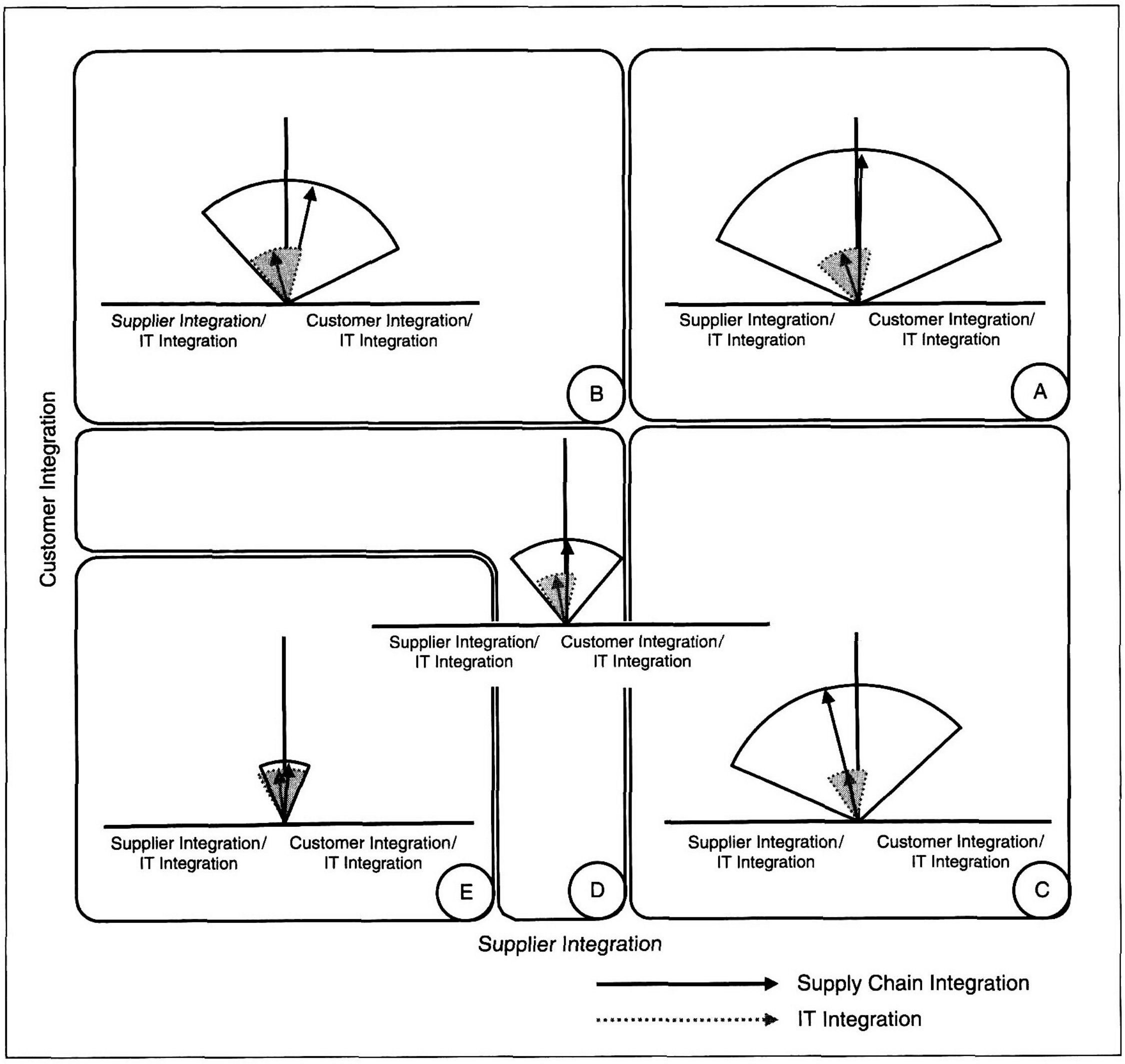
CONCLUSION AND FURTHER RESEARCH

In this paper, we have investigated the alignment of supply chain integration and IT integration. In order to analyze the integration activities of manufacturers empirically, factors were created based on the data of 235 plants. Using the angles of integration approach, the overall degree of integration as well as the strategic focus of integration has been analyzed. This approach allows supply chain integration and IT integration to be illustrated simultaneously. In general, it might serve as a promising instrument to visualize a company's position on a dyadic scale contrasting two different aspects of interest.

In this paper, we concentrated on the implementation of Internet applications. The results show that Internet applications have not been implemented to a great extent. This is consistent with results of other empirical studies on Internet adoption by manufacturing firms (van Hoek 2001; Cagliano et al. 2003). Furthermore, a comparison of supply chain integration and IT integration leads to the conclusion that the majority of plants do not align their adoptions of Internet applications to the focus pursued in supply chain integration.

Reasons for the relatively low implementation of Internet applications might be the following. First, the cost of implementing these applications can be high. Accordingly, decision makers might not estimate the cost-value ratio as satisfactory and reject or at least postpone an implementation. Second, organizational problems might lead to a rejection of Internet applications. If people are not open to accept organizational change, organizational inertia (Hannan and Freeman 1984) would hamper the adoption. Additionally, implementation problems due to necessary process modifications in the organization can lead to a low implementation in the long run. Third, new IT applications are often accompanied by technical start-up problems. The adoption to an existing IT system might be difficult. Fourth, the acceptance of a particular Internet application in the market might be an important issue. The question is whether the usage of such an IT application will

FIGURE 7
Supply Chain Integration and IT Integration



emerge as an industry standard. If decision makers doubt this, it can also be a reason for a low implementation degree. Finally, data security aspects can result in a negative attitude toward IT applications.

A reason for the fact that the majority of plants do not align their adoptions of Internet applications to the focus they pursue in supply chain integration might be a missing strategic consistency due to a lack of communication between the IT department and other functional areas (Rathnam et al. 2005). Furthermore, it might be the case that companies are not really aware of their intended strategy or that the strategies are not communicated companywide. Additionally, departmental self-interests can lead to a noncooperative behavior between the involved functional areas. Also, existing interfaces instead of functional integration can hamper the alignment. Another reason for this insufficient alignment could be that managers think that the usage of Internet applications is more beneficial with suppliers in a business-to-business (B2B) setting and that Internet applications in terms of supplier integration seem to be more promising or easier to implement. Different perceptions of the decision makers from the two different functional areas in terms of cost-value ratios can result in a mismatch of the functional strategies.

The strategic alignment of e-business activities, however, is important to the realization of the potential of e-business. If approaches to the flow of information in the supply chain remain operational and fragmented, then strategic and supply-chain-wide benefits will not be achieved (van Hoek 2001). Accordingly, a supply chain strategy must be supported by an equivalent IT integration approach. This aspect is also stressed by van Hoek (2001, p. 27): "Otherwise, we may run into the situation where 'everything' only starts with an 'e'."

Some limitations apply to our research. We only investigated Internet applications, and the analyses could be extended to other IT technologies as well. Furthermore, we focused on supplier integration and customer integration and asked managers from individual companies for their estimations in that regard. It would be interesting to look at entire supply chains in order to investigate the supply-chain-wide implementation of customer integration and supplier integration, as well as the alignment of the implemented IT.

Further research should investigate other industries in order to give a more comprehensive picture of the manufacturing domain. Service companies should also be investigated. This would allow a generalization of the presented results. Furthermore, a longitudinal study of the investigated issue might give the chance to observe emerging patterns of IT and supply chain strategies. Such an analysis would give the opportunity to identify dominant strategies.

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APPENDIX A

TABLE A1

Cronbach's α by Country

Cronbach's α	Customer Integration	Supplier Integration
Germany	0.703	0.848
Japan	0.791	0.682
Korea	0.806	0.794
Italy	0.775	0.823
Austria	0.767	0.864
Sweden	0.753	0.648
USA	0.876	0.641
Finland	0.310	0.743

TABLE A2

Mean Values for Supplier-Oriented IT Integration

	Receiving and Comparing Suppliers' Offers	Providing Dynamic Pricing	Transmitting Orders to Supplier	Tracking/Tracing Supply Orders
Non-integrators	0.33	0.33	0.42	0.23
Moderate integrators	0.45	0.16	0.53	0.30
Supplier integrators	0.58	0.26	0.67	0.45
Customer integrators	0.53	0.26	0.60	0.40
Simultaneous integrators	0.40	0.20	0.80	0.60
All plants	0.49	0.22	0.58	0.36

TABLE A3

Mean Values for Customer-Oriented IT Integration

	Online Product Configurator	Providing Dynamic Pricing	Online Order Entry	Online Delivery Status of Orders
Non-integrators	0.27	0.09	0.36	0.36
Moderate integrators	0.13	0.03	0.24	0.11
Supplier integrators	0.17	0.14	0.19	0.27
Customer integrators	0.20	0.15	0.27	0.20
Simultaneous integrators	0.20	0.40	0.40	0.20
All plants	0.17	0.10	0.25	0.19