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INTER-ORGANIZATIONAL INFORMATION SYSTEMS VISIBILITY IN BUYER-SUPPLIER RELATIONSHIPS: BUYER AND SUPPLIER PERSPECTIVES

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Abstract

Many researchers have called for the need to improve the understanding of the concept and working of supply chain visibility. The facilitating role of inter-organizational information systems (IOIS) in achieving SC visibility has received inadequate research attention. This paper is to elaborate on the novel concept of IOIS visibility and to look into the antecedents and consequences of IOIS visibility. Further, investigating SC cooperation from the perspectives of both partners is important, especially when channel partners depend on each other and there can be asymmetries in IOIS visibility. This study attempts to accommodate both partners' perspectives in IOIS visibility.

The data that this study requires were collected from 51 matched pairs of intermediate producers of telecommunication equipment components and their immediate suppliers. The results show that IOIS visibility from the supplier's perspectives is an important predictor of supply chain performance. In turn, IOIS visibility is significantly influenced by supply chain partner's internal IS integration and inter-organizational IT infrastructure compatibility. The impact of asymmetries in IOIS visibility on supply chain performance is also investigated.

Keywords: Inter-organizational Information systems (IOIS) visibility, Asymmetries in IOIS, Supply chain cooperation, Information visibility.

1 INTRODUCTION

IT-enabled supply chain cooperation has recently received increasing attention in the supply chain management (SCM) and information systems (IS) literature (Rai et al. 2006; Barua et al. 2004; Pereira 2009). Many researchers have highlighted the need to elucidate the concept and operation of supply chain visibility (Sahin & Robinson 2005; Tan 2001). The facilitating role of inter-organizational information systems (IOIS) in achieving supply chain visibility has received inadequate research attention.

This paper proposes a new aspect of IOIS visibility, namely, the extent to which firms in a supply channel have access to information/knowledge from partner firms related to supply chain cooperation through inter-organizational information systems. The enhanced visibility of customer and/or supplier operations may help improve the entire supply chain performance and their own internal decision making and operating performance (Rungtusanatham et al. 2003; Fiala 2005; Kulp et al. 2004). Thus, the first objective of this paper is to elaborate on the novel concept of IOIS visibility and to explore the IS-related antecedents and consequences of IOIS visibility.

In the meantime, most existing empirical investigations of supply chain cooperation investigate the phenomenon from the perspective of only one partner. Investigating supply chain cooperation from the perspectives of both partners (buyers and suppliers) is important, especially when channel partners depend on each other when asymmetries in IOIS visibility can exist (Kim et al. 2009). Asymmetric IOIS visibility may increase the possibility of opportunistic behavior by a trading partner (Williamson 1985), leading to uncertainty surrounding the level and division of the benefits from the increased information sharing.

While the buyer's perspective in buyer-supplier relationships receives much attention, prior studies have shown discrepancies in the perspectives of buyers and suppliers. Kim et al. (2009) have found that buyers' perspectives are different from those of suppliers in regard to both the facilitators and barriers of buyer-supplier relationships. Therefore, studying supply chain cooperation from mutual perspectives is important in understanding how each partner regards the supply chain. Hence, this study attempts to accommodate both partners' perspectives in IOIS visibility and to look into the consequences of IOIS visibility from each participant's perspective.

The research model is investigated, using a sample of 51 matched-pairs of buyers and suppliers in the telecommunication industry. Specifically, the sample firms consist of manufacturers of telecommunication equipment parts and components. Intermediate producers (buyers in this sample) purchase low-level parts from their first-tier suppliers and assemble them into stable intermediate components. The final outputs from the intermediate producers are sold to telecommunication service providers who integrate them into a whole system. Effective manufacturing requires mutual adjustments and cooperation between the equipment manufacturers, because modular technologies must be integrated according to a certain agreed-upon protocol. Further, customer needs are constantly evolving in this industry, as is the technology required to meet them. In this type of environment, both SC partners benefit from cooperation because of the considerable interdependence between buyers and suppliers. Thus, the pair of intermediate producers and their suppliers provides a good context in which to study IOIS visibility.

2 CONCEPTUAL BACKGROUND

2.1 Inter-Organizational Information Systems (IOIS) Visibility

Previous studies have identified supply chain visibility as an important determinant of supply chain competitiveness (Kulp et al. 2004; Wang & Wei 2007). As a cornerstone of supply chain visibility, the SCM literature proposes the concept of information visibility, which is the degree to which the supply chain partners have on-hand information related to demand and supply for planning and control management (Mohr & Spekman 1994).

IOIS visibility should be distinguished from information visibility for the following two reasons: First, information sharing can be realized without IOIS, for example, through social contacts and procedural venues (Wareham 2003). IOIS requires significant investment from the participating firms in long-term relationships. Investments into computing / telecommunication resources for an inter-organizational relationship often represent relation-specific capital, which has little value for other economic activities outside the relationship (Kim et al. 2006). Further, the assets residing in IOIS are of a company-specific nature, which a firm would not reveal to outsiders. Making these IS assets visible to outside firms allows such knowledge assets to become public knowledge, thereby removing the firm's competitive edge over others in the industry group. These characteristics of IOIS visibility result in much higher transaction risks than information visibility without IOIS. In order to realize the benefits of IOIS visibility, participating firms require an effective governance structure that minimizes transaction costs, thereby enhancing efficiency (Dyer & Singh 1998).

Second, information visibility often works as a mechanism to mitigate problems such as opportunistic behavior that result from information asymmetry (Wang & Wei 2007). Exchanging information about forecasting, planning, product design, and manufacturing schedules reduces information asymmetry and monitoring costs, thus lowering the incentives of participants to behave opportunistically (Dyer 1997). However, IOIS visibility may not mitigate, but actually strengthen asymmetric relationships by reflecting the asymmetry in terms of the scope and depth of the partner information that can be accessed through IOIS. In the context of supply contract design, the more powerful party usually can assume the leadership position and, as a result, IOIS asymmetry remains a key feature of real supply chain relationships (Liu & Çetinkaya 2009). Therefore, IOIS visibility should be treated separately from information visibility.

2.2 Relational Rents from IOIS Visibility

The relational view (Dyer & Singh 1998) asserts that a firm may choose to seek advantages by creating assets that are specialized in conjunction with the assets of an alliance partner (Klein et al. 1978; Teece 1987). Productivity gains in the value chain are possible when firms are willing to make relation/transaction-specific investments (Williamson 1985). IOIS as a relation-specific asset provides an electronic channel through which firms can instantly access their partner firm's information, without incurring significant costs for transactions. IOIS visibility has the potential to achieve relational rents by reducing communication errors, lowering total value chain costs, and fostering greater product differentiation.

IOIS visibility also creates opportunities for organizational learning and knowledge exchange. For example, collaborative planning and forecasting (CPFR) systems allow channel partners to learn concurrently about changes in the market situation and to adapt flexibly to changing circumstances cooperatively. Product development systems shared with first-tier suppliers allow virtual simulations for assembling parts produced by various manufacturers and thereby enable faster product development cycles. Von Hippel (1988) asserts that a production network with superior knowledge-transfer mechanisms among users, suppliers, and manufacturers will be able to "out-innovate" production networks with less effective knowledge-sharing procedures.

Further, a cumulative (snowball) effect due to the interconnectedness between current and previous relation-specific investments develops (Dyer & Singh 1998). Existing IOIS held by a firm or its alliance partner may enable enhanced interconnectedness in cumulative increments. The key strategic implication of this cumulative effect is that competitors may need to make "bundles" of related relation-specific investments in order to realize the full potential of IOIS visibility.

3 RESEARCH MODEL AND HYPOTHESIS DEVELOPMENT

For our empirical investigations, we proposed the research model shown in Figure 1. IOIS visibility is expected to influence two dimensions of supply chain performance, that is, joint profit performance and the expectation of relationship continuity. The determinants of IOIS visibility are each partner's internal IS integration and inter-organizational IT infrastructure compatibility.

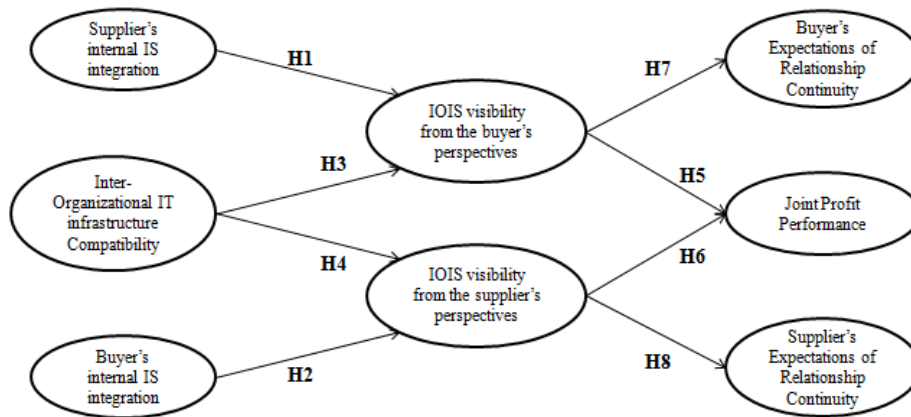


Figure 1. Research model

3.1 Internal IS Integration and IOIS Visibility

IOIS visibility depends on the extent to which the partner's internal information system is integrated. Firms with poor IS integration often face difficulties in connecting their customers, suppliers, and business partners, causing a delay in collecting and exchanging market information among supply chain participants (Zhu 2004). In the absence of the supplier's internal IS integration, the supplier's supply chain activities may have only limited visibility for the buyer. In his study on the business value of e-commerce capability and IT infrastructure, Zhu (2004) points out the importance of internal IS integration for front-end customer connectivity in reducing the constraints of time and distance on businesses. This rationale leads to the following hypotheses:

H1: The supplier's internal IS integration positively relates to IOIS visibility from the buyer's perspectives.

H2: The buyer's internal IS integration positively relates to IOIS visibility from the supplier's perspectives.

3.2 Inter-Organizational IT Infrastructure Compatibility and IOIS Visibility

When organizations are connected through electronic networks, inter-organizational IT infrastructure becomes an important environment for information sharing. Inter-organizational IT infrastructure encompasses the underlying inter-organizational system resources that can be harnessed to exploit resources held by supply chain partners. In particular, it refers to IT resources such as database, software, and networks for an inter-organizational relationship (Weill & Vitale 2002). Compatible infrastructure channels help reduce the costs of information sharing and leverage the appropriate resources during the information-sharing process (Colombo & Mosconi 1995), leading to higher IOIS visibility.

Dong et al. (2009) finds empirical evidence that compatible inter-organizational IT infrastructure, 'partner support' in their terms, implemented along the supply chain influences IOIS visibility. They assert that incompatible IOIS along the supply chain hinders supply chain partners from sharing real-time information. Supply chain partners with highly compatible infrastructure can have access to partner firm-specific information such as inventory backorder status, production capacity constraints, and demand forecast information (Barua et al. 2004). This discussion leads to the following hypotheses:

H3: Inter-organizational IT infrastructure compatibility positively relates to IOIS visibility from the buyer's perspectives.

H4: Inter-organizational IT infrastructure compatibility positively relates to IOIS visibility from the supplier's perspectives.

3.3 IOIS Visibility and Supply Chain Performance

Firms participating in a supply chain with high IOIS visibility can have on-time access to the required information for their decision making so that they can make informed decisions about supply chain activities. In a broader context, Dyer (1996) finds a positive relationship between relation-specific investments and performance in a sample of automakers and their suppliers. Parkhe (1993) also finds that the commitment of "nonrecoverable investments" in a sample of strategic alliances is positively related to performance.

The positive relationship between IOIS visibility and supply chain performance can work to the advantage of the buyers and/or the suppliers. Suppliers with high IOIS visibility of buyer's internal activities, such as sudden demand increases in certain products, can be better prepared by effectively adjusting their raw material procurement plans. Buyers with high IOIS visibility of supplier's internal activities, such as unexpected events in vehicle management, can make better decisions about inventory replenishment and storage planning. Thus, the following hypotheses:

H5: The buyer's IOIS visibility positively relates to joint profit performance.

H6: The supplier's IOIS visibility positively relates to joint profit performance.

High visibility of the partner's internal activities through IOIS reduces monitoring costs and lowers the incentives for opportunistic behavior. When firms are assured with IOIS visibility that the partner is trustworthy, the buyer-supplier relationship will proceed to the long transaction period (Jap & Anderson 2003). The positive relationship between IOIS visibility and the expectations of relationship continuity may work to the advantage of the buyers and/or the suppliers and therefore lead to the following hypotheses:

H7: The buyer's IOIS visibility positively relates to the buyer's expectation of relationship continuity.

H8: The supplier's IOIS visibility positively relates to the supplier's expectation of relationship continuity.

4 RESEARCH METHODS

4.1 Sample and Data Collection

Since a supply channel is a dyadic environment, this research examines the phenomenon from the perspectives of both the buyer and supplier in a dyad. The unit of analysis in this study pertains to the inter-organizational relationship — more specifically, matched pairs of buyers and suppliers. The data required for this study were collected from two distinct sources, namely, (1) the intermediate producers of telecommunication equipment components and (2) their immediate suppliers. The intermediate producers were identified through a major telecommunication service provider who purchases the intermediate components and assembles them into an integrated system. For the selection of the suppliers, the intermediate producers (buyers in this sample) were asked to select an important part and a major supplier for the part that was electronically connected to the buyer. Contact information about the chosen supplier was also solicited in order to collect data about the supplier's view of the relationship.

All of the buyers and their counterpart suppliers were invited to participate in the study. Follow-up emails were sent five and ten days after the initial contact. Respondents sent the completed questionnaires to the primary author. Of the 98 intermediate producers who received the buyer questionnaire, 64 usable responses were returned for a 65.3% response rate. The supplier questionnaires were sent to the 64 matched suppliers. Fifty-one usable responses were received for a 79.7% response rate. Therefore, the final sample consisted of 51 matched pairs of buyers and suppliers. To evaluate any systematic differences between paired responses and non-paired responses in the sample, ANOVA was performed for all independent variables. No statistically significant differences were found among the companies at the 0.05 level of significance.

With the exception of a few large corporations, most of the firms who participated in this study were small-to-medium firms. At the time the data were collected, the annual sales of the buyers for 2008 were as follows: 39.2% made less than US\$ 10 million, 58.8% made between US\$ 10 million and US\$ 100 million, and 2.0% made over US\$ 100 million. The annual sales of the suppliers for the year 2008 were as follows: 68.6% made less than US\$ 10 million, 15.7% made between US\$ 10 million and US\$ 100 million, and 15.7% made over US\$ 100 million.

4.2 Measures

To measure our research variables, existing scales, excluding that for IOIS visibility, were adapted to the study context, all of which were multi-item, seven-point Likert scales. Supply chain performance was operationalized in two dimensions: joint profit performance and the expectation of relationship continuity. The measures for these dimensions were adapted from Jap and Anderson (2003). For joint profit performance, responses from the buyer and supplier pair were averaged to obtain the relationship score.

IOIS visibility from the buyer's perspective refers to the extent to which the buyer has access to the supplier's information through IOIS in the following areas: order completion status, backorder status, production schedules, current production capacity, and demand planning information. The buyers answered these questions. Meanwhile, IOIS visibility from the supplier's perspective refers to the extent to which the supplier has access to the buyer's information through IOIS in the following areas: inventory status, order status, production plans, production capacity, and demand forecast information. The suppliers answered these questions.

Internal IS integration refers to the degree to which the focal firm's IS provides integrated data and process integration (Bharadwaj et al. 2007). Functional areas covered in this measure include sales, manufacturing, purchasing, new product development, and accounting. These measures were adapted from the study of Bharadwaj et al. (2007). Each participant answered questions about its own internal IS integration.

Inter-organizational IT infrastructure compatibility was measured in three dimensions, following the approach of Grover and Saeed (2007): database management systems compatibility, software compatibility, and file exchangeability. Both buyers and suppliers answered the questions, and their responses were averaged to obtain the relationship score.

5 RESULTS

We used Partial Least Squares (PLS) Graph, version 3.00, to conduct statistical analyses, following the general procedures laid out by Gefen (2000). PLS is most suitable during the early stage of theory development and enables the modeling of latent variables, even for small-to-medium size samples. Our sample of 51 cases is considered adequate for PLS analysis.

Descriptive statistics for the constructs used in this study are shown in Table 1.

Construct variable	Mean	S.D.	Min.	Max.
Buyer's internal IS integration	5.0	1.1	2.0	6.5
Supplier's internal IS integration	4.5	1.2	1.4	6.6
Inter-Organizational IT infrastructure Compatibility	3.1	1.3	1.0	6.0
IOIS visibility from the buyer's perspective	2.9	1.5	1.0	6.8
IOIS visibility from the supplier's perspective	3.3	1.6	1.0	7.0
Joint Profit Performance	4.5	1.0	1.8	6.5
Buyer's expectation of relationship continuity	5.6	0.8	3.0	7.0
Supplier's expectation of relationship continuity	5.7	0.9	3.0	7.0

Table 1. Descriptive statistics of the research variables

5.1 Measurement Model

For the measurement model, each construct was modeled to be reflective. We tested the measurement model by examining individual item reliability, internal consistency, convergent validity, and discriminant validity. For all the constructs, internal consistency and convergent validity were evaluated by examining item-construct-loading, composite reliability, and average variance extracted (AVE). For individual item reliability, item loadings should be higher than 0.6 (Yoo & Alavi 2001). As the confirmatory factor analysis results, all items load highly on their intended construct except for one item in the buyer's internal IS integration, which was loaded on a dependent variable and thus excluded from subsequent analyses. As shown in Table 2, the values of composite reliabilities all exceed 0.8, which is above the 0.7 guideline suggested by Nunnally and Bernstein (1994), and the values of AVE all exceed the recommended threshold of 0.5 (Fornell & Larcker 1981).

Discriminant validity was evaluated by examining (1) the extent to which each measure loads more highly on their intended construct than other constructs; and (2) the extent to which the square root of AVE is larger than inter-construct correlations (Gefen et al. 2000). Table 3 show that all items correlated most strongly with their intended construct and that the square root of AVE for these constructs was larger than any respective inter-construct correlations, providing evidence for discriminant validity. These results, taken together, suggest good measurement properties for all indicators.

Construct variable	Items			Composite Reliability	Average Variance Extracted(AVE)
	Buyer	Supplier	Total		
Buyer's internal IS integration	4	N/A	4	0.942	0.804
Supplier's internal IS integration	N/A	5	5	0.928	0.724
Inter-Organizational IT infrastructure Compatibility	3	3	6	0.910	0.627
IOIS visibility from the buyer's perspective	5	N/A	5	0.973	0.877
IOIS visibility from the supplier's perspective	N/A	5	5	0.970	0.867
Joint Profit Performance	3	3	6	0.920	0.656
Buyer's expectation of relationship continuity	2	N/A	2	0.962	0.927
Supplier's expectation of relationship continuity	N/A	2	2	0.948	0.902

Table 2. Results of convergent validity test

	BI	SI	IOC	BIV	SIV	JP	BERC	SERC
Buyer's internal IS integration (BI)	0.897							
Supplier's internal IS integration (SI)	0.148	0.851						
Inter-Organizational IT infrastructure Compatibility (IOC)	0.114	0.355	0.792					
IOIS visibility from the buyer's perspective (BIV)	0.174	0.478	0.533	0.937				
IOIS visibility from the supplier's perspective (SIV)	0.336	0.491	0.390	0.421	0.931			
Joint Profit Performance (JP)	0.396	0.145	0.307	0.252	0.514	0.810		
Buyer's expectation of relationship continuity (BERC)	0.538	0.111	0.077	0.122	0.274	0.420	0.963	
Supplier's expectation of relationship continuity (SERC)	0.387	0.220	0.235	0.182	0.285	0.405	0.357	0.950

Note: Figures in shaded diagonal are values of the squared root of the AVE.

Table 3. Inter-construct correlations and average variance extracted (AVE)

5.2 Structural Model

The results, including the path coefficients and the explained variances (R^2) for the research model, are shown in Figure 2. The structural model of this study explained 26.6% of the variance for joint profit performance. The R^2 of IOIS visibility from the buyer's perspective was 0.379, while from the supplier's perspective it was 0.238.

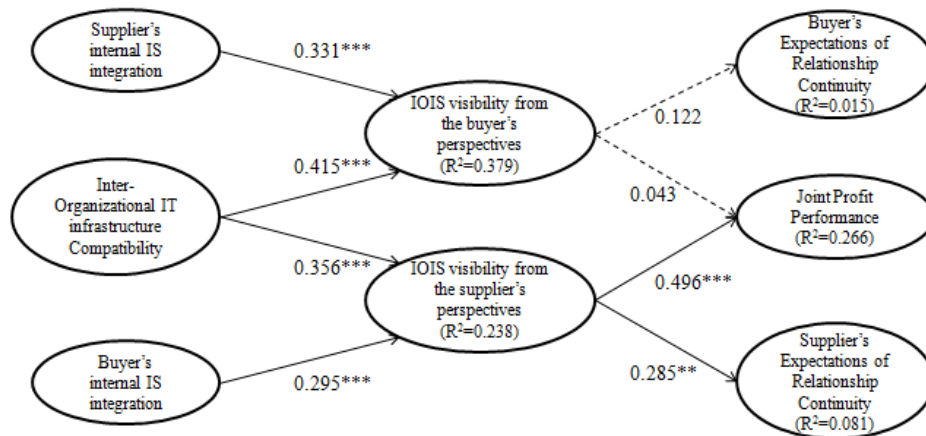


Figure 2. Results of hypothesis testing

As for the results of testing the hypotheses, both the supplier's internal IS integration (H1, $t=3.979$, $p=0.000$) and inter-organizational IT infrastructure compatibility (H3, $t=4.152$, $p=0.000$) significantly influenced IOIS visibility from the buyer's perspective. In addition, the buyer's internal IS integration (H2, $t=4.441$, $p=0.000$) and inter-organizational IT infrastructure compatibility (H4, $t=3.767$, $p=0.000$) significantly influenced IOIS visibility from the supplier's perspective. Furthermore, IOIS visibility from the supplier's perspective significantly influenced both joint profit performance (H6, $t=5.076$, $p=0.000$) and the supplier's expectation of relationship continuity (H8, $t=3.205$, $p=0.001$). However, contrary to our expectations, neither joint profit performance (H5, $t=0.492$, $p=0.312$), nor the buyer's expectation of relationship continuity (H7, $t=0.473$, $p=0.319$) was significantly influenced by IOIS visibility from the buyer's perspective. Table 4 summarizes the results of testing all hypotheses.

Hypothesis	Path coefficient	t-value	p-value	Outcome
H1 Supplier's internal IS integration → IOIS visibility from the buyer's perspective	0.331	4.174***	0.000	Supported
H2 Buyer's internal IS integration → IOIS visibility from the supplier's perspective	0.295	4.282***	0.000	Supported
H3 Inter-Organizational IT infrastructure Compatibility → IOIS visibility from the buyer's perspective	0.415	4.391***	0.000	Supported
H4 Inter-Organizational IT infrastructure Compatibility → IOIS visibility from the supplier's perspective	0.356	3.398***	0.001	Supported
H5 IOIS visibility from the buyer's perspective → Joint Profit Performance	0.043	0.520	0.303	Not supported
H6 IOIS visibility from the supplier's perspective → Joint Profit Performance	0.496	5.829***	0.000	Supported
H7 IOIS visibility from the buyer's perspective → Buyer's expectation of relationship continuity	0.122	1.136	0.131	Not supported
H8 IOIS visibility from the supplier's perspective → Supplier's expectation of relationship continuity	0.285	3.045**	0.002	Supported

Note: $df=50$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$ in one-tailed tests.

Table 4. Results of hypothesis testing

In order to gain deeper insight into the effect of asymmetries in IOIS visibility on supply chain performance, additional analyses were performed. The differences in IOIS visibility between the buyer's and the supplier's perspectives were used as a surrogate for asymmetries in IOIS visibility. Joint profit performance was then regressed on asymmetries in IOIS visibility. The results ($b = -0.160$, $t = -1.868$, $p = 0.034$, one-tailed test) show that the larger the asymmetries in IOIS visibility, the lower the joint profit performance. This result supports our contention that asymmetric IOIS visibility works against joint profit performance.

6 CONCLUSIONS

This study makes two novel contributions to the SCM and IS literature. First, it explores the understudied construct of IOIS visibility, which is very important in achieving supply chain visibility in today's economy. We develop an instrument to measure IOIS visibility and empirically validate it. The results of this study support our contention that IOIS visibility, specifically from the supplier's perspective, is indeed an important determinant of supply chain performance.

Second, this study attempts to accommodate both partners' perspectives on IOIS visibility. The results show that in our sample IOIS visibility from the supplier's perspective is important to supply chain performance, but IOIS visibility from the buyer's perspective is not. This finding may be attributed to the dependence asymmetry in the supply channel in which buyers enjoy relative power over their suppliers (Kumar et al. 1995).

The limitations of our study must be mentioned before concluding. The first limitation of this research is its selection of research variables; specifically, the model did not cover all important antecedents of IOIS visibility. These omitted variables may have affected the results of this study and, thus, the findings should be interpreted with some caution.

Second, this study sample consists of intermediate producers and their suppliers in a single industry. Therefore, the results are characteristic of buyer-supplier relationships only in a single industry (telecommunication industry). To increase the external validity of the findings of this study, future research should incorporate a sample from multiple industries in non-monopsonistic situations.

This paper attempts to elaborate on a novel concept of IOIS visibility and its IS-related antecedents and consequences. Future research may benefit from incorporating other, non IS-related, antecedents such as relational and political factors. It would be interesting to investigate the relationship between IOIS visibility and inter-organizational trust, specifically, whether this relationship is moderating or mediating with respect to SC performance.

This paper finds that asymmetric IOIS visibility results in decreases in supply chain performance. Increasing interdependence asymmetry may lead to higher levels of suspicion and conflict in the relationship. However, interdependence asymmetry does not necessarily cause irreversible and damaging conflict. Firms in a supply channel may behave differently because their strategic positions and market situations are different. Future research should explore the contingencies under which asymmetric IOIS visibility occurs and whether the consequences of asymmetric IOIS visibility differ depending on the contingencies.

This study offers some implications for practitioners. First, despite the high transaction risk associated with IOIS, partner-specific IT investments should be made to enhance supply chain performance. With the appropriate governance mechanism in place, investments into relation-specific capital can bear fruitful results in a cooperative long-term relationship. As described above in regard to the snowball effect of IOIS, initial investments into IOIS, if successfully implemented, can make subsequent investments economically viable and eventually lead to supply chain competitiveness.

Second, buyer firms should bear in mind that making their internal IS visible to supplier partners is important to improving supply chain performance. In particular, buyers need to integrate their information systems so that suppliers can have timely access to the integrated information for informed decision making. In addition, buyer firms need to assist their suppliers by having compatible IT infrastructure. Buyer firms can provide suppliers with technical training, necessary funds, and

comparable data formats. Considering the technological advances in IOIS, such as Internet-based applications (Pereira 2009), service-oriented architectures, and software as a service (Zhu et al. 2006), compatible IT infrastructure will play ever more important roles in enhancing IOIS visibility.

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