Sharing information strategically in a supply chain: antecedents, content and impact

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Online publication date: 03 May 2011

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Information sharing has been an important research issue in supply chain management. Although it has been studied frequently, our understanding of sharing information strategically and appropriately remains limited. To fill the gap, this study aims to understand the content of information sharing strategy (ISS) in a supply chain, and specifically how ISS influences supply chain uncertainty and performance. A survey of the Taiwanese manufacturing industry was carried out in order to test a proposed model. Results indicated that ISS includes information sharing and coordination aspects, and that these aspects have a strong impact on reducing supply chain uncertainty and enhancing chain performance. While a supply chain partner must share high-quality information to assist its supply chain partners' decision-making, it is also clear that a supply chain partner must rely on mutual adjustment and formalised inter-organisational processes to cope with demands. Future research directions and contributions to theory are provided.

Keywords: information sharing; uncertainty; trust; commitment; supply chain performance

1. Introduction

Supply chain management (SCM) is an integrated managerial system for the control and planning of logistics, from suppliers and going all the way down to end-users. The goal of SCM is to pursue the efficiency of the overall supply chain, and to reinforce the cooperation between all partners, in order to provide products or services that can ensure customer satisfaction (Metz 1998). To achieve this goal, supply chain members need to share a complex array of information about resources, processes, products, markets, and customer forecasts with their partners who need to resolve problems and gain advantages for the whole supply chain.

Information technologies have long been proved to be a major enablers of information sharing across firms (Frohlich and Westbrook 2002). Recently, there has also been a proliferation of technology platforms, using lighter-weight protocols for creating electronic bonds, such as e-marketplaces (e.g. E-Steel) or hubs (e.g. Covisint) as well as tools for inter-enterprise integration (e.g. Webmethods) (in the supply chain). The advance of information technology (IT) usage makes

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it possible for supply chain firms to exchange information on a variety of levels, ranging from operational to strategic. Not surprisingly, information is shared strategically and operationally for the purposes of achieving cohesion of all functions amongst supply chain members, to enable them to make good decisions that can improve the total chain profitability.

Information sharing plays a critical role in collaborative, supply-chain based business models (Fawcett *et al.* 2007). Increasing the level of information sharing among the members in a supply chain is necessary for improving its effectiveness (Sezen 2008) and efficiency (Jayaraman *et al.* 2008). Although information is shared among businesses every day, sharing appropriately is not an easy undertaking in the business world. In order to achieve flexibility, companies need to exchange large amounts of planning and private information, rather than data on annual contracts and periodic progress reports (Chan and Chan 2009). Even though information sharing is often considered as a strategic approach in supply chain collaboration and B2B e-commerce procurement (Wagner *et al.* 2005), there has been less discussion on the formation of information sharing strategy (ISS) and its measurement.

ISS refers to the circumstances under which a supply chain player will decide to share information on key variables in SCM with its business partners. Previous research suggested that applying different ISS to the supply chain under different demand patterns may improve supply chain performance (Tan and Wang 2001). In order to explore an effective strategy of information sharing, this research conceptually proposes that ISS should include two aspects: information sharing and coordination. The information sharing aspect addresses the provision of a shared data basis for concerted actions (by different functions) across interdependent firms. Examples of shared data include points of sale data, demand forecasts, inventory levels, delivery schedules and inventory costs (Lee *et al.* 2000). The coordination aspect of ISS refers to the coordination outcomes existing between supply chain members, which enable members to design effective supply chain strategy to deal with various levels of uncertainties (Alexander 1998, Argyres 1999). In addition, this paper will investigate critical factors which would improve supply chain performance and reduce uncertainties.

Previous research on ISS has mainly concentrated on providing normative guidance to supply chain players about how to interpret different demand uncertainty scenarios to improve the likelihood that their decisions will maximise the value for their firms (Lee 2002, Kauffman and Mohtadi 2003). By comparison, this study attempts to develop a behavioural model of ISS whose constructs are addressed by the content and the process aspects based on the conventional wisdom of strategic management (Mintzberg *et al.* 1998).

The research questions are set as below:

How can enterprises in supply chains use 'information sharing' and 'coordination' aspects of ISS to increase performance and reduce uncertainty? What antecedents affect ISS?

The rest of the paper is organised as follows. The next section reviews the literature on ISS, its antecedent factors and relationships with supply chain performance. It then presents and develops a literature-based framework and hypotheses for explaining how antecedent factors influence ISS, leading to performance impacts on SCM. The subsequent section describes the research methodology used to test the proposed hypotheses, and is followed by presenting the data analysis and results. Finally, it discusses the research contributions and implications for both academics and practitioners.

2. Literature review

2.1. *Effective information sharing in the supply chain*

Undoubtedly information is shared in supply chains every day, but the real value is dependent on how it is shared (Li *et al.* 2005). Information can be shared but there may not be any alignment

in terms of incentives, objectives and decisions (Lee *et al.* 1997). To implement information sharing as an effective strategy, coordination must be formulated into organisational strategy to synchronise managerial decision and achieve incentive alignment (Simatupang and Sridharan 2004). Various analyses of different coordination mechanisms have been carried out to develop optimal solutions for coordinating supply chain system decisions and objectives (Sahin and Robinson 2002). Supply chain collaboration requires a reasonable amount of coordination effort from all participating chain members to ensure maximal benefits (Corbett *et al.* 1999, Barratt and Oliveria 2001).

Strictly speaking, information sharing is different from coordination. Frohlich and Westbrook (2002) for example contended that information sharing alone does not eliminate the bullwhip effect when managing the supply chain, because coordination among the trading partners is also required. Research of a general nature does not allow for the impacts of information sharing and coordination to be isolated, and therefore additional research examining specific supply chain interactions is needed in which these two aspects are clearly identified.

2.2. *Two aspects of ISS*

In line with the above discussion, an effective ISS includes two aspects – information sharing and coordination. The information sharing aspect includes the breadth and quality of information sharing. Gosain *et al.* (2005) suggest these two are the major factors which could ease the uncertainty and improve the performance of a supply chain. The breadth of information sharing refers to the range of disseminating each firm's private information among the supply chain members. The breadth of information sharing depends on the coordination of the level of collaboration, and can be of three types: order information, partial information, and strategic information.

Sharing future order information with the supplier is beneficial since the supplier has more time to improve its service level and cost structure (Zhao *et al.* 2002). While exchanging order information involves the transmission of order quantity, payment, and cost information between chain members, partial information sharing allows selected data, such as sales and inventory data, to be available to the upstream members for the better planning and controlling of activities. Exchanging strategic information may include sharing information such as market research, category management, and cost-related data (Landeros and Monczka 1989, Argyres 1999, Gosain *et al.* 2005).

The quality of information sharing is important to achieve accuracy, timeliness, speed, integrity and appropriateness of inter-organisational resource placement (Vijayasarathy and Robey 1997, Gustavsson and Jonsson 2008). In today's constantly changing business environment, achieving competitive advantage requires businesses to respond rapidly to a range of uncertainties that may arise. Thus, sharing high quality information in a supply chain is expected to involve not only exchanging appropriate and accurate information, but also doing so in an effective and efficient manner in order to facilitate quality decision-making (Mohr and Spekman 1994, Choudhury and Sampler 1997, Gosain *et al.* 2005).

From the perspective of coordination, an effective ISS is about building an appropriate and mutually beneficial partnership between supply chain partners through the aid of an inter-organisational coordination (IOC) process. IOC is an overarching process involving two concepts: inter-organisational information sharing and coordination. Inter-organisational information sharing aims at reducing the number and impact of uncertainty factors so as to enhance the performances of supply chain members. It means sharing proper information with suppliers, customers, and other related parties mutually, and this is critical for controlling inventory in modern supply chains (Alexander 1998, Strader *et al.* 1999). Unlike inter-organisational information sharing, the purpose of IOC is to develop a mutually beneficial and well-defined relationship for two or more organisations to achieve common goals (Johnston and Vitale 1988, Stevens 1989, Bakos

and Brynjolfsson 1993, Clemons *et al*. 1993, Carter and Ferrin 1995, Metz 1998, Cachon and Fisher 2000, Krajewski and Wei 2000). Hence the coordination aspect discussed in this research goes beyond the function of sharing information inter-organisationally; it also includes reaching adjustment and agreement.

Since the inter-organisational information sharing has been considered in the information sharing aspect, the coordination aspect of an effective ISS is only concerned with reaching adjustment and agreement. In line with this clarification, the coordination aspect of an effective ISS includes formalisation and mutual adjustment. Formalisation refers to the formal processes of trading and payment occurring between supply chain partners (Bensaou and Venkatraman 1995). The way to achieve formalisation is to use boundary spanning tasks, e.g. negotiating the price with the supplier, monitoring the supplier's performance, coordinating with suppliers for continuous improvements, and exchanging ideas and future plans (Corbett *et al*. 1999). Mutual adjustment refers to the degree of adjustment that a firm is prepared to undertake and the extent to which it is prepared to compromise its own individual goals or intentions for the good of the whole (Ford 2002).

2.3. *Antecedents of ISS*

Until now, very little research has been published that systematically studies the antecedent factors of ISS. A number of studies have found that trust and commitment are two important factors that affect long-term cooperation in a partner relationship between organisations (Mohr and Nevin 1990, Anderson and Weitz 1992, Kumar *et al*. 1995, Ryssel *et al*. 2004). A lack of trust and commitment may hinder a supply chain member from sharing its information (Kauffman and Mohtadi 2003). How these two antecedents affect the strategy of information sharing will be discussed in the following sections.

2.3.1. *Trust*

While it is a common expectation that rich and varied information should be exchanged between supply chain members, researchers found that firms often share formal information but seldom share more advanced information with other members (Kauffman and Mohtadi 2003, Yan and Woo 2004). The reason why firms decide not to share advanced material is because it may be used by opportunists to conduct unethical activities (Steckel 2004, Ireland and Webb 2007). A number of studies also found that firms usually consider their key information as an organisational competitive competence (Clemons *et al*. 1993, Chen *et al*. 2000, Brown and Duguid 2001, Croson and Donohue 2002, Saeed 2005). Trust can reduce the feeling of risk on both sides of a transaction, as well as guarantee the sharing of benefits in the future (Chow and Holden 1997). It is one of the prerequisites before two parties can form a partnership (Makukha and Gray 2004). When mutual trust is established, the two parties believe that their mutual obligations will be fulfilled, and the risk resulting from speculative behaviours will be consequently lowered (Moore 1998).

Although trust is critical in information sharing, uncertainties and opportunism arising from the clock-speed environment of today undermine the trust existing between two cooperative parties (Parkhe 1998). Trust is also undermined by the unequal distribution of power or resulting benefits that may incite one party to attempt to control the cooperative relationship (Mayer *et al*. 1995, Carr and Smeltzer 1997). Since trust in a cooperative relationship can easily be violated by a suspicious or speculative mindset of either of the two parties, both parties should adhere to an honesty policy. Once supply chain organisations establish such a policy, all members can work together accordingly, and reap the benefits of a long-term partnership.

2.3.2. *Commitment*

Commitment is also an indispensable prerequisite for a long-term partner relationship (Moore 1998). A partner relationship is an agreement that covers a long-term commitment for pooling information and risks, as well as enjoying all the benefits derived from such a relationship (Ellram 1991). Commitment can offer incentives for both trading partners to pool risks and share benefits (Bowersox 1990).

The commitment existing between organisations can be classified as either 'unconscious' or 'substantial' (Kim and Frazier 1997). Unconscious commitment is concerned with the degree of qualitative differentiation in task completion, in relation to quantitative investments of affective energy. It follows that the greater the synergy of each of these levels between cooperative parties, the more productive their working relationship is likely to be. Substantial commitment denotes a complementary function which demonstrates a concrete commitment to a long-term relationship, and a willingness to distribute information resources and operational control in a cooperative spirit.

Morgan and Hunt (1994) revealed that a relationship commitment is created when one trading partner regards its current relationship with the other partner as so important that it guarantees to maintain that relationship no matter what. In other words, once commitment is in place, uncertainty can be lower and performance will be improved by the mechanism of mutually reflexive contribution.

2.4. *Uncertainty and supply chain performance*

Uncertainties can impact the capabilities of the supply chain and its supporting IS (Prater 2005). The goal of effective information sharing in a supply chain is to enhance the performance of the overall supply chain, and to reduce information asymmetry between all supply chain members in order to deliver products or services that will ensure customer satisfaction (Metz 1998, Bensaou 1999). To achieve this goal, it is critical for members in the supply chain to comprehend and manage the uncertainty factors in order to alleviate their influences on the efficiency and performance of the supply chain (Davis 1993, Strader *et al*. 1999). Sun *et al*. (2009) found that reducing environmental uncertainty through the actualisation of an effective supply chain strategy had a positive impact on supply chain performance. The top and middle management should monitor their primary metrics of overall supply chain performance regularly to ensure SCM success (Chae 2009).

As discussed in previous literature reviews, ISS, which is divided into information sharing and coordination aspects, can influence supply chain performance through lowering the level of uncertainty. Both trust and commitment influence how supply chain members share information and they are considered as the major antecedents of ISS.

3.   Research model

3.1. *Overall research structure*

The overall structure of this research is shown in Figure 1. The four dimensions in this structure are 'The Antecedents of Information Sharing', 'ISS', 'Supply Chain Uncertainty', and 'Supply Chain Performance'.

The dimensions of 'The Antecedents of Information Sharing' include two sub-dimensions, namely 'trust' and 'commitment'. The dimensions of 'ISS' also include two sub-dimensions, which are the 'Information Sharing Aspect' and the 'Coordination Aspect'. The sub-dimensions of the 'Information Sharing Aspect' include 'Quality of Information Sharing' and 'Breadth of Information Sharing' whereas the sub-dimensions of the 'Coordination Aspect' include 'Formalisation'
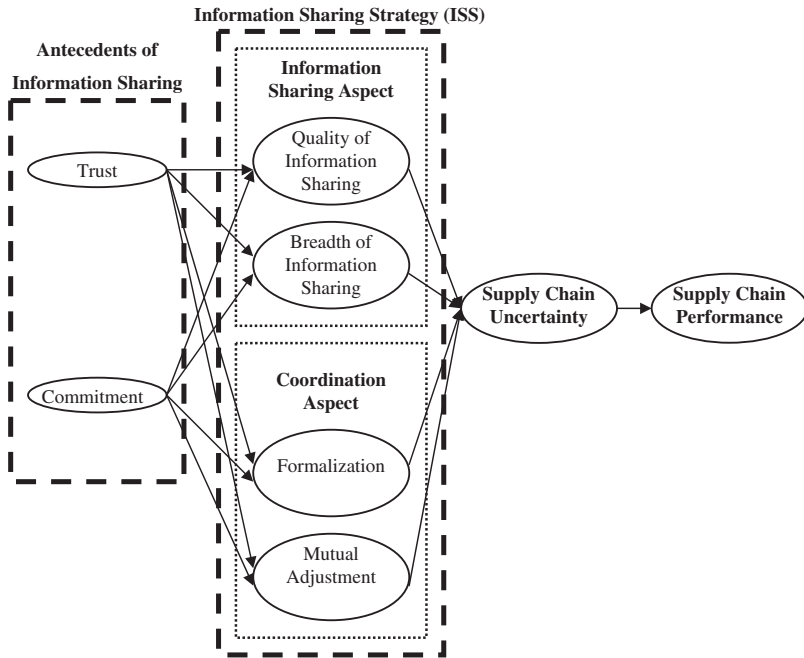
Figure 1. Overall research structure of this research.
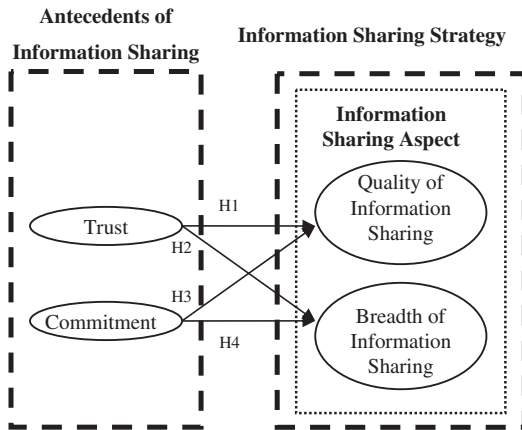
Figure 2. The relationship between antecedents and the content aspect of ISS.

and 'Mutual Adjustment'. The relationships in this hypothesised model will be discussed in the
following sections.

3.2. *Research hypotheses*

3.2.1. *Antecedents and the information sharing aspect*

The information sharing aspect of ISS includes the quality and breadth of information shar-
ing (Figure 2). The quality of information sharing refers to the overall value-added, timeliness,
appropriateness and integrity of the information shared among supply chain partners (Gosain *et al*.

2005). Appropriateness captures the validity of the information content delivered, whilst integrity concerns its comprehensiveness. The breadth of information sharing refers to on what level and within what range the required information can be delivered (Gosain *et al*. 2005).

When sharing high-quality information, supply chain partners, not surprisingly, may feel inclined to worry if the other party engages in various kinds of speculative behaviour (Clemons *et al*. 1993, Parkhe 1998, Brown and Duguid 2001, Croson and Donohue 2002, Kauffman and Mohtadi 2003, Saeed 2005). Studies have found that when trust holds up to critical scrutiny, it will facilitate the continuance of a mutually assured sharing of high-quality information (Newell *et al*. 2003). Thus, supply chain partners must rely on trust to counteract the potentially corrosive effects flowing from possible misconceptions. Hence, we propose the first hypothesis:

H1: Trust among supply chain partners has a positive impact on the quality of information sharing.

Previous studies have found that when trust has been established between supply chain members, they will have a greater degree of willingness to share more advanced information in order to help increase overall performance (Kumar *et al*. 1995, Choudhury *et al*. 1998, Saeed 2005, Ireland and Webb 2007). When organisations feel the situation is too risky for sharing, they may be reluctant to divulge more valuable information, such as information relating to unpredictable product quality and delivery time (Li and Lin 2006). Thus, the trust established between supply chain members facilitates wider information sharing. This inference leads us to our second hypothesis:

H2: Trust among supply chain partners has a positive impact on the breadth of information sharing.

Commitment among supply chain partners is a key to achieving valuable outcomes, for instance, buyers and sellers are encouraged to invest in tangible and intangible assets (Landeros and Monczka 1989). The tangible assets can include physical warehouses and machines whereas the intangible assets can be training programs, information and knowledge. Without commitment, one may regard the investments of labour and material resources as a sunk cost involved in inter-organisational information sharing. Only when the commitment to amicable interactions and a good relationship between supply chain partners are in place, would they be willing to provide each other with information aiding better decision-making (Bowersox 1990, Morgan and Hunt 1994, Moore 1998).

Zhao *et al*. (2002) specifically found that sharing more useful marketing information is positively related to the commitment between supply chain customers and the manufacturer. Customers tend to show more willingness to cooperate with the manufacturer when they are in a mutual and ongoing relationship over an extended period of time. Hausman and Johnston (2010) also proposed that commitment had a strong impact on the willingness to share useful information between supply chain partners. Hence, we hypothesise:

H3: Commitment among supply chain partners has a positive impact on the quality of information sharing.

Gosain *et al*. (2005) argued that to sense and react positively to an environment, supply chain partners need to share information across a broad range. Yet, not all members are willing to do this. When members are more ready to deal with unanticipated changes, reduce risks, and seize new opportunities, they tend to make a concerted effort to share the most advanced information with their suppliers and customers (Cohen and Levinthal 1990, Gulati *et al*. 2000). Zhao *et al*. (2002) found that the willingness of customers to share various kinds of information (e.g. demand forecast and available inventory) with the manufacturer is positively associated with the relationship commitment existing between them. Thus it can be concluded that firms in a supply chain which share a wide range of information are more likely to participate in a strong commitment relationship. Thus we hypothesise:

H4: Commitment among supply chain partners has a positive impact on the breadth of information sharing.
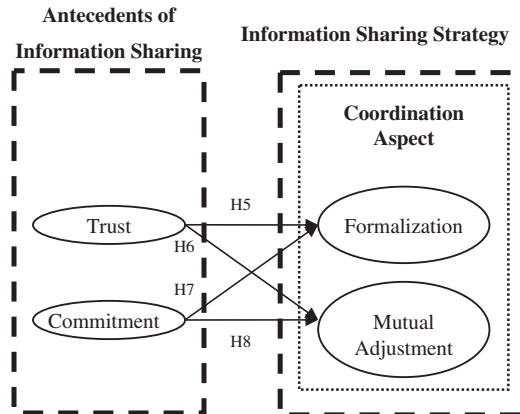
Figure 3.   The relationship between antecedents and the process aspect of IOC.

3.2.2.   *Antecedents and the coordination aspect*

The coordination aspect of ISS includes two kinds of coordination outcomes: formalisation and mutual adjustment. The relationships between the antecedents (trust and commitment) and the coordination aspect are shown in Figure 3.

Trust undoubtedly plays a very important part in every business transaction among organisations (Kumar *et al*. 1995, Carr and Smeltzer 1997, Chow and Holden 1997). Without trust, these transactions will become more speculative and inherently risky for every partner. Previous studies have discovered that commitment has a strong impact on the cooperation between inter-organisational supply chain partners (Leonidou *et al*. 2008, Hausman and Johnston 2010). This is meaningful especially when coordinating organisations may have different cultures, strategies, and operational contexts. Trust between supply chain partners should encourage them to invest the time, energy, and resources required to augment the inter-organisational formalisation process. Sharing advanced information with each other to reduce the operational uncertainty can therefore be achieved (Mayer *et al*. 1995, Moore 1998, Parkhe 1998, Brown and Duguid 2001, Kauffman and Mohtadi 2003). Based on the foregoing literature, we deduce hypothesis $H5$:

*H*5: Trust among supply chain partners has a positive impact on the formalisation of IOC.

Carter and Ferrin (1995) found that SCM is gradually adjusted where suppliers, customers and other related organisations seek to build a closer relationship with each other thus linking up all the members in their supply chain architecture. The supply chain, which utilises a series of efficient adjustment methods to integrate the processes of suppliers, manufacturers, warehouses and stores, will produce accurate quantities, distribute product to the correct locations at the right time, minimise total system cost, and ensure customer satisfaction (Simchi-Levi *et al*. 2000). If two parties can trust each other, then such a practice is conducive to positive developments of collaboration for SCM (Kumar and Dissel 1996, Hsieh 2004, Malhotra *et al*. 2005). Due to this inference, we would expect the following relationship to hold true:

*H*6: Trust among supply chain partners has a positive impact on the mutual adjustment of IOC.

Well-formalised information sharing is usually based on the existence of a high degree of commitment among channel members (Barratt and Oliveria 2001). The establishment of a strong partner relationship, then, can encourage partners to share information regularly and consistently (Moore 1998). Research studies into the relationship between supply chain partners have found that with a strong commitment workers tended to coordinate better with others and have higher

motivation to share their own information (Keh and Xie 2009, Hausman and Johnston 2010). Thus, we hypothesise:

*H*7: Commitment among supply chain partners has a positive impact on the formalisation of IOC.

Based on Morgan and Hunt (1994), the decision to build relationship commitment is derived from analysis whereby one trading partner may calculate the tradeoffs in a cost benefit analysis between the investment of resources needed to nurture the partnership, and the probable losses incurred should they choose to withdraw their commitment. When the benefits outweigh the costs, commitment follows and the firms are likely to come to some kind of agreement with one another (Bowersox 1990, Malhotra *et al*. 2005). Based on this viewpoint, this research deduces the following hypothesis *H*8:

*H*8: Commitment among supply chain partners has a positive impact on the mutual adjustment of IOC.

3.2.3. *ISS, supply chain uncertainty, and supply chain performance*

This section will discuss how the ISS influences the degree of supply chain uncertainty and performance. The relationships between these are shown in Figure 4.

In terms of the quality of information sharing, high-quality information denotes information that is extremely specific and useful to the needs of the firm. Such information is expected to be suitable for making joint decisions at an inter-organisational planning and operational level (Gustavsson and Jonsson 2008), and thereby will help improve supply chain performance for the chain members involved (Miller 1996, Mendelson and Pillai 1998, Frohlich and Westbrook 2002, Gosain *et al*. 2005). For this reason, we deduce the hypothesis:

*H*9: Uncertainty in supply chain architecture can be reduced through the quality of information sharing among supply chain partners.
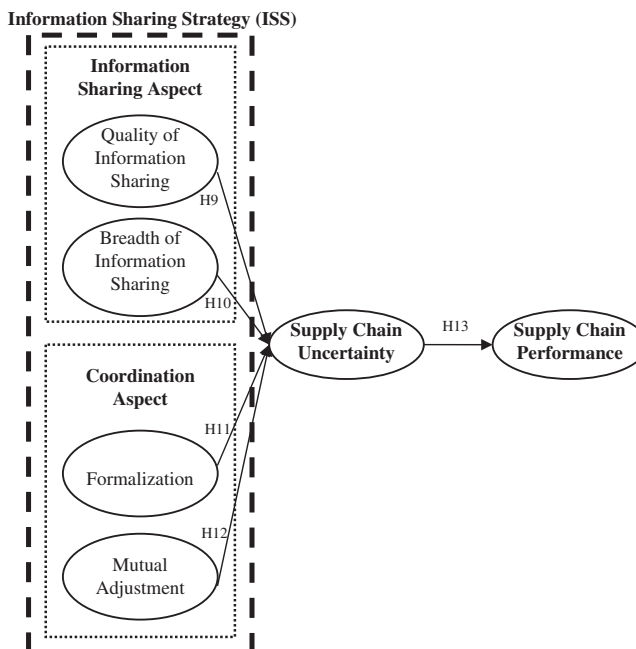

Figure 4.   The relationships between ISS, supply chain uncertainty and performance.

Evans and Wurster (1997) noted that with a high degree of information sharing and integration, supply chain partners could form a so-called 'virtual organisation' with a relatively strong ability to cope with uncertainty. Other research has also acknowledged that comprehensive information and data flows exchanged across members are particularly important to SCM (Malone *et al*. 1989, Wise and Morrison 2000, Croom 2001, Gosain *et al*. 2005). Therefore, we deduce the hypothesis:

*H*10: Uncertainty in supply chain architecture can be reduced through the breadth of information sharing among supply chain partners.

Uncertainty can not only be reduced through information sharing, but also could result in the smoother operation of supply chain processes (Tan *et al*. 1998). Supply chain partners can utilise a formalised process to reduce the production lead-time, to lower the inventory cost at each node, to increase the probability of successful just-in-time operation, and ultimately reduce uncertainty (Farrell and Saloner 1985, Antonelli 1995, Argyres 1999, Gosain *et al*. 2005). Thus, we deduce the hypothesis:

H11: Uncertainty in supply chain architecture can be reduced through formalisation among supply chain partners.

Today's SCM continues to be confronted by the uncertainties of operation; hence members need to coordinate inter-organisationally to cope with it (Sharfman *et al*. 2009). What is of crucial importance concerning mutual adjustment between partners is realizing that risks usually occur because of unanticipated events. By adjusting the information systems and standards of both parties, the errors caused by complicated channels of information flow can be avoided, and the presentation of inventory data will be more accurate and objective (Smith and Barclay 1997, Adler *et al*. 1999). To be specific, a manufacturer can only respond to the material demands of their suppliers if their communications are kept up to date along with inventory notifications and accurate forecasting data (Lohtia *et al*. 2005). Therefore, real time, smooth flowing, and appropriate ISS will ensure an immediate response to market fluctuations and reduce uncertainty in a supply chain (Choudhury and Sampler 1997). Hence, we hypothesise:

*H*12: Uncertainty in supply chain architecture can be reduced through the mutual adjustment of IOC among supply chain partners.

Uncertainty affects the extent to which firms engage in supply-chain management (Sharfman *et al*. 2009). Supply chain members could use various strategies to reduce the uncertainty in supply chains so as to improve performance (Sun *et al*. 2009). Kauffman and Mohtadi (2003) noted that firms will have to perform IOC in order to gain competitive advantage and raise performance. Moreover, supply chain partners could ease the bullwhip effects, and ultimately enhance supply chain performance by sharing information on orders and storage level accurately (Bowersox and Close 1996). Given this, we propose:

*H*13: Reducing the uncertainty in supply chains has a positive impact on supply chain performance.

4. Methodology

To meet the objectives of this research, the manufacturing industry (which is relatively advanced in the implementation and operation of supply chain strategy) was adopted as the primary object, while other industries (such as the retail industry) were treated as complementary. A confirmatory empirical study was conducted based on a questionnaire survey of a group of 122 companies which had particular experience in conducting supply chain activities with both upstream suppliers and downstream customers. The respondents were drawn from a random sample of senior operations managers from the list of 'Top 500 Taiwanese corporations'. Those who were involved in sharing supply chain information and conducting industrial and organisational supply chain activities were finally selected for testing the hypotheses.

Respondents were required to fill out a questionnaire based on their company's current experience in SCM. The questionnaires were delivered to them through mail and e-mail. Completed and returned questionnaires were processed and subjected to statistical analyses of variables including reliability, validity, and verification of their causality. The design of this questionnaire is explained in greater detail in the next section.

4.1. *Questionnaire design*

The initial stage of the questionnaire design involved a literature search to determine the operational definitions and scale of the research variables. This was followed by the drafting of the questionnaire's content based on the original scale. The content, layout and glossary of the questionnaire were subsequently revised (and translated from the original English into Chinese) through a series of discussions with several SCM experts. In addition to these revisions, the presentation of questions and phrases in the questionnaire was subjected to modification through discussions with several mid- to high-level senior managers who had first-hand knowledge of supply chain related activities. Finally, the questionnaire was pre-tested by a group of business students who each had at least three years managerial experience. These results were tested to establish the reliability and validity of the questionnaire. Once this verification had taken place, the questionnaire was distributed to the main sample.

This research developed the items in the questionnaire either by adapting measures that had been validated by other researchers or by converting the definitions of constructs into a questionnaire format. Specifically, the items for the two antecedents – trust and commitment – were developed based on relevant theories and prior studies (Morgan and Hunt 1994, Mayer *et al*. 1995, Moore 1998). The items measuring the IOC and quality of information sharing were adapted from Heide and John (1988), Alexander (1998), and Gentry (1996). Finally, the items for uncertainty and performance of the supply chain were adapted from Ho *et al*. (2005) and Gosain *et al*. (2005), respectively. Because the constructs were measured by multiple items, summated scales based on the average score of the multi-items were used in the analysis. Responses were recorded on a five-point Likert scale with the endpoints labelled as 'strongly disagree' and 'strongly agree'.

4.2. *Studying objects and data analysis*

The questionnaire was mailed to 200 senior managers who conducted supply chain related activities in the 'Top 500 Taiwanese corporations' in Taiwan. Eventually, 122 valid questionnaires were received, yielding a 61% valid response rate.

This study chooses partial least squares (PLS) to analyse the proposed model shown in Figure 1 and the relevant hypotheses discussed previously. The analytical approach of PLS is generally recommended for predictive research models where the emphasis is on theory development, whereas LISREL is recommended for confirmatory analysis and requires a more stringent adherence to distributional assumptions (Jöreskog and Wold 1982). Given that there has been little prior theory and very few empirical studies exploring the impacts of ISS on supply chain performance, the focus of this study is on theory development. Thus, PLS is more appropriate for this research. Our analysis procedure consists of two steps: the first is the assessment of measurement properties, and the second is the test of the structural model.

5. Results

5.1. *Results from assessing measurement properties*

This section will present the assessment of the measurement properties of constructs. This study assessed convergent and discriminant validity by factor analysing items grouped under the

Table 1.   Factors – structure and loadings ($N = 122$).

	Trust	COM	FO	MA	QIS	BIS	SC-UN	SC-PE
Trust 1	**0.8209**	0.2071	0.4148	0.5775	0.3384	0.3567	−0.4706	0.3369
Trust 2	**0.8569**	0.2762	0.4016	0.6101	0.3489	0.4519	−0.5043	0.3659
Trust 3	**0.8785**	0.3079	0.4856	0.5198	0.4822	0.383	−0.4529	0.3548
COM 1	0.2374	**0.7764**	0.2929	0.4475	0.2012	0.324	−0.3607	0.3197
COM 2	0.25	**0.8826**	0.4431	0.4801	0.4517	0.4292	−0.4933	0.3331
COM 3	0.2937	**0.8349**	0.3139	0.3567	0.3496	0.42	−0.4045	0.2363
FO 1	0.3802	0.3282	**0.8052**	0.3966	0.48	0.3487	−0.4243	0.2712
FO 2	0.5382	0.3225	**0.8186**	0.4597	0.4292	0.3525	−0.3816	0.2708
FO 3	0.3002	0.3884	**0.7915**	0.4286	0.3747	0.4582	−0.442	0.2575
MA 1	0.7036	0.4006	0.4745	**0.9092**	0.4354	0.3953	−0.503	0.3342
MA 2	0.4429	0.5241	0.465	**0.8493**	0.4717	0.3437	−0.3807	0.2692
QIS 1	0.3618	0.3733	0.467	0.4596	**0.8111**	0.2952	−0.4179	0.3358
QIS 2	0.3605	0.2712	0.2457	0.4542	**0.751**	0.3191	−0.3843	0.3085
QIS 3	0.3168	0.3647	0.5026	0.3279	**0.7833**	0.3423	−0.4364	0.3119
QIS 4	0.3861	0.2713	0.4186	0.346	**0.753**	0.3002	−0.4018	0.3869
BIS 1	0.36	0.3779	0.4167	0.3144	0.2623	**0.8158**	−0.3853	0.1792
BIS 2	0.375	0.4327	0.3773	0.3314	0.3252	**0.806**	−0.4202	0.2105
BIS 3	0.3705	0.3622	0.3147	0.4082	0.381	**0.8389**	−0.4643	0.2257
SC-UN 1	−0.4791	−0.4246	−0.4452	−0.4655	−0.4507	−0.4236	**0.8713**	−0.5454
SC-UN 2	−0.5007	−0.4163	−0.4579	−0.4283	−0.4737	−0.449	**0.8497**	−0.4647
SC-UN 3	−0.4602	−0.4148	−0.4152	−0.4597	−0.4032	−0.4543	**0.8575**	−0.5339
SC-UN 4	−0.4929	−0.5033	−0.4641	−0.4116	−0.5027	−0.5391	**0.8828**	−0.6115
SC-PE 1	0.1998	0.2517	0.1128	0.1949	0.3414	0.0465	−0.4491	**0.7741**
SC-PE 2	0.3934	0.4167	0.3579	0.3703	0.4272	0.3379	−0.5634	**0.8231**
SC-PE 3	0.3934	0.3327	0.3432	0.3818	0.3579	0.2506	−0.5223	**0.8467**
SC-PE 4	0.3602	0.2561	0.3152	0.2213	0.3256	0.2222	−0.4998	**0.8231**
SC-PE 5	0.3239	0.1839	0.1978	0.2257	0.3108	0.1538	−0.5144	**0.8205**

Note: The bold item signifies the highest value of the row.

Table 2.   Reliability and average variance extracted (AVE).

Construct	Composite reliability	AVE	Cronbach's alpha
Trust	0.889	0.727	0.808
COM	0.871	0.693	0.779
FO	0.847	0.648	0.729
MA	0.872	0.774	0.709
QIS	0.857	0.601	0.777
BIS	0.922	0.704	0.893
SC-UN	0.923	0.749	0.888
SC-PE	0.910	0.669	0.873

constructs (i.e. trust, commitment (COM), formalisation (FO), mutual adjustment (MA), quality of information sharing (QIS), breadth of information sharing (BIS), supply chain uncertainty (SC-UN) and supply chain performance (SC-PE)). Items should be one-dimensional in their representation of the latent variable, and therefore correlated with each other. Table 1 shows the factor structure and loadings.

The bold items' loadings are above 0.75, showing that the variance is captured by the constructs. The internal consistency of reflective constructs was assessed by using Cronbach's alpha and computing the composite reliability (CR). A score of 0.70 or above is an acceptable value of internal consistency for exploratory research. As shown in Table 2, Cronbach's alpha ranged from 0.709 to 0.888 and CRs ranged from 0.847 to 0.923, and hence all of them were above the 0.7 acceptable threshold.

Another suggested criterion for ensuring discriminant validity is that the variance shared by a construct with its indicators should be greater than the variance shared with other constructs in

Table 3.   Inter-correlation among constructs.

	Trust	COM	FO	MA	QIS	BIS	SC-UN	SC-PE
Trust	**0.853**							
COM	0.311	**0.832**						
FO	0.51	0.429	**0.805**					
MA	0.667	0.515	0.533	**0.879**				
QIS	0.459	0.416	0.532	0.511	**0.775**			
BIS	0.467	0.473	0.478	0.422	0.405	**0.839**		
SC-UN	−0.558	−0.51	−0.515	−0.509	−0.53	−0.541	**0.865**	
SC-PE	0.414	0.357	0.331	0.346	0.433	0.255	−0.626	**0.818**

Note: Diagonal elements (bold) are the square roots of AVE by latent constructs from their indicators.

the model. The percent of variance captured by a construct is given by its AVE. A construct is considered to be distinct from other constructs if the square root of the AVE is greater than its correlations with other latent constructs. Table 3 shows that the square root of the AVE for each construct is greater than the correlation between that construct and other constructs.

5.2.   *Results from testing the structural model*

A test of the structural model is used to assess the structure of the impact of ISS on supply chain performance. In addition, the PLS structural model and hypotheses were assessed by examining path coefficients and their significance levels. The PLS method does not directly provide significance tests and confidence interval estimates of path coefficients in the research model. In order to estimate the significance of path coefficients, a bootstrapping technique was used. Bootstrap analysis was conducted with 200 resamples and path coefficients were re-estimated using each of these samples. The vector of parameter estimates was used to compute parameter means, standard errors, significance of path coefficients, indicator loadings, and indicator weights. Results of the analysis for the structural model are presented in Figure 5.

   The results provide support for the research model. One indicator of the predictive power of path models is to examine the explained variance or R^2 values. R^2 values are interpreted in the same manner as those obtained from multiple regression analysis. They indicate the amount of variance in the construct that is explained by the path model. As shown in Figure 5, 29.3% of the variance in the quality of information sharing was explained by trust and commitment. 35.2 per cent of the variance in breadth of information sharing was explained by trust and commitment. 34.1 per cent of the variance in formalisation was explained by trust and commitment. Fifty-five per cent of the variance in mutual adjustment was explained by trust and commitment. 46.8 per cent of the variance in supply chain uncertainty was explained by the quality of information sharing, breadth of information sharing, formalisation, and mutual adjustment. 39.2 per cent of the variance in supply chain performance was explained by supply chain uncertainty.

   Moreover, the results shown in Figure 5 provide strong support for hypotheses 1–13. $H1$ is supported since the relationship between trust and quality of information sharing is positive and significant (path coefficient $b = 0.365$, $p < 0.05$). $H2$ is also supported since the relationship between trust and breadth of information sharing is positive and significant (path coefficient $b = 0.356$, $p < 0.05$). $H3$ is supported since the relationship between commitment and quality of information sharing is positive and significant (path coefficient $b = 0.302$, $p < 0.05$). $H4$ is also supported since the relationship between commitment and breadth of information sharing is positive and significant (path coefficient $b = 0.377$, $p < 0.05$). $H5$ is supported since the relationship between trust and formalisation is positive and significant (path coefficient $b = 0.416$, $p < 0.01$). $H6$ is also supported since the relationship between trust and mutual adjustment is positive and significant (path coefficient $b = 0.516$, $p < 0.001$). $H7$ is also supported since the

relationship between commitment and formalisation is positive and significant (path coefficient $b = 0.299$, $p < 0.05$). $H8$ is also supported since the relationship between commitment and mutual adjustment is positive and significant (path coefficient $b = 0.341$, $p < 0.05$).

$H9$ is supported since the relationship between quality of information sharing and supply chain uncertainty is negative and significant (path coefficient $b = -0.234$, $p < 0.05$). $H10$ is also supported since relationship between breadth of information sharing and supply chain uncertainty is negative and significant (path coefficient $b = -0.326$, $p < 0.05$). $H11$ is supported since the relationship between formalisation and supply chain uncertainty is negative and significant (path coefficient $b = -0.134$, $p < 0.05$). $H12$ is also supported since the relationship between mutual adjustment and supply chain uncertainty is negative and significant (path coefficient $b = -0.179$, $p < 0.05$). $H13$ is supported since the relationship between supply chain performance and supply chain uncertainty is negative and significant (path coefficient $b = -0.626$, $p < 0.001$).

5.3. *Discussion of results*

Previous results lead to several key directions for discussion. Firstly, the results confirmed that trust and commitment are recognised as key antecedents for information sharing, and play a determining role in the influence of ISS. From a broad perspective, trust and commitment impact both on the information sharing and the coordination aspects of ISS. From a more specific perspective, trust and commitment fall under the umbrella of the coordination aspect, given that they promote both formalisation and the mutual adjustment-based process. Although both trust and commitment have important impacts on mutual adjustment, the former shows a greater coefficient, typifying that trust contributes more than commitment in establishing a mutual adjustment.

Based on data collected from US organisations, Li and Lin (2006) suggested that commitment may not be conducive to information sharing in SCM. In our current studies of commitment the opposite was found. Other research conducted in Asia supports our findings. For example Cai *et al*. (2010) surveyed the integration of supply chain information in China and reported that
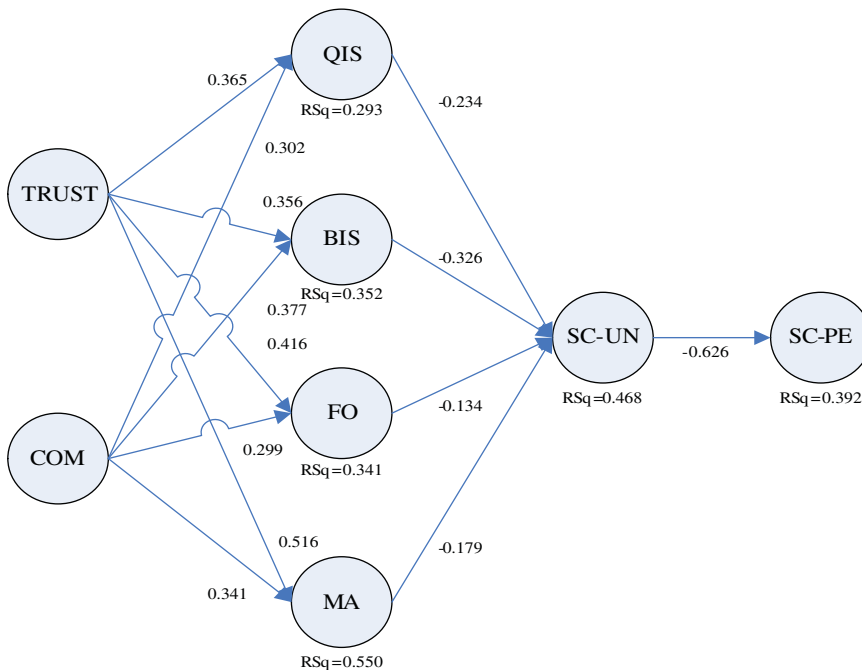

Figure 5.   Results of path analysis.

information sharing is influenced by commitment. Likewise, other studies have suggested that commitment plays a dominant role in the business relationships between Asian companies (Lohtia *et al*. 2005, Keh and Xie 2009). This contradiction between findings is reflected in studies of social behaviour which have argued that the importance of commitment may differ between cultures. While westerners tend to share information according to nominal agreements, contracts and laws, easterners tend to emphasise the importance of interpersonal relationships (e.g. commitment and trust). This implies that a high level of commitment might well be helpful for information sharing in SCM in eastern companies.

Secondly, our findings reveal that both the coordination aspect of information sharing and the quality of information sharing significantly reduces supply chain uncertainty. Although formalisation and mutual adjustment are revealed in the literature as two factors in the coordination aspect of ISS that are often associated with supply chain uncertainty, our results show that close ties to mutual adjustment can reduce more supply chain uncertainty. For supply chain organisations to establish a dedicated cooperative relationship, they have to invest in long-term commitments. The mutual adjustment between supply chain organisations requires enterprises to make practical and highly specialised investments in money, equipment, information and personnel training. Those investments include, for example, inter-organisational processes-specific manufacturing, a transaction-specific information system, and customer-specific training. If costs and time are considered, it would be difficult to redeploy or redevelop such investments, especially if there was the possibility of one or both parties terminating the relationship (Keh and Xie 2009). Hence, we suggest that once long-term commitments are in place, it is easier for supply chain partners to perform mutual adjustment that includes understanding each other's needs, resolving disagreements in their communication, and thereby improving the entire process.

Thirdly, making strategic decisions for pursuing high performance of supply chains is difficult since the precise market information is often unavailable or belated. Our results indicate that the improved performance of a supply chain can be attained through the reduction of supply chain uncertainty if appropriate ISS, including information sharing and coordination aspects, are in place.

The coordination aspect plays an important role in the formulation and validation of ISS, and this finding is confirmed by similar work previously conducted on coordination (Gosain *et al*. 2005). In their work, coordination based on the capability of IT infrastructure contributes to supply chain performance (i.e. supply chain flexibility). In our work, combining both information sharing and coordination aspects into a strategic dimension contributes to the reduction of uncertainty and therefore improves supply chain performance. The impact of coordination on the supply chain lies in the process alignment between supply chain partners, which is addressed by the construct of mutual adjustment.

Although the interrelationships have been clarified between information sharing and uncertainty, and between strategy and performance in previous studies, the causality relationships between ISS, supply chain uncertainty and supply chain performance are missing in the literature. For example, Fynes *et al*. (2004) found that whilst supply chain relationship quality, which includes information sharing, communication and trust, has a positive effect on supply chain performance, how those mentioned variables can be used to form effective ISS remains unclear. Hence the main contribution of our paper to theory is to provide a unifying approach to information sharing and the strategy concept.

6. Conclusion

To cope with uncertainty in today's rapid, highly fluctuating environment, supply chain members need to establish an effective ISS. In this research, we have extended current understanding

of the ISS in the SCM arena by dividing the operational strategy into information sharing and coordination aspects. A confirmatory empirical survey was conducted, and empirical evidence on the effects of ISS on supply chain performance has also been presented. The outcomes of this research reveal that trust and commitment are significant complementary predictors of ISS, and that they affect both variables in the coordination aspect - formalisation and mutual adjustment. Second, there is evidence to suggest that the formalisation of information sharing and mutual adjustment have a significant effect on supply chain uncertainty. According to the results, it is inferred that formalisation and mutual adjustment provide contribution to reduce uncertainty in the supply chain architecture. Our findings provide a unifying approach to information sharing and the strategy concept and also shed light for supply chain managers to further develop enhanced and appropriate information sharing strategies.

6.1. *Practical implications*

The study yields three major managerial implications for executives and managers. First, to prosper in the modern competitive industrial environment, with its varying consumer demands and preferences and dramatic shortening of product life cycles, supply chain members need to acquire more accurate, integral and timelier information from each other, such as the amount of orders, the quantity survey of materials, the level of storage, and the lead-time of delivery. The empirical findings indicate that both trust and commitment are germane to the IOC and the quality of information sharing. While each contributes to high-quality information, trust has greater overall impact. Thus, creating trust is the top priority for organisations to build channels for sharing quality information in the future.

Second, the more precise the information shared with others, the more trust and commitment the supply chain members will have. That is, from our findings, the more willing organisations are to establish strong trust and commitment between themselves, the more helpful it will be for them to develop deeper levels of mutual adjustment. Only when mutually adjusted and high quality information is shared can supply chain partners reduce the information asymmetry, bringing benefits to all supply chain participants.

Third, the coupling of process adjustment and the act of information sharing contributes to better supply chain performance. In the future, organisations should pay attention to developing additional organisational coordination measures which will be necessary to exploit supply chain synergies for the achievement of better supply chain performance.

6.2. *Limitations and future research*

This study has limitations which may encourage future research. First, our study focused on how ISS contributes towards the performance of a supply chain, but paid limited attention to many other variables that may possibly influence the magnitude of uncertainty and performance. Future research could add variables to capture a more complete vision of enhancing supply chain performance.

Second, the antecedents of ISS considered in this paper were trust and commitment. Since researchers in social exchange theory (Wayne *et al*. 1997, Muthusamy and White 2005) have found that the partner relationship includes other measurable attributes such as communication, force, confliction and dependence, we recommend that future research tests those factors for greater comprehensiveness.

Finally, the hypothesised model was tested using cross-sectional data from the Taiwanese manufacturing industry. Since this data represents a snapshot in time, the imputation of cause–effect relationships between the constructs in the model must be treated with caution. Although we

established the associations between the causing and the caused constructs statistically, we argued for the sequential relationships between the constructs based on a theoretical linkage between strategy, uncertainty and performance. Such linkage may be contingent upon time and industrial dynamics. Thus, we recommend that future research could test our results through longitudinal studies and involve more respondents from different industries and countries.

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Appendix. Contents of questionnaire

Part 1 Company and personal backgrounds

Please place a tick (✓) in the square box (□) of each question according to your company's and your real situations. Thanks!

1. Which industry does your company belong to?	□ Manufacturer □ Public Service □ IT Service Industry □ Healthcare Service	□ Educational Institution □ Retailer □ Government Authority □ Others
2. How many employees are there in your company?	□ Under 50 □ 101–500 □ 1001–5000	□ 51–100 □ 501–1000 □ Over 5000
3. How many years has your company been established?	□ Under 5 □ 11–15 □ 21–25 □ 31–35	□ 6–10 □ 16–20 □ 26–30 □ Over 36
4. What is your job position in your company?	□ Senior Executive □ Junior Level Manager	□ Middle Level Manager □ Technician/ Administrator

Part 2 Factors influencing information sharing

Trust

Please place a tick (✓) in the square box (□) of each question according to your agreement on your company's real situation. Thanks!	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
✳ Supply chain partners include up-stream suppliers and down-stream customers.					
1. In the process of cooperation with major supply chain partners, we can always trust each other	□	□	□	□	□
2. In the process of cooperation with major supply chain partners, we can always trust the decision made by partners	□	□	□	□	□
3. In the process of cooperation with major supply chain partners, they treat us with the attitude of high integrity	□	□	□	□	□

Commitment

Please place a tick (✓) in the square box (□) of each question according to your agreement on your company's real situation. Thanks!	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1. The relationship that our company has with major supply chain partners is something that we are very committed to	□	□	□	□	□

Continued

2. The relationship that our company has with major supply chain partners is something my firm intends to maintain indefinitely	☐	☐	☐	☐	☐
3. The relationship that our company has with major supply chain partners deserves our firm's maximum effort to maintain	☐	☐	☐	☐	☐

Part 3 ISS

Quality of information sharing

Please place a tick (✓) in the square box (☐) of each question according to your agreement on your company's real situation. Thanks!	Very low	Low	Medium	High	Very high
1. How would you rate the information exchanged with major supply chain partners in terms of its relevance to your company's business needs, compared to information exchanged with other similar partners?	☐	☐	☐	☐	☐
2. How would you rate the information exchanged with major supply chain partners in terms of its value-added to your company's business needs, compared to information exchanged with other similar partners?	☐	☐	☐	☐	☐
3. How would you rate the information exchanged with major supply chain partners in terms of its timeliness, compared to information exchanged with other similar partners?	☐	☐	☐	☐	☐
4. How would you rate the information exchanged with major supply chain partners in terms of its completeness, compared to information exchanged with other similar partners?	☐	☐	☐	☐	☐

Breath of information sharing

Please place a tick (✓) in the square box (☐) of each question according to your agreement on your company's real situation. Thanks!	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. Our company and major supply chain partners exchange information related to transaction and payment	☐	☐	☐	☐	☐
2. Our company and major supply chain partners exchange information related to procurement, production and delivery	☐	☐	☐	☐	☐
3. Our company and major supply chain partners exchange information related to product research and design, promotion plan and demand forecast	☐	☐	☐	☐	☐

Formalisation

Please place a tick (✓) in the square box (□) of each question according to your agreement on your company's real situation. Thanks!	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. Our company spent a significant amount of time on negotiating price with major supply chain partners	□	□	□	□	□
2. Our company spent a significant amount of time on monitoring major supply chain partners' performance	□	□	□	□	□
3. Our company spent a significant amount of time on resolving urgent problems with major supply chain partners	□	□	□	□	□

Mutual adjustment

Please place a tick (✓) in the square box (□) of each question according to your agreement on your company's real situation. Thanks!	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. Our company is willing to tailor our production systems to meet the requirements of major supply chain partners	□	□	□	□	□
2. Our company is willing to provide or develop specialised tools and equipment for the purpose of doing business with major supply chain partners	□	□	□	□	□

Part 4 Supply chain uncertainty

Please place a tick (✓) in the square box (□) of each question according to your agreement on your company's real situation. Thanks!	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. The functional needs of final products are hard to predict	□	□	□	□	□
2. The supply of raw materials is hard to control	□	□	□	□	□
3. The procurement process is always inefficient	□	□	□	□	□
4. It is difficult to fulfil the required quality of products for orders	□	□	□	□	□

Part 5 Supply chain performance

Please place a tick (✓) in the square box (□) of each question according to your agreement on your company's real situation. Thanks!	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. Our transactions with major supply chain partners meet agreed upon costs per unit	□	□	□	□	□
2. Our transactions with major supply chain partners meet productivity standards	□	□	□	□	□
3. Our transactions with major supply chain partners meet on-time delivery requirements	□	□	□	□	□
4. Our transactions with major supply chain partners respond to each others' requests	□	□	□	□	□
5. Our transactions with major supply chain partners meet inventory requirements (finished goods)	□	□	□	□	□