European Journal of Information Systems (2010) 19, 238–249

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The strategic value of supply chain visibility: increasing the ability to reconfigure

Hsiao-Lan Wei[1] and
Eric T.G. Wang[2]

[1]*Department of Information Management, National Taiwan University of Science and Technology, R.O.C.;* [2]*Department of Information Management, National Central University, R.O.C*

Correspondence: Hsiao-Lan Wei, Department of Information Management, National Taiwan University of Science and Technology, Taipei, 106, Taiwan, R.O.C.
Tel: +886-2-27303226;
Fax: +886-2-27376777;
E-mail: hlwei@cs.ntust.edu.tw

Abstract
To understand the role of supply chain visibility in creating strategic value, this study uses the dynamic capabilities view to uncover the nature of supply chain visibility. The study identifies four important constructs of supply chain visibility that are helpful in driving supply chain reconfigurability and thus improving supply chain strategic performance. They are visibility for sensing, visibility for learning, visibility for coordinating, and visibility for integrating. The results show that visibility for sensing has direct impact on supply chain strategic performance. Empirical evidence also supports that visibility for learning, visibility for coordinating, and visibility for integrating are important for enhancing supply chain reconfigurability, thus creating strategic value in supply chains. Supply chain visibility therefore enables firms to reconfigure their supply chain resources for greater competitive advantage. Implications of the results regarding the nature and the role of supply chain visibility in enhancing supply chain strategic performance are provided.
European Journal of Information Systems (2010) **19,** 238–249.
doi:10.1057/ejis.2010.10; published online 9 March 2010

Keywords: supply chain visibility; dynamic capabilities; reconfigurability; strategic value

Introduction

Collaborations between firms and integrated partnerships have become very popular in recent years (Madhok & Tallman, 1998). Firms are seeking synergistic combinations of resources and changing their roles and value positions through digital collaborations. The cross-organizational information system collaborations provide informational resources to exploit market knowledge and create competitive advantage (Barratt & Oke, 2007; Klein *et al*., 2007). Accordingly, research in supply chain management (SCM) has demonstrated the importance of information technology (IT) in developing and maintaining successful interorganizational collaborations (Barua *et al*., 2004; Rai *et al*., 2006; Bala & Venkatesh, 2007).

Recently, research topics related to e-procurement, e-SCM, business-to-business exchanges, and net-enabled organizations have emerged rapidly (Min & Galle, 1999; Mukhopadhyay & Kekre, 2002; Cagliano *et al*., 2003; Barua *et al*., 2004; Gosain *et al*., 2004; Kauffman & Mohtadi, 2004). These studies claim that the web-based applications can provide much more benefits, for example flexibility and time-to-market, than traditional inter-organizational information systems, thus leading to greater financial benefits (Barua *et al*., 2004; Gosain *et al*., 2004; Straub *et al*., 2004). The reason behind the superior Internet-enabled advantages for buyers and suppliers is the enhanced information visibility in their supply chains. Supply chain visibility can determine how the physical and cash flows are carried out, and thus is central to effective supply chain decision-making (Lejeune & Yakova, 2005). However, whether this visibility can be

Received: 1 April 2009
Revised: 7 November 2009
2nd Revision: 5 December 2009
Accepted: 11 December 2009

translated into strategic value for supply chain partners, especially in turbulent environments, remains unclear.

Supply chain visibility has been viewed as the degree to which supply chain partners have access to information related to supply chain operations and management and considered to benefit each other (Mohr & Spekman, 1994; Barratt & Oke, 2007). Real time strategic and tactical information is important for supply chain members to lower uncertainty, improve coordination, and enhance customer satisfaction (Barua *et al.*, 2004). In particular, the timely sharing of information along the supply chain can dramatically reduce demand distortion, which is termed the 'bullwhip effect' (Lee *et al.*, 1997). Empirical studies in the information system (IS) literature have investigated the influence of IT on information sharing and subsequent improved performance (Min & Galle, 1999; Narasimhan & Kim, 2001; Moberg *et al.*, 2002; Mukhopadhyay & Kekre, 2002; Gosain *et al.*, 2004; Subramani, 2004; Wang & Wei, 2007). However, there still is a missing link between information sharing and supply chain visibility (Barratt & Oke, 2007) with information sharing being an activity while visibility an outcome of such activity. In fact, visibility can be an important capability that may lead to sustainable competitive advantage in supply chains. Both technological and non-technological antecedents of supply chain visibility have been explored, but the relationship between supply chain visibility and competitive advantage still requires further investigation (Barratt & Oke, 2007). Thus, this study aims at examining how supply chain visibility can provide strategic advantage, especially in turbulent environments.

In fast-moving business environments, whether organizational capabilities can generate sustainable competitive advantage has been of interest from a dynamic-capability perspective (DCP), which focuses on capabilities required both to adapt to changing market and technological opportunities and to shape external environments (Teece, 2007). This paper identifies different types of supply chain visibility as important intangible, dynamic capabilities that are capable of generating sustainable competitive advantage in supply chains. By utilizing a DCP framework (Teece, 2007), we conceptualize the nature of supply chain visibility and extend its role from coordination to strategic value creation. Sustainable supply chain advantage is attainable through the dynamic capabilities of a supply chain. Therefore, our research question is: can supply chain visibility provide strategic value through building up interorganizational dynamic capabilities?

The structure of this paper is organized as follows. The next section first explains the conceptual background based on the dynamic capabilities view, and then the section after that discusses the research constructs, derives the hypotheses, and presents the research model. The subsequent section describes the methodological issues and measurement. The penultimate section analyzes the data and tests the research hypotheses. Finally, the paper concludes with a summary of the contributions and implications of this research.

Conceptual background

Supply chain visibility – the dynamic capabilities view

The dynamic capabilities view focuses on exploiting internal and external firm-specific competences and developing new ones to address changing environments (Teece *et al.*, 1997). Renewing competences and reconfiguring organizational resources are two key aspects to achieve new forms of competitive advantage. Dynamic capabilities are the unique processes to integrate, reconfigure, gain, and release resources (Teece *et al.*, 1997; Eisenhardt & Martin, 2000). The SCM process that integrates new resources into the firm from external sources can be viewed as an important dynamic capability because it may create the need to modify certain operating routines in both the buying and the supplying firms. Moreover, dynamic capabilities rely on real-time information to quickly understand the changing situation and adjust actions (Eisenhardt & Martin, 2000). Therefore, we can understand the nature and important role of supply chain visibility in SCM from the dynamic capabilities view.

Dynamic capabilities are difficult to conceptualize, operationalize, and measure due to their complex and tacit nature (Dierickx & Cool, 1989), but they can be identified as a specific set of processes (Eisenhardt & Martin, 2000; Zollo & Winter, 2002; Pavlou & El Sawy, 2006). The framework proposed by Teece (2007) suggests that dynamic capabilities can be disaggregated into the capacity to sense and shape opportunities, to seize opportunities, and to maintain competitiveness through reconfiguring enterprise's assets. Coordinating/integrating, learning, and reconfiguring are processes that support sensing, seizing, and managing threats/transforming (Teece *et al.*, 1997; Teece, 2007). Reconfiguration is the goal process to achieve new configuration and can be facilitated by four enabling processes: (a) sensing the environment; (b) learning; (c) coordinating activities; and (d) integrating resources (Pavlou & El Sawy, 2006). Accordingly, we identify four important constructs that constitute supply chain visibility: visibility for sensing, visibility for learning, visibility for coordinating, and visibility for integrating. The former two are important for sensing and shaping opportunities and threats in Teece's (2007) framework. The latter two are critical for seizing opportunities. It is maintained that all these four constructs are important for supply chain reconfiguration and competitiveness.

Visibility for sensing represents the extent to which a firm can acquire real-time external information and quickly recognize changes in the environment. In order to react to change, firms in supply chains have to be able to sense both information about external sensed events and information about supply chain change (Gosain *et al.*, 2004). The most important external information in supply chains is market intelligence about customer needs. Market trend and customer demand information

is critical for both responding to market change and creating new opportunities. Sharing change information is needed to allow a firm to sense the needs of its partners and also communicate its own needs to the partners (Gosain *et al*., 2004). Firms that engage in broader information exchanges with current partners, including product changes, customer preferences changes, and demand changes, are likely to be aware of new opportunities and may be able to sense and adapt to key supply chain events (Madhavan *et al*., 1998).

Visibility for learning represents the extent to which a firm can learn and gain new information and knowledge from its supply chain partners. As external knowledge is fundamental to building capabilities, a firm can extend its knowledge base via supply chain relationships to improve performance (Teece *et al*., 1997; Eisenhardt & Martin, 2000; Johnson & Sohi, 2004). Learning from customers or suppliers is critical for properly understanding market signals and for innovation creation, because managers need to interpret external information to discover and create opportunities (Teece, 2007). Zollo & Winter (2002) suggest that dynamic capabilities arise from learning and emerge from three important learning mechanisms: experience accumulation, knowledge articulation, and knowledge codification. For building dynamic capabilities through learning from supply chain partners, firms need to exchange information related to their own specific domain experience, discuss different ideas and viewpoints, and share performance evaluation and knowledge for performance improvement. Complementary knowledge from external linkages may evolve into important sources of new ideas and performance improvement (Shan & Walker, 1994; Deeds & Hill, 1996; Decarolis & Deeds, 1999). Frequent contact and regular meeting among supply chain members can increase the amount of complex knowledge transferred and facilitate the sharing of different interpretation of information. In these interaction processes, people are forced to reflect on how they understand their work and articulate their tacit knowledge into explicit knowledge. The explicit knowledge then can be combined into more complex and systematic sets of new knowledge (Nonaka *et al*., 2000).

Visibility for coordinating is central for the decision-making in supply chains (Sahin & Robinson, 2002). More complete information to support supply chain decision-making can better align the decisions for accomplishing global system objectives and provide the required visibility for coordinating the product flows in the supply chain (Simatupang *et al*., 2004). Malone & Crowston (1994) propose a general definition of coordination: 'coordination is managing dependencies'. Three kinds of dependency need to be coordinated in SCM: prerequisite constraints, transfer, and usability (Malone & Crowston, 1994). Thus, visibility for coordinating should provide critical information for managing different kinds of dependency in supply chain relationships. Managing prerequisite dependency is the most common coordination in a supply chain. Christiaanse & Kumar (2000) indicate that upstream flows of customer orders and downstream flows of shipping notices coordinate the operations of supply chains. One way of managing transfer dependency about storage is to share information regarding when certain items are delivered and used such as the just-in-time practice (Malone & Crowston, 1994). Another way is establish certain levels of inventory stock to buffer between two dependent activities. Therefore, some planning-related information like material requirement plans, order forecasts, production schedules, and transportation schedules can help manage transfer dependency. For usability dependency, organizations must realize what characteristics customers want. This can be done by market research or by participatory design (Malone & Crowston, 1994). Supplier involvement in new product design is for managing this kind of dependency in supply chains. In the participatory processes, suppliers can gain rich customer preference as well as product requirement information.

Visibility for integrating emphasizes on the information that can provide consensus to arrive collaborative goals and build up collective identity for a supply chain. The integration of external activities and technologies is important for creating strategic advantage (Teece *et al*., 1997). Dyer (2000) asserts that developing a collective identity of a supply chain is very important in SCM. Therefore, a strategic mind-set with regard to supply chain partners and a collective identity of a supply chain are important characteristics of supply chain integration. To develop strong supply chain identity, it requires supply chain members share understandings about the key features in a supply chain. Greater sharing of information allows the creation of collective meanings and consensus on action with partners (Gosain *et al*., 2004). It provides the understanding of each firm's capabilities, strengths, goals, and skills and help achieving goal congruence in a supply chain (Jap, 1999). As goals become increasingly clarified and aligned, the perceived accomplishment of common goal is an important facilitating condition to achieve strategic outcomes. Long-term, collaborative relationships utilizing shared information will display greater levels of integration (Elgarah *et al*., 2005). In this sense, visibility for integrating can help create a supply chain identity and enhance mutual understanding for consensus.

Supply chain competitive advantage

Supply chain reconfigurability is an important dynamic capability in a supply chain for generating competitive advantage in changing environments. Reconfigurability is the ability to reconfigure resources with timeliness and efficiency in order to deploy a new configuration that matches the new environment. A new configuration of competencies relates to the innovative redeployment of existing resources and their novel synthesis

into new applications. Therefore, different supply chain configurations may exhibit different levels of operational efficiency and market knowledge creation (Malhotra *et al*., 2005). It is important for a supply chain to quickly reconfigure resources within the chain into a better combination for addressing shifted market opportunities. Many firms have adopted new supply chain practices to deliver better products/services to customers, such as postponement strategies, virtual integration, just-in-time purchasing, vendor managed inventory, collaborative planning, forecasting, and replenishment(CPFR) programs (Magretta, 1998; Raghunathan, 1999; van Hoek, 1999; Waller *et al*., 1999). These practices reconfigure supply chain processes as a whole by integrating physical and information flows of collaborative firms.

Supply chain performance has received substantial attention in SCM. Different aspects of time-based performance, including delivery speed and reliability, new product development time, manufacturing lead-time, and customer responsiveness, are proposed as the critical supply chain benefits (Handfield & Pannesi, 1995; Vickery *et al*., 1995; Jayaram *et al*., 1999). More specifically, Beamon (1999) argues that three types of performance measures must be included in any supply chain performance measurement system: resource measures (e.g., costs and inventory), output measures (e.g., fill rate, on-time delivery, and customer response time), and flexibility (e.g., volume flexibility, mix flexibility, and new product flexibility) measures. Moreover, Gunasekaran *et al*. (2001) classify a list of key supply chain performance variables into strategic, tactical, and operational levels. Craighead *et al*. (2006) also indicate that the benefits of SCM systems can be classified as strategic- or operational-oriented. In this regard, Ho *et al*. (2002) suggest that supply chain performance measure must be tied to the strategy reflected by the choice of competitive priorities including cost, quality, flexibility, and delivery. This priority-based supply chain performance is pursued by supply chain members collectively.

Theoretical framework and hypotheses

The dynamic capabilities view provides the overarching theory base for the research model as illustrated in Figure 1. Supply chain visibility is proposed as an important enabler of supply chain reconfigurability – an important dynamic capability for supply chains. From the dynamic capabilities view, firms need to respond to uncertain environments through reconfiguring supply chain resources. In the supply chain context, environmental turbulence arises mainly from market turbulence, the unpredictability in market demands, customer needs, and competitor strategies. Studies of supply chain dynamic suggest the critical role of supply chain visibility in dealing with environmental turbulence (Sahin & Robinson, 2002; Huang *et al*., 2003). From the dynamic capabilities view, supply chain visibility consists of four important constructs: visibility for sensing, visibility for learning, visibility for coordinating, and visibility for integrating. Thus, the research model links supply chain visibility, reconfigurability, and performance. Considering the example of IKEA, it transforms from a small Swedish mail-order furniture operation into the world's largest retailer of home furnishings by reconfiguring the roles, relationships, and organizational practices of the furniture business (Normann & Ramirez, 1993). Customers transport and assemble the high-quality and low-price products themselves, which are traditionally done by manufactures and retailers. The innovative IKEA business system is supported by providing detail product information to customers and sharing market information, technical learning information, and business goals with suppliers. We explain our research hypotheses in the following section.

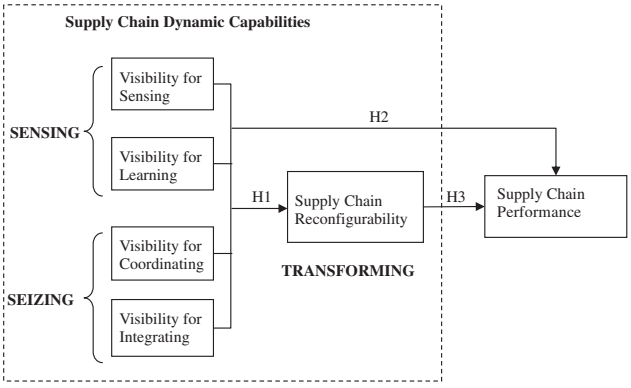

Figure 1 Research model.

Supply chain visibility and supply chain strategic performance

Reconfiguration requires the ability 'to scan the environment, to evaluate markets and competitors, and to quickly accomplish reconfiguration and transformation ahead of competition' (Teece *et al*., 1997). For instance, visibility for sensing is the prerequisite of the ability that enterprises can quickly adapt to change (Gosain *et al*., 2004). The broad range and reach of market information provided by supply chain partners open up the possibilities of rapidly reconfiguring the supply chain to respond to customer's demand for value (Christiaanse & Kumar, 2000). Visibility for learning has been proposed to be a strategic resource (Hult *et al*., 2003), which renews a firm's knowledge base necessary for using and reconfiguring current resources (Zahra & George, 2002). Sharing each other's experience among supply chain partners can extend their current knowledge bases to create new ones that facilitate the development of innovative resource configurations. Further, exchanging ideas in supply chain meetings can clarify many causal ambiguities for producing supply chain performance, and therefore result in adaptive adjustments to the existing configuration or more radical reconfiguration for more fundamental changes (Zollo & Winter, 2002).

For effectively allocating and using disperse resources in a supply chain, visibility for coordinating can help partners recognize the value of their existing resources and synchronize their activities in new configurations (Iansiti & Clark, 1994). Modern IT, which provides a broad range of channels for communication and coordination, facilitates supply chain redesign (Christiaanse & Kumar, 2000). For example, IT makes it possible to detach information flows from physical flows, thus allowing firms to anticipate and prepare for the arrival of a physical shipment. Consequently, firms can create many different new ways of rapidly reconfiguring supply chains to respond to market under a broader solution space expanded by greater visibility for coordinating. For developing new supply chain configurations, visibility for integrating can help build a shared understanding, create a common ground of knowledge, and develop new perceptual views in a supply chain. Therefore, it contributes to the attainment of consensus and shared goals among partners at the strategic level, and therefore facilitates supply chain reconfigurability. Accordingly, we propose the following hypotheses:

H1: *Supply chain visibility is positively associated with supply chain reconfigurability.*

H1a: *Visibility for sensing is positively associated with supply chain reconfigurability.*

H1b: *Visibility for learning is positively associated with supply chain reconfigurability.*

H1c: *Visibility for coordinating is positively associated with supply chain reconfigurability.*

H1d: *Visibility for integrating is positively associated with supply chain reconfigurability.*

It is maintained that supply chain visibility can not only enhance supply chain reconfigurability but also improve supply chain strategic performance directly. The benefits of visibility could be significant, especially in reducing the bullwhip effect, supply chain cost, and cycle time (Lee *et al*., 1997; Sahin & Robinson, 2002; Vickery *et al*., 2003). Through seamless information channels from and to suppliers, the buying firm can integrate its planning effort with the information of the suppliers' production capacity, quality condition, inventory level, and delivery capability, thereby reducing the uncertainties associated with transactions. Similarly, the suppliers can benefit from the buyer's early release of product or order information to optimize the allocation of production capacity, thus reducing time to market (Rabinovich *et al*., 2003). The delivery time and product quality of both the buyer and its suppliers can be jointly improved.

Firms would have better performance if their network relationships maximize diverse information access (Baum *et al*., 2000). The flexibility created from new knowledge stocks obtained from partners can enhance supply chain performance because it gives the supply chain the ability to handle customized orders, to rapidly adjust production capacity, and to respond to target markets (Vickery *et al*., 1999). These new knowledge sources prevent firms from overemphasizing on existing knowledge and being trapped in limited organizational actions (Zahra & George, 2002), thus enhancing the innovativeness of the partners. Therefore, we present the following hypotheses:

H2: *Supply chain visibility is positively associated with supply chain strategic performance.*

H2a: *Visibility for sensing is positively associated with supply chain strategic performance.*

H2b: *Visibility for learning is positively associated with supply chain strategic performance.*

H2c: *Visibility for coordinating is positively associated with supply chain strategic performance.*

H2d: *Visibility for integrating is positively associated with supply chain strategic performance.*

Rapidly shifting environments force firms to respond quickly to the changing competitive priorities (Handfield & Bechtel, 2002). To capture the benefits of flexible response to changing conditions, time-based capabilities are critical (Hult *et al*., 2000). Firms who can respond quickly to changes often rely on new strategies such as vendor management inventory, just-in-time delivery, and postponement. These strategies typically require supply chain redesign and resource reconfiguration. From the dynamic capabilities view, supply chain reconfigurability helps firms recombine their existing resources into superior new configurations with desired changes. This creates favorable innovations to better match market needs and prevent supply chain configurations from being too rigid (Leonard-Barton, 1992; Pavlou & El Sawy, 2006). As such, supply chain reconfigurability can provide firms the capability not just to add value but also to reinvent value. This provides firms with the competitive advantages of understanding customer needs, creating innovative products/services, and even building up new business opportunities more rapidly. Therefore, we present the following hypothesis:

H3: *Supply chain reconfigurability is positively associated with supply chain strategic performance.*

Methodology

Data collection

A cross-sectional mail survey was administrated for collecting data from manufacturing firms in Taiwan. A draft survey was developed largely based on measures that were identified in the literature as suitable for the

Table 1 Demographic characteristics of the responding firms ($n = 181$)

	Number of firms	*Percentage of firms*
Industry		
Automobile	11	6.1
Chemical	11	6.1
Computer and electronics	61	33.7
Food	10	5.5
Machine and tool	10	5.5
Mental and steel	26	14.4
Textile	19	10.5
Others	33	18.2
Total asset (NT$)		
Less than $0.8 Billion	47	26.0
$0.8 – $1.2 Billion	27	14.9
$1.3 – $2 Billion	24	13.3
$2.1 – $3 Billion	15	8.3
$3.1 – $5 Billion	26	14.4
$5.1 – $8 Billion	13	7.2
$8.1 – $10 Billion	5	2.8
Over $10 Billion	18	9.9
Non-response	6	3.3
Number of employees		
Less than 100	13	7.2
101–500	72	39.8
501–1000	35	19.3
1001–3000	40	22.1
Over 3000	21	11.6

current study. After compiling the English version of the questionnaire, the survey items were first translated into Chinese by a bilingual research associate and verified and refined for its translation accuracy by one *MIS* professor and two senior doctoral students. The Chinese version of the draft was then pre-tested with 35 senior managers (including purchasing, operation, material management, SCM, sales, and marketing managers and CEOs) for reliability and validity, resulting in modifications of the wording of some survey items. Nine hundred and eighty five survey packages were mailed to the senior purchasing manager of the companies from the directories of 2002 *Top 1000 largest firms in Taiwan* published by *Common Wealth Magazine*. Totally 187 surveys were returned, with 181 having completed data available for subsequent analysis, yielding an effective response rate of 18.4%. We present the characteristics of the responding firms in Table 1. As the production value of computer and electronics industries has contributed to one-third of the Taiwan's gross domestic product, 33.7% of the respondents are from these industries. Metal and steel, and textile industries are around 10% in the sample. The sample consists of medium- to large-sized firms in Taiwan. Sixty eight percent of the respondents identified their positions as purchasing managers or higher, 15% indicated purchasing staff positions, 12% others, and 5% non-response. The average working year of informants is 13.4 years in the firm, indicating the informants should have sufficient knowledge to answer the survey.

Non-response bias was assessed by showing that early and late respondents did not significantly differ in their demographic characteristics (Armstrong & Overton, 1977). The respondents were divided into two halves based on the dates of return. Early respondents were identified by selecting those who responded in the first 4 weeks ($n = 105$). The comparison on company capital and employee numbers between the two groups showed no significant differences based on the independent sample t test ($P = 0.60$ and 0.58, respectively). Accordingly, non-response bias should not be a serious concern in this study.

Measures

Supply chain visibility includes four important constructs based on the dynamic capabilities view: visibility for sensing, visibility for learning, visibility for coordinating, and visibility for integrating. The measure of visibility for sensing consists of four items that focus on product changes, marketing plan, market trend, and demand or customer preference changes (Gosain *et al.*, 2004). We assessed visibility for learning with six items based on the three learning mechanisms for dynamic capability building, that is experience accumulation, knowledge articulation, and knowledge codification (Zollo & Winter, 2002). The measure of visibility for coordinating consists of nine items pertaining to notification (e.g. ordering and shipping information), planning (such as material requirement and production schedule), and requirement (e.g. customer needs and product specification). Visibility for integrating consists of six items that focus on business planning, strategic issues, competences, business processes, and shared understanding.

Supply chain reconfigurability is the ability to deploy new supply chain configurations for matching the changed environment and to reconfigure supply chain resources timely and efficiently. We assessed it with a three-item scale that focused on reconfiguring resources to generate new assets, to better match market, and to create novel combinations (Pavlou & El Sawy, 2006). *Supply chain strategic performance* focuses on strategic benefits from supply chain relationships. Strategic benefits are related to learning about customers and markets, new product creation, and business opportunities (Subramani, 2004). All the measurement items are provided in the Appendix.

Result

Partial least squares (PLS), as implemented in PLS Graph version 3.0, was selected to analyze both measurement validity and linkages in the proposed model. This technique has root in regression, path, and principal components factor analysis. PLS generates estimates of standardized regression coefficients for model paths and 'bootstrapping' is then used to evaluate the statistical

Table 2 Correlation matrix and composite factor reliability scores

Constructs	*Composite reliability*	*Mean*	*STD*	*1*	*2*	*3*	*4*	*5*	*6*
Supply chain visibility									
1. Visibility for sensing	0.92	3.53	0.73	0.86					
2 Visibility for coordinating	0.95	3.76	0.74	0.66	0.81				
3. Visibility for learning	0.93	3.58	0.70	0.65	0.59	0.82			
4. Visibility for integrating	0.94	3.49	0.74	0.71	0.63	0.84	0.86		
5. Supply chain reconfigurability	0.96	3.42	0.88	0.60	0.59	0.76	0.75	0.94	
6. Strategic performance	0.93	3.51	0.79	0.60	0.48	0.70	0.70	0.74	0.90

Items on diagonal (shaded) represent the square root of the AVE scores.

significance of the path coefficients (Wold, 1985). PLS also generates factor loadings for each measurement item. Sample size can be small and assumptions of normality are not necessary (Fornell, 1982). Therefore, PLS is appropriate for analyzing predictive research models in the early stages of theory building and testing, as is the model in the present study.

Measurement model

The psychometric properties of the scales were assessed in terms of item loadings, discriminant validity, and internal consistency. Item loadings and internal consistencies (also known as composite reliability) greater than 0.70 are considered acceptable (Fornell & Larcker, 1981). From the factor analysis results, all the items loaded highly (>0.70) on their respective construct. All the constructs also exhibited good internal consistency as evidenced by their composite reliability scores, which were all greater than 0.90 (see Table 2).

Discriminant validity was assessed by two criteria (Chin, 1998): (1) items should load more highly on the construct that they are intended to measure than on other constructs (i.e. loadings should be higher than cross-loadings) and (2) the square root of the average variance extracted (AVE) should be larger than the inter-construct correlations. Cross-loadings were computed by calculating the correlations between a latent variable's component scores and the manifest indicators of other latent constructs (Chin, 1998; Agarwal & Karahanna, 2000). Without exception, all items loaded more highly on their own construct than on other constructs (see Appendix A). As shown in Table 2, the square root of the AVE (shaded leading diagonal) for each construct was greater than 0.707 and also greater than the correlations between the construct and other constructs, indicating that all the constructs share more variances with their indicators than with other constructs. Overall, the self-report measurement instrument exhibited sufficiently strong psychometric properties to support our subsequent test of the proposed structural model.

Structural model

The PLS structural model and hypotheses were assessed by examining path coefficients (similar to standardized beta weights in regression analysis) and their significance

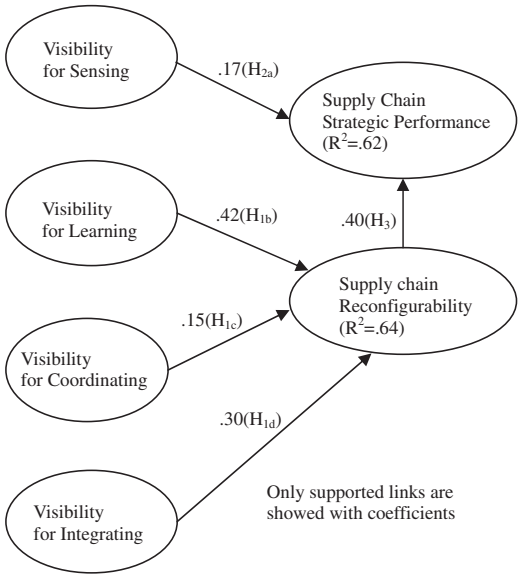

Figure 2 PLS results for research model.

levels. The significant path coefficients and explained variances for the model are shown in Figure 2. All of the constructs were modeled as reflective. Following Chin (1998), bootstrapping (with 200 resamples) was performed to obtain the estimates of standard errors for testing the statistical significance of path coefficients using t test.

Table 3 summarizes the model-testing results. As for H1, we find that supply chain visibility is positively associated with supply chain reconfigurability in some aspects. Visibility for learning ($t=4.72$, $P<0.01$), visibility for coordinating ($t=2.00$, $P<0.05$), and visibility for integrating ($t=3.25$, $P<0.01$) have significant impacts on reconfigurability, supporting H1b, H1c, and H1d. However, the direct impacts of visibility for sensing on reconfigurability are insignificant ($t=0.17$, $P>0.1$), thereby H1a is not supported. H2, which posits that supply chain visibility would influence supply chain performance, is only partially supported. Visibility for sensing ($t=2.13$, $P<0.05$) has significant impacts on strategic performance, thereby partially supporting H2a. The direct impacts of visibility for learning, visibility for coordinating, and visibility for integrating on supply

Table 3 PLS results of path significance

Hypothesis	*Path*	*t-value*	*Significance*
SCV → SCR (H1)	SVIS → SCR (H1a)	0.17	No
	LVIS → SCR (H1b)	4.72***	Yes
	CVIS → SCR (H1c)	2.00**	Yes
	IVIS → SCR (H1d)	3.25***	Yes
SCV → SCSP (H2)	SVIS → SCSP (H2a)	2.13**	Yes
	LVIS → SCSP (H2b)	1.29	No
	CVIS → SCSP (H2c)	1.24	No
	IVIS → SCSP (H2d)	1.88	No
SCR → SCSP (H3)	SCR → SCSP R (H3)	4.78***	Yes

**and ***indicate significance at $P<0.05$ and $P<0.01$, respectively.
SCV = Supply chain visibility; SVIS = Visibility for sensing; CVIS = Visibility for coordinating; LVIS = Visibility for learning; IVIS = Visibility for integrating; SCR = Supply chain reconfigurability; SCSP = Supply chain strategic performance.

chain strategic performance are insignificant, thus H2b, H2c, and H2d are not supported. As for H3, we find that, supply chain reconfigurability is positively associated with supply chain performance (validating H3, $t=4.78$, $P<0.01$). Supply chain visibility explains 64% of the variances in supply chain reconfigurability. Explained variances for supply chain strategic performance are 62%.

Discussion and Conclusion

In a fast-changing competitive environment, managers find ways to reinvent value as the fundamental logic of value creation is also changing. As such, firms need to collaborate with their suppliers and customers to create value together through the reconfiguration of roles and relationships in the value-creating system. In this paper, we argue that supply chain visibility can provide firms capabilities to reconfigure their supply chains and create strategic value. For achieving the strategic value, this study identifies, conceptualizes, and operationalizes the important concepts of supply chain visibility from the dynamic capabilities view, providing a specific set of measurable constructs, that is visibility for sensing, visibility for learning, visibility for coordinating, and visibility for integrating. These four constructs thoroughly encompass the rich information needs in a supply chain. In doing so, this study overcomes the ambiguity of supply chain visibility and opens new avenues for empirical, quantitative, and analytical research in SCM in turbulent environments. Also, the dynamic capabilities view provides a theoretical foundation to investigate the role of supply chain visibility in obtaining superior performance and reveals that it can improve performance not only directly but also indirectly through supply chain recongfigurability. Overall, the findings suggest that supply chain visibility is critical for creating supply chain strategic performance, especially through enhancing supply chain recongfigurability.

The literature has suggested the positive influence of supply chain visibility on performance; however, previous research focused mainly on coordination information and operational performance. This study reveals the impacts of the different aspects of supply chain visibility on supply chain reconfigurability and performance. Visibility for sensing plays a key role in improving strategic performance and helps firms understand their market quickly and create new business opportunities to obtain strategic benefits. The results suggest the importance of visibility for learning, visibility for coordinating, and visibility for integrating in facilitating supply chain reconfigurability. Therefore, supply chain members should promote these aspects of visibility for creating dynamic capabilities in their own supply chains.

We find strong support for the association between supply chain reconfigurability and strategic performance. This reveals that recombining existing resources to create new value is important for a firm to improve strategic performance. Firms are able to improve operational performance through SCM. But managers who just focus on operational efficiency may run the risk of having comparatively lower capabilities that can generate strategic performance. Therefore, establishing supply chain reconfigurability is very important in order to reinvent value in the new forms in SCM.

From an academic perspective, our research introduces the dynamic capabilities view in IS and SCM areas, providing a different view to investigate IT value in SCM. For better understanding how IT can enable competitive advantage in turbulent environments (Sambamurthy *et al*., 2003) and how SCM capabilities can create value in response to uncertain environments, the proposed model lays the groundwork for exploring the role of supply chain visibility as a potential driver of competitive advantage in turbulent environments through dynamic capabilities. Our empirical findings suggest the mediating links between supply chain visibility and supply chain performance through supply chain reconfigurability. Moreover, we extend the dynamic capabilities view beyond the traditional firm level. The findings contribute to the relational view (Dyer & Singh, 1998) in the sense that dynamic capabilities can also be inter-organizational in nature and serve as the basis of competitive advantage in a collaborative relationship.

From a practical perspective, this research provides a number of insights into how managers should create strategic value from supply chain visibility. Importantly, decision makers need to leverage different aspects of supply chain visibility in order to use and recombine resources in a value creation way. As managers must be very adaptable in order to prepare for environmental changes, supply chain visibility should not be restricted within the transaction-related information. Many firms may focus mainly on improving coordinated information exchange, which is just part of the overall supply chain visibility that a firm needs to respond to environmental changes. Managers can investigate their current needs and status of the different aspects of supply chain visibility and invest in the parts that they need to improve.

This study has some limitations that create opportunities for future research. The cross-sectional design of this study did not allow us to observe the longitudinal impact of supply chain visibility on performance. Studies that collect data in different time period will enhance understanding of the long-term effects of supply chain visibility. In addition, the proposing model of supply chain visibility is not exhaustive, but it is merely representative of the key elements needed for effective supply chain reconfigurability. Other aspects from different theoretical perspectives might provide a different view to explore the supply chain visibility construct in an effort to gain a greater understanding of supply chain visibility's contribution to strategic value creation. Future research could identify additional aspects of supply chain visibility to comprehensively capture the concept. Furthermore, market characteristics of products/services as well as other factors may have intervening effects on the relationships between supply chain visibility and performance. Future efforts should investigate the relationships by considering other intervening variables.

In the Internet era, managers may be trapped in implementing various information systems for improving their supply chains (Christiaanse & Kumar, 2000), but this study demonstrates that the improved supply chain visibility should be utilized for reconfiguration of resources and competences in the supply chain and four different kinds of visibility should be pursued simultaneously. Visibility for sensing helps decision makers understand market trend and customer needs, thus managers could think the new value creation ways in advance. Visibility for learning can stimulate new ideas and challenge current business thinking, therefore, managers can redesign a better supply chain through combing internal and external knowledge. Visibility for coordinating can provide better information to allocate resources for the new forms of supply chain. Visibility for integrating helps establish mutual goals and understanding for the supply chain members and managers thus can implement the new reconfiguration in a better way. We provide an important step in understanding the nature of supply chain visibility and its strategic value through enhancing supply chain reconfigurability.

Acknowledgements

We thank the editors and reviewers for their helpful comments. We also acknowledge the financial support from the National Science Council of Taiwan (R.O.C.) under the contract NSC94-2416-H-008-001 and NSC96-2416-H-011-010.

About the authors

Hsiao-Lan Wei is an assistant professor in the Department of Information Management at National Taiwan University of Science and Technology, Taiwan (R.O.C.). She received her M.B.A. and Ph.D. in Information Management from National Central University, Taiwan. Her research interests include enterprise resource planning, organizational learning, and supply-chain management. Her research has appeared in *European Journal of Information Systems*, *Journal of Management Information Systems*, *Decision Sciences*, and others.

Eric T.G. Wang is Information Management Chair Professor in the Department of Information Management at National Central University, Taiwan (R.O.C.). He received the Ph.D. degree in Business Administration, specialized in Computer & Information Systems, from the William E. Simon Graduate School of Business Administration, University of Rochester. His research interests include supply chain management, electronic commerce, organizational economics, and organizational impact of information technology. His research has appeared and will appear in *European Journal of Information Systems*, *Information Systems Research*, *Management Science*, *Journal of Management Information Systems*, *Decision Sciences*, *Decision Support Systems*, *Information Systems Journal*, *Information & Management*, *International Journal of Information Management*, *Omega*, *European Journal of Operational Research*, and others.

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Appendix A

See Table A1.

Table A1 Results of factor analysis

Items	*SCVS*	*SCVL*	*SCVC*	*SCVI*	*SCR*	*SCP*
SCVS1	**0.78**	0.59	0.53	0.65	0.60	0.47
SCVS2	**0.89**	0.56	0.57	0.61	0.53	0.52
SCVS3	**0.89**	0.53	0.58	0.59	0.45	0.51
SCVS4	**0.86**	0.54	0.57	0.57	0.45	0.56
SCVL1	0.57	**0.78**	0.57	0.71	0.73	0.61
SCVL2	0.55	**0.86**	0.46	0.68	0.72	0.67
SCVL3	0.52	**0.78**	0.44	0.63	0.55	0.56
SCVL4	0.50	**0.78**	0.39	0.68	0.51	0.49
SCVL5	0.56	**0.87**	0.50	0.73	0.62	0.57
SCVL6	0.50	**0.84**	0.52	0.71	0.61	0.54
SCVC1	0.50	0.47	**0.82**	0.52	0.45	0.36
SCVC2	0.54	0.47	**0.84**	0.53	0.44	0.38
SCVC3	0.43	0.41	**0.78**	0.42	0.41	0.30
SCVC4	0.51	0.43	**0.83**	0.47	0.41	0.37
SCVC5	0.46	0.46	**0.82**	0.46	0.44	0.32
SCVC6	0.60	0.56	**0.81**	0.55	0.52	0.42
SCVC7	0.47	0.40	**0.81**	0.48	0.47	0.38
SCVC8	0.62	0.58	**0.76**	0.58	0.61	0.50
SCVC9	0.62	0.51	**0.81**	0.54	0.55	0.46
SCVI1	0.63	0.69	0.53	**0.86**	0.64	0.57
SCVI2	0.63	0.70	0.48	**0.87**	0.65	0.61
SCVI3	0.61	0.79	0.52	**0.87**	0.73	0.65
SCVI4	0.54	0.67	0.57	**0.80**	0.55	0.52
SCVI5	0.60	0.75	0.53	**0.88**	0.62	0.64
SCVI6	0.62	0.74	0.62	**0.86**	0.68	0.63
SCR1	0.54	0.70	0.55	0.73	**0.94**	0.70
SCR2	0.56	0.71	0.57	0.69	**0.95**	0.68
SCR3	0.58	0.75	0.55	0.71	**0.94**	0.71
SCSP1	0.55	0.68	0.48	0.69	0.69	**0.88**
SCSP2	0.54	0.62	0.42	0.63	0.67	**0.92**
SCSP3	0.55	0.60	0.40	0.60	0.65	**0.91**

SCVS = Supply chain visibility: Visibility for sensing; SCVC = Supply chain visibility: Visibility for coordinating; SCVL = Supply chain visibility: Visibility for learning; SCVI = Supply chain visibility: Visibility for integrating; SCR = Supply chain reconfigurability; SCSP = Supply chain strategic performance. Item loadings of each construct (shaded area) are significant at $P < 0.01$.

Appendix B

Survey questions used in study
While answering the following sections, please choose the major supplier of your company as the responding target.

Supply chain visibility This section describes supply chain visibility. Please respond to the questions by circling the most appropriate response according to your assessment.

Visibility for sensing Please indicate the complete information that you exchange with the supplier in the following areas.
(Scale: very low 1–2–3–4–5 very high)

(SCVS1) Upcoming product or service-related changes
(SCVS2) Promotion and marketing plans
(SCVS3) Market demand trends and forecast
(SCVS4) Demand shifts and changes in customer preferences

Visibility for learning Please evaluate the description of the following information exchanging behaviors between your company and the supplier.
(Scale: very disagree 1–2–3–4–5 very agree)

(SCVL1) We exchange performance evaluation information with the supplier.
(SCVL2) New ideas are generally shared with the supplier.
(SCVL3) Different knowledge can be acquired from the supplier.
(SCVL4) Different points of view are discussed in our regular meeting with the supplier.
(SCVL5) New insights are developed through the joint decision-making process with the supplier.
(SCVL6) We exchange documents containing valuable knowledge, which help to improve our supply chain performance with the supplier.

Visibility for coordinating Please indicate the complete information that you exchange with the supplier in the following areas.
(Scale: very low 1–2–3–4–5 very high)

(SCVC1) Ordering information
(SCVC2) Shipping information
(SCVC3) Payment processing information
(SCVC4) Transportation schedule
(SCVC5) Material requirement
(SCVC6) Order forecasting
(SCVC7) Production schedule
(SCVC8) Customer preference or needs information
(SCVC9) New product requirement information

Visibility for integrating Please evaluate the description of the following information exchanging behaviors between your company and the supplier.
(Scale: very disagree 1–2–3–4–5 very agree)

(SCVI1) We exchange information that helps establishment of business planning with the supplier.
(SCVI2) We frequently discuss strategic issue with the supplier.
(SCVI3) We share the information with the supplier related to the common issue of this supply chain for improving chain performance.
(SCVI4) We have enough information to understand the skills and competencies of the supplier.
(SCVI5) We exchange information of core business processes with the supplier.
(SCVI6) We develop a shared understanding of the available supply chain information with the supplier.

Supply chain reconfigurability This section describes the usage of supply chain resources. Please respond to the questions by circling the most appropriate response according to your assessment.
(Scale: very disagree 1–2–3–4–5 very agree)

(SCR1) We can successfully reconfigure supply chain resources to come up with new productive assets.
(SCR2) We can effectively integrate and combine existing resources into novel combinations in this supply chain.
(SCR3) We are able to engage in resource recombinations to better match the product-market areas in this supply chain.

Supply chain strategic performance This section describes supply chain performance. Please indicate the extent to which you are receiving the following benefits as a result of your relationship with the supplier.
(Scale: very low 1–2–3–4–5 very high)

(SCSP1) Learning about customers and markets for our products
(SCSP2) Creation of new products, product enhancements
(SCSP3) Development of new business opportunities