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Information technology and supply chain agility in Chinese automotive industry

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1 Introduction

Agility is considered a vital factor for business success in complex industrial landscapes as it enables rival firms to efficiently perform under time-to-market pressures. Relevant literature has showed that business success can only be achieved through effective coordination of all the participant companies across the supply chain (Van Hoek *et al*., 2001) to shorten product life cycle and reduce product costs (Levery, 2000), as demand and supply fluctuate more rapidly than they used to. With current view of the unit of competition to be a supply network, agile supply chain is becoming a focal area (Ismail and Sharifi, 2006). It has gained significant attention from both academics and practitioners in recent years (Christopher, 2000; Naylor *et al.*, 1999; Power *et al.,* 2001), and it has been a primary objective for leading organizations (Fisher, 1997).

Information technology (IT) plays an important role in supply chain management, as an enabler in achieving supply chain integration and agility (Gunasekaran and Ngai, 2004, Power *et al*., 2001). As Breu *et al*. (2001) argue, '*information systems are seen to assume a fundamental role in developing agility*'. Many studies have concerned with the impact of IT on supply chain management (Auramo *et al.,* 2005; Bowersox and Daugherty, 1995; Gunasekaran and Ngai, 2004), and the recognition of IT as a competitive tool in achieving supply chain

agility (Power *et al.,* 2001; Yusuf *et al.,* 2004). However, these studies fall short on unravelling potential mechanisms in which IT applications may affect supply chain agility as well as the impact on suppliers throughout the supply chain. The question of how IT contributes to supply chain agility is important as organizations heavily invest on IT. In this paper, we attempt to explore the above question on how IT applications may affect supply chain agility.

The paper is organized as follows. Section 2 presents a review of relevant literature on supply chain agility, and discusses the relationship of IT with supply chain management, especially with agile capability, while section 3 proposes a framework of IT and relevant propositions. Section 4 discusses the theoretical and practical implications of the paper. We conclude by illustrating current limitations and propose avenues for future research.

2 Literature Review

2.1 Supply chain agility

Supply chain management (SCM) is moving from traditional vertical hierarchy based organization to structured processes units. In this processes, the vertical integration has been replaced by horizontal integration, involving inter-firm integration and extensive outsourcing to achieve efficiency (van Hoek *et al.*, 2001). Moreover, firms move towards mass customization which stresses on efficiency

with short time responses and product variety from mass market, and it combined '*the standardization and customization with one supply chain*' (van Hoek *et al.*, 2001); hence, leanness is important at this stage to achieve high quality with waste limitation (Aitken *et al.*, 2002). Further movement will be to have a fast market response and high product and service variety through applying these capabilities. Therefore, under such operating environments, agility is important as it is about '*customer responsiveness and mastering market turbulence*' (van Hoek *et al.*, 2001).

The origin of agility as a business concept lies in flexible manufacturing systems (FMS) (Aitken *et al.*, 2002). Initially, manufacturing flexibility was realized through automation to enable rapid changes and as a consequence, a greater responsiveness to changes in product volume and variety and later this concept was spread into the wider business context (Christopher and Towill, 2000). On the other hand, leanness, with reference to automotive industry, to the Toyota Production Systems (TPS), is often used in connection with lean manufacturing to minimize inventory of components and work-in-progress and to move towards a 'just-in-time' environment wherever possible (Womack *et al.,* 1990). Hence, agility stresses on fast response to changes in volume and variety while leanness is used for quality and waste elimination (Christopher, 2000). However, they are not

totally separate concepts and often recognized that supply chains need to encompass both. Many companies that have adopted lean manufacturing as business practices are actually being agile in their supply chain, as the car industry in many ways illustrates (Christopher and Towill, 2000). However, such implementation tend to be focused on the OEM and first tier suppliers, and less developed and integrated with second and third tier suppliers upstream the supply chain (Taylor and Brunt, 2001).

Goldman *et al.* (1995) identify four basic dimensions of agility: enriching customers, cooperating to enhance competitiveness, organizing to master change and uncertainty, leveraging the impact of people and information. The definition provides a basic conceptual view with the relevant elements of agility, stressing the responses to changes and capturing changes as opportunities (Sharifi and Zhang, 1999).

In the context of supply chain, agility lies in the same theoretical premises as agile manufacturing (Ismail and Sharifi, 2006). More specifically, Aitken *et al.* (2002) propose a three-level model with key principles to agile enterprises from rapid replenishment, lean production, and organizational agility to individual action. Yusuf *et al.* (2004) treat supply chain agility as a measurement of how well the relationships across supply chains involve in the process of manufacturing,

design, delivery and customer service. Christopher (2000) defines supply chain agility '*as a business-wide capability that embraces organizational structures, information systems, logistics processes and in particular, mindset*'. In the research of van Hoek *et al*. (2001), four dimensions of agile supply chain have been identified, which are customer sensitivity for a customer oriented supply chain; virtual integration to leverage information across supply chains; process integration to master changes through focusing on core competencies; and network integration to coordinate with partners (Christopher, 2000; van Hoek *et al*., 2001).

Supply chain management is moving away from traditional processes to agile capability to realize operation on actual demand, where information is instantly available through information sharing and exchange and organizations are designed for maximum efficiency during integration processes (Yusuf *et al*., 2004).Therefore, IT plays a key role on realizing by adopting the 'information enrichment' supply chain (Gunasekaran and Ngai, 2004) and synchronizing suppliers in the network by providing real time information (Christopher, 2005).

In the case of automotive industry, the supply chain is characterized by complexity, uncertainty and heterogeneity (Xu *et al.,* 2003). Over the past decades, a large number of studies illustrate the strategic importance of agile manufacturing (Cheng *et al.*, 1998; Sharifi and Zhang*,* 1999). An important factor to the agility in

manufacturing enterprises is flexibility among firms so that they can react to changes effectively, driven by customer designed products and production capacity to rapid new product launching (Gunasekaran, 1998). However, it has been recognized that when a product, as in the case of automotive manufacturing, is heavily dependent on the whole supply chain, a single agile manufacturing enterprise may have difficulties responding rapidly to changing market requirements due to limited resources (Jin *et al.,* 2005; Xu *et al.,* 2003). Employing an IT system that links customers and suppliers at various stages through real time communication and information exchange may enable innovative and cost-effective product design (Christopher, 2005). Hence, agility in automotive supply chains is a indispensable trend in supply chain management, and it is accomplished by integrating available resources, including technology, people and organization into coordinated independent systems which are capable of achieving short product development cycle times by speeding up information flow (Cheng *et al.,* 1998). Through the process of supply chain management one factor that drives manufacturers to integrate with partners is market turbulence such as rapid introduction and customization of products. Moreover, with intensive competition, efforts to reduce cost through Just-In-Time (JIT) manufacturing, scheduling and distributing have led to more frequent attention on quality and on-time scheduling

(Russ and Camp, 1997). With the advent of intelligent products whose requirements are difficult to satisfy for individual companies, inter-firm collaborations are encouraged in order to add value to end customers through the process of design, manufacturing and delivery processes (Yusuf *et al*., 2004).

Another important driver is advanced information technology, which can integrate business processes across the supply chain and provide real time information. IT applications with great functionality in terms of reach, modularity, generating automatic upgrading and data protection satisfy companies' requirements for data exchanging in the forms of design, plan, and reports across operational units (Yusuf *et al*., 2004). Although at the early stage IT only supported secure data transfer, it has been extended to support and facilitate supply chain integration (Russ and Camp, 1997). Furthermore, IT can also change the physical and organizational structure of companies through re-constructing its processes with suppliers and customers to survive in this new business environment (Auramo *et al*., 2005).

2.2 The role of IT in supply chain management

Supply chain management involves the control of both material flow and information flow among suppliers, manufacturers and customers (Levery, 2000) through the processes of information sharing, communications and transmission.

Furthermore, it enhances supply chain processes by virtually eliminating the barriers of individual organizations to achieve higher flexibility and responsiveness on market requirements (Sanders and Premus, 2002). IT applications automate many routine activities such as distribution processes to create value along the supply chain (Benjamin and Wigand, 1995). This may have significant implications for both an OEM and its suppliers along the supply chain.

According to Simchi-Levi *et al.* (2003), the objectives of IT in SCM are to enhance information availability, to provide 'a single point' to access data, and to facilitate collaboration among partners. Furthermore, Auramo *et al.* (2005) illustrate that IT supports the coordination across the supply chain through information sharing, and reduces transaction costs. A bulk of literature have addressed the benefits of IT on SCM ranging from direct operational benefits to the creation of strategic advantages (e.g. Auramo *et al.,* 2005; Bowersox and Daugherty, 1995; Malone et al., 1987). More specifically, Porter and Millar (1985) advocate that IT could change industry structure and rules of competition, and create competitive advantage and new business opportunities. Bowersox and Daugherty (1995) identify IT as a key element on creating strategic advantage. Levary (2000) illustrates several implications of IT on SCM such as product cycle time and inventories reductions, a minimization of the bullwhip effect, and

improvement in the effectiveness of distribution channels. Meanwhile, suppliers may provide better support and collaboration with an OEM due to the IT application (Goldman *et al*., 1995). Malone *et al.* (1987) identify three core values of IT on SCM including electronic communication, electronic brokerage and electronic integration. In particular, when agility is needed, IT is of particular importance (Sanders and Premus, 2002).

A popular belief is that IT can increase information processing capabilities, thereby enabling greater supply chain integration to leverage supply chain agility and to reduce uncertainty (Bowersox and Dougherty, 1995), and also overcome the complexity of the supply chain driving buyer-supplier relationship especially in the case of highly geographically dispersed suppliers (Gunasekaran and Ngai, 2004). On the other hand, this complexity of SCM drive enterprises to adopt online communication since Internet provides information richness and communication richness through intense interaction between firms and customer. For example, big US automakers have launched the automotive network exchange to further understand the impending effects of electronic business communities. Automotive network exchange will establish a platform to suppliers to communicate with and obtain information from auto manufacturers (Graham *et al.,* 2000).

3 Conceptual framework

So far we have showed the pivotal role of IT in managing supply chains, taking under consideration the increasing role of EDI and ERP systems in SCM (Gunasekaran and Ngai, 2004; Levary, 2000). We posit that IT can significantly enhance supply chain agility through customer sensitivity enhancement, network integration, process integration and virtual integration, as we believe that IT per se can not create value (Powell and Dent-Micallef, 1997). Furthermore, we argue that IT applications in SCM can be regarded as the technologies used for managing and controlling supply chain related data, activities and information exchange between organizations (Auramo *et al*., 2005). More specifically, IT applications include EDI, ERP, application service providers (ASP) and web portals (Auramo *et al*., 2005). Figure 1 illustrates our conceptual model on the impact of IT applications on supply chain agility

Figure 1

Customer sensitivity emphasizes customers and markets, including customer-focused logistics and rapid response. Supply chains are becoming demand-driven rather than forecast-driven in order to effectively respond in real-time demand. Firms have relied heavily on forecasting techniques to predict manufacturing and inventory based on historical data due to lack of direct feedback from market. However, with IT application development, supply chain partners can capture data

on demand, thus leading to customer-focused supply chains (Christopher, 2000).

For example, Cisco created an e-hub which connects the company with suppliers

through internet. It allows firms across the supply chain to simultaneously access

the same demand or supply data and exploit time-based competition (Christopher,

2005). Hence, IT can facilitate supplier, and in turn supply chain, responsiveness

(Lee and Billington, 1992). Accordingly, organisations further upstream, such as

second and third tier suppliers, will have access to similar customer data as

downstream organisations closer to the customer.

It was argued that firms gain competitive advantage through fast delivery

and product variety rather than price. Therefore, the effectiveness of supply chains

can be measured by its responsiveness (Lee and Billington, 1992). Through sharing

and transferring real time information among suppliers and customers, IT

encourages a fast response to market requirements. Thus we propose that,

P1a: IT has a positive impact on responding to changes in production

and services (market uncertainty).

P1b: IT has a positive impact on the responsiveness of processing

market demands on new products.

There is a growing recognition that individual companies need to operate in

networks where partners have close and committed partnerships and shared targets

to compete in today's highly competitive markets. Therefore, in order to sustain

competitive advantage, it is critical to leverage the strengths and competencies of partners to realize fast responsiveness to market requirements (Christopher, 2000), which is called network competition where prices will go to the organizations which can have better co-ordination with partners. For example, in the automotive industry, first tier suppliers are involved in the design of car components and at the same time, automotive companies help the manufacturing process and technology improvement of suppliers (Martinez and Perez, 2005). This can be interpreted as a company's dependability on its partners across the supply chain. Whether this applies equally to suppliers horizontally or vertically remains to be explored, albeit network concepts suggest it may (Lee, 2000).

Various literatures have concerned with the issue of the dependability among partners, such as the capability of suppliers (Lascelles and Dale, 1990) or the performance of suppliers in terms of speed and reliability of delivery (Narasimhan and Jayaram, 1998). This research regards dependability as coordinating with partners while focusing on their own competencies through network integration. Thus we propose that,

P2: IT increases the degree of dependability among partners in the supply chain.

Process integration is related to uncertainty across the supply chain, placing emphasis on self-management teams instead of standardization so that core

modules of products can be delegated within networks of agile competitors. Therefore, alliances among various suppliers, manufacturers and customers will be inevitable (Christopher and Towill, 2000), and it enables collaborative working methods such as joint product design. For example, Taiwan Semiconductor Manufacturing Company, the world's largest semiconductor corporation, gives suppliers proprietary tools and data of the product requirements so that they can execute changes accurately. Therefore, while focusing on their own competencies, companies are much more likely to increase product variety and improve the ability to handle orders with special customer requirements. Arrangements among suppliers may also appear, such as order or design sharing, particular to given production orders from an OEM or a supplier downstream the supply chain. Meanwhile, with the availability of real time demand data, it improves company volume flexibility - that is, increasing or reducing production based on demand. Flexibility is another important operational dimension which can improve the company's competitiveness (Martinez and Perez, 2005), and in the context of supply chain, it is a significant measure for supply chain performance (Vickery *et al*., 1999).Thus we propose that

> P3: IT improves product and volume flexibility along the supply chain.

Virtual integration emphasizes on leveraging people and information on operations along the supply chain. Supply chains can be structured around the flow of information to ensure that members within organisations along the supply chain are have access to relevant information (Tippins and Sohi, 2003) and facilitate the process of information gathering and dissemination. The latter are two important attributes towards organizational learning and associated organizational development. Given the complex and often dynamic nature of supply chain management, organisational learning has been presented as one key dimension of competitive supply chains (Hult *et al*., 2000). Furthermore, though the acquisition of information, and its associated dissemination and application, each member may access relevant information (Tippins and Sohi, 2003). Due to IT enhanced connectivity, individuals can share their own interpretations of information to make consensus-focused development more efficient. Meanwhile, shared information may encourage organizational learning among suppliers (Goldman *et al*., 1995). Thus we propose that,

> P4: IT positively impacts on information acquisition and
>
> information dissemination of organizational learning.

Through the application of IT in the supply chain agility process, many operational dimensions may be influenced or improved. The model in Figure 2 has been

developed based on the previous conceptual framework. It indicates the operations

impact of IT on agile capabilities of the supply chain.

Figure 2

Table 1 summarizes the definitions of latent constructs.

Table 1

4 Discussion and conclusion

The exponential increase of corporate investment on IT suggests a strong impact of

IT applications on reshaping and improving firm capabilities. However, it has been

recently argued that IT cannot create value in a vacuum, as illustrated by the

significant failure of IT firms to create sustained growth in high technology

markets (Powell and Dent-Micallef, 1997). In this paper, we investigate indirect

links of IT and corporate value creation. In doing so, we focus on supply chains,

and more specifically on supply chain agility. Our research is motivated by the

importance of IT on supply chain agility in complex manufacturing environments

such as the automotive industry. We develop a conceptual model to address the

theoretical gap of IT, supply chain agility and value creation. We show how IT can

affect certain operational drivers which impact on supply chain agility. These

drivers may vary depending on an organisations position in the chain, eg suppliers

at various horizontal or vertical stages.

This paper has several theoretical and practical implications. First, we extend the current literature of IT and supply chain agility by investigating the impact of IT and the possible ways of realizing value. Moreover, we highlight the role of IT as a platform for various integration processes in an agile supply chain and the direct link among IT application, agility and operational drivers and the consequential changing role of suppliers.

Second, we lay the theoretical ground for applying IT to achieve supply chain agility. Our framework indicates the way of realising value from IT applications in agile supply chains. Furthermore, we provide an integrated perspective of IT and supply chain agility and illustrate how to leverage IT applications along agile supply chains to improve its responsiveness, dependability and flexibility.

This research can be extended in a number of ways. First, there may be other mechanisms that IT impacts on the agility of a supply chain. The operational dimensions identified here is only a starting point rather than a complete recipe. Furthermore, supply chain management involves IT at various levels from operational to strategic, while we only are concerned with the operational level. As for application, with rapid technology change in information intensive industries,

the question may be how IT will change as a response to emergent technologies (White *et al*. 2005).

6 References

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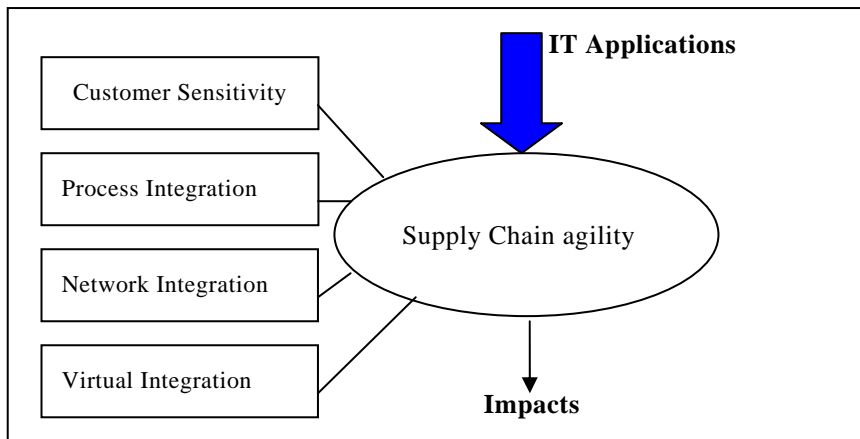
Figures:

Figure 1 Framework of the impact of IT application on supply chain agility
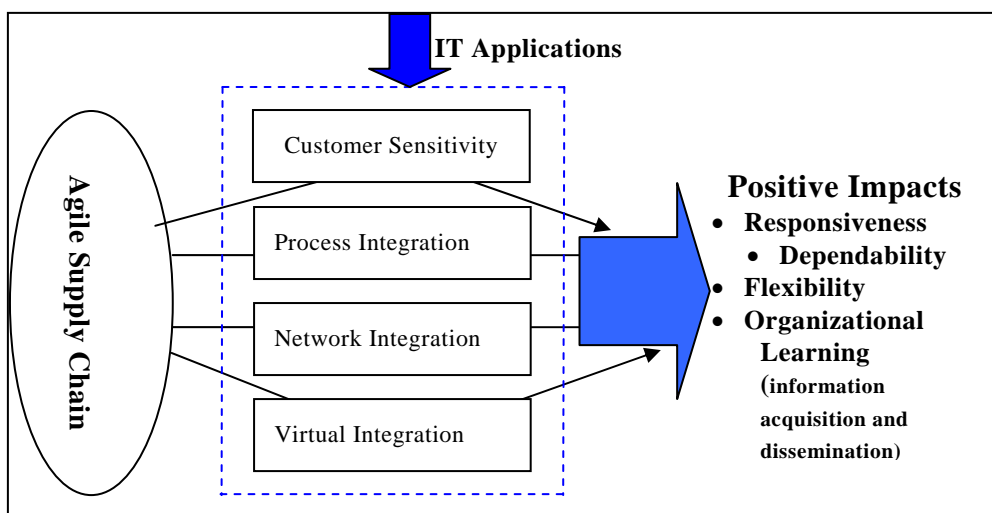

Figure 2 Revised framework of the impact of IT application on supply chain agility

Table:

Definitions	
Construct	Definition
IT application *Technology that can be used for managing and controlling supply chain related data, processes and information exchange*	

Supply Chain Agility *Using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile marketplace* (Naylor *et al.*, 1999), *including customer sensitivity, virtual integration, process integration and network integration* (van Hoek *et al.*, 2001)	
Customer sensitivity	Extent of understanding markets, customer enrichment and market response
Virtual Integration	Extant of leveraging information in supply chain context
Process Integration	Extent of mastering uncertainties to maximize immediate response
Network Integration	Cooperating to compete
Operation Impact	
Responsiveness	Responding to converting demands to products and changes in product and service offerings
Dependability	Extent of cooperating with the focus of core competencies
Flexibility	Product flexibility: *ability to handle difficult, non-standard orders to meet special customer requirements* (Vickery *et al.*, 1997) Volume Flexibility: *ability to adjust volume of products from peak demand and slack periods* (Sanders and Premus, 2002)
Organizational Learning	Information acquisition: *process of company seeking usable information* (Slater and Narver, 1995) Information dissemination: *extend to which information obtained by a firm is shared with its functional units* (Slater and Narver, 1995)

Table 1 Definitions of latent constructs