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Shaping Agility through information systems integration throughout the supply chain

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1 Introduction

The automotive industry acts as a flagship of the national economy and much has been written on the theory and practice of automotive supply chains. It has been recognized that the automotive industry is addressing the growing need for agility in this complex environment in order to react quickly and effectively to a changing market (Jin et al., 2005), and Information Systems (IS) are recognized as a competitive tool in achieving supply chain agility (Power et al., 2001; Yusuf et al., 2004). Supply chain agility has been realized through various integration processes, and it can be hampered by fragmented IS across supply chain (Barua et al., 2004) because information flow and the coordination of activities are essential for integration processes which are realized by integrated IS across functional unities and value network partners (Broadben et al., 1999). In particular, first tier suppliers are essential enablers as the complexity of supply chains and long lead time and their relations have made the transition to new methods more turbulence than before, consequently suppliers and Original Equipment Manufacturers (OEMs) are having concurrent pressures to market competition (Childhouse et al., 2003).

However, studies have focused on OEMs, with little research on how IS integration may affect supply chain agility from the viewpoint of first tier suppliers. We attempt to explore the following questions in the perspective of first tier suppliers:

1) What are the critical factors for IS integration?
2) What are the impacts of integrated IS in the context of supply chain?

As an exploratory study, a case study based methodology was used and data collected from twelve senior managers in first tier suppliers in Chinese automotive

industry employing open-ended questions. The study recognized the constraints of integrating IS in the context of achieving agile capabilities, the approaches of realizing agility and the operational consequence of IS integration.

The next section presents a review of the relevant literature on supply chain agility, and discusses the relationship of IS with Supply Chain Management (SCM), especially with agile capability, while section 3 proposes the conceptual framework and the relationships related to the framework. Then follows the description of the empirical study and discussion. The final section offers some concluding comments.

2 Literature review and the conceptual models

The concept of supply chain management is introduced and the reason for agility becoming an important issue within the field. Supply chain agility determinants are identified including the role of information systems integration in supporting operational performance. This leads to the development of a research framework showing the relationships between IS integration, supply chain agility and operational performance.

2.1 Supply chain agility

In today's markets, firms face stiff competition due to time-based competition and fast technology development. Sustainable competitiveness is focused on SCM (Swafford et al., 2007). SCM usually consists of individual functional entities with commitments to provide related resources and information to achieve the objectives of efficient management of suppliers as well as the flow of parts (Lau and Lee, 2000).

SCM has evolved from traditional command and control, vertical hierarchy based organization to one structured around process units (van Hoek et al., 2001). Traditional

vertical integration is replaced by horizontal integration, involving outsourcing and inter-firm integration. Meanwhile, organizations are moving to mass customization which combines standardization and customization within one supply chain, as well as minimizing waste through overall business processes. Therefore, agility is becoming important as it is all about 'customer responsiveness and mastering market turbulences' (van Hoek et al., 2001).

Supply chain agility can be seen as a measure of success of the relationships within a supply chain in the process of manufacturing, design, delivery and customer service (Yusuf et al., 2004), particularly responsiveness (Christopher and Towill, 2000). This leads to the adoption of Christopher's (2000) definition of supply chain agility 'as a business-wide capability that embraces organizational structures, information systems, logistics processes and in particular, mindset'. The origin of supply chain agility as a concept lies in flexible manufacturing systems (Aitken et al., 2002). Initially, manufacturing flexibility enabled rapid changes and consequently, a greater responsiveness to changes in product volume and variety. Agility stresses 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 it is recognized that supply chains need to encompass both (Christopher and Towill, 2000).

The literature suggests that there are four determinants of success for supply chain agility. These are customer sensitivity, process integration, network integration and virtual integration.

- Customer sensitivity focuses on developing co-operative relationships with customers

- Process integration focuses on core competences to change business processes
- Co-ordination with partners is the key issue in network integration
- Virtual integration is leveraging information across the supply chain (Christopher, 2000; Goldman et al., 1995; van Hoek, 2001).

These determinants are supported through organizational and supply chain design, information sharing among functional units (Crocitto and Youseeff, 2003), internet-based collaboration and networking with partners rather than marketing alliances (Yusuf et al., 2004). Among these factors, IS integration has been identified as a key enabler to supply chain agility (Breu et al., 2001; White et al., 2005).

2.2 IS integration

A common belief is that IS can increase information processing capabilities, thereby enabling greater supply chain integration to leverage supply chain agility and to reduce uncertainty (Ho et al., 2002). However, IS cannot per se create sustained performance or value (Powell and Dent-Micallef, 1997). Therefore, it is important for companies to integrate resources and embed them in their social and cultural context (Barua et al., 2004) to develop operations and workflow coordination (Rai et al., 2006). An integrated information system is more than just individual component integration. It requires the integration of communication, data and application (Muller et al., 2007; Ross, 2003) to enable consistent and real-time connectivity among function units across supply chains (Rai et al., 2006).

In this research, we adapt the definition of IS integration developed by Rai et al (2006), employing two aspects: data consistency and cross-functional SCM application system integration. Data consistency is ‘the degree to which common data definition and

consistency in stored data have been established across a focal firm's supply chain' (Rai et al., 2006). Cross-functional SCM application system integration is 'the degree of real time communication of a focal firm's function-specific SCM applications with each other' (Rai et al., 2006), such as planning applications, transaction applications and connectivity with ERP. Planning applications support planning for procurement, production, and logistics. Transaction applications realize the execution of order management, production management and distribution (Kalakota and Robinson, 1999).

2.3 IS impacts on supply chain agility

The literature indicates that IS integration can significantly enhance supply chain agility thus improving operational performance. Figure 1 presents our framework of the impact of IS integration on supply chain agility.

Figure 1 Research framework

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 planning and safety stock for inventory based on historical data due to lack of direct feedback from market. But IS integration within and among organizations enables them to capture data on demand, leading to customer-focused supply chains (Christopher, 2000). It has been 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 their responsiveness (Lee and Billington, 1992). Through sharing and transferring real time information among suppliers and customers, IS encourages a fast response to market requirements.

There is a growing recognition that companies need strategic partnerships with shared targets to compete in competitive markets. Therefore, to sustain competitive advantage it is critical to leverage the strengths and competencies of partners to realize fast responsiveness to market requirements (Christopher, 2000). 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 their manufacturing process and technology improvement (Martinez and Perez, 2005). Thus, dependability among partners, such as the performance of suppliers in terms of speed and reliability of delivery is key (Narasimhan and Jayaram, 1998).

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 process integration enables collaborative working methods such as joint product design. Furthermore, 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. Meanwhile, the availability of real time demand data improves company volume flexibility. Flexibility is another important operational dimension which can improve the company's competitiveness (Martinez and

Perez, 2005), and in the context of the supply chain, it is a significant measure of performance (Vickery et al., 1999).

Virtual integration emphasizes the leveraging of people and information along the supply chain, structured around the information flow to ensure that members along the supply chain have access to relevant information (Tippins and Sohi, 2003) and facilitate information gathering and dissemination, contributing to organizational learning (Tippins and Sohi, 2003). IS integration facilitate each member accessing to related information and share their interpretations to make consensus-focused development more efficient (Tippins and Sohi, 2003). Figure 2 demonstrates the operational impacts of IS integration on agile capabilities of the supply chain drawn from the discussion above.

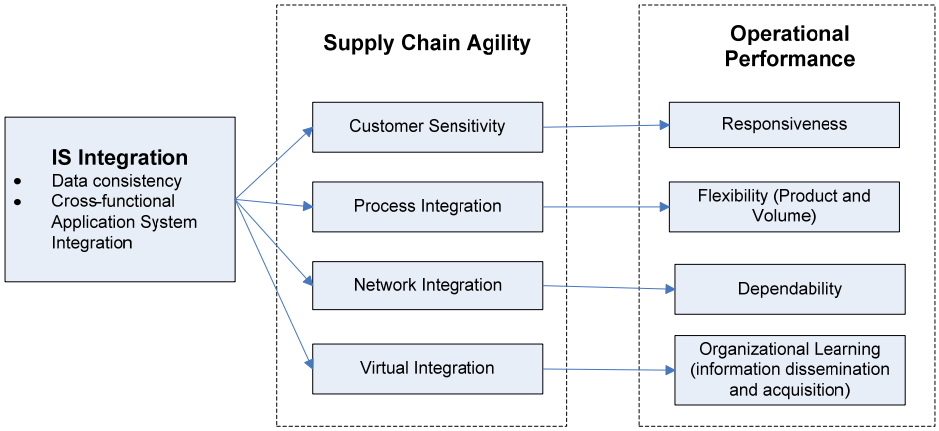

Figure 2 Research framework

3 Research methods

The research has been carried out through multiple case studies as they are useful when exploring new areas of research (Eisenhardt, 1989), particularly in information systems because they cope with technical situation with many variables of interests (Yin, 2003). Twelve semi-structured interviews were conducted to explore the issue related to IS integration and supply chain agility. Data was collected from senior managers in the

departments related to IS, procurement, manufacturing and logistics within four first tier suppliers, as procurement, manufacturing and logistics are identified as necessary basic functional activity in supply chains (Gunasekaran et al., 2008). First tier suppliers set up plant in each OEM's supplier park. Therefore, each plant only supplies auto-parts to one OEM. We visited all plants, as well as their Headquarters where the IS department is located.

Interviews were conducted with senior managers in the case of large organizations and general managers in SMEs. The interviews were taped under interviewees' permission and confidentiality if the participate firms was assured.

In order to minimize the bias of interpretation, the summary of the interview was written up and passed back to interviewees in order to justify and improve the accuracy of our understanding of each interview. Ten out of twelve feedbacks were received. Interviews were coded using Nvivo to identify the communication way with upstream suppliers and downstream OEMs, the approach to achieve agility and the operational impacts of IS integration in the context of supply chain agility. Following table presents the basic site background.

Site	Description
A	Joint venture, manufacturing harnesses for General Motor, Shanghai Volkswagen, providing daily sequence delivery. Has approximate 1500 employees with annual turnover RMB 680 million (£47.99 million).
B	Joint venture, manufacturing seating systems for KIA with sequence delivery every three hours. Has around 60 employees with annual turnover RMB 70 million (£4.94 million)
C	Joint venture, manufacturing plastic molded parts for KIA with

	sequence delivery every two hours. Has approximate 400 employees with annual turnover RMB 600 million (£42.33 million)
D	State-owned SME, manufacturing punching parts for Shanghai Volkswagen, with approximately 450 employees and annual turnover RMB 218 million (£15.31 million)

Table 1 Company background description

4 Results and discussion

4.1 Present IS integration practice

Communication among the departments

The research shows that company A and B have an integrated IS among departments and ERP (SAP) is considered as a backbone to the overall businesses, linked with function-specific applications in departments, especially related to manufacturing, procurements, logistics (raw materials and finished products). In plant B, financial department has been integrated into the system so that '*it is much easier and more convenient system of processing payment*', mentioned by senior managers in plant B. Plant C has fragmented systems in departments and information is shared or exchanged based on paper. It is difficult to integrate systems that are applied in departments as they were lunched at different stages, with various designs and programming. It did not implement ERP yet. Company D implemented MRP to integrate the procurement, manufacturing execution scheduling and inventory management (finished products).

The systems in the plants of A, B and C were developed by IT departments based in their headquarters, basically using company's templates which are the standard function-specific applications. In these plants, all employees are trained to apply IS and

the plants normally only employ one IT professional to maintain systems and some plants can only get support from the IS department of the Headquarters.

Communication with OEMs

All plants we visited have access to web portals provided by OEMs to gain general information, such as long term planning (by year), short term planning (by quarter), notices, and online bidding for new project. '*Currently it is rare that suppliers take initiatives to integrate with OEMs….OEMs are still focal firms in supply chains. Suppliers often receive one-way information about OEM forecast, manufacturing and daily manufacturing execution data, but no feedback is send back to OEM digitally. Instead, the feedback is carried out through the face to face discussions among co-coordinators from companies*' (IT senior manager of company A). No direct communication was established between first tier suppliers and the end-users.

As for the plants with sequence delivery, in this study, plant A, B and C receive daily manufacturing data from Shanghai Volkswagen and KIA to transfer the data of product sequence for delivery. The technology is provided by OEMs, and first tier suppliers only receive the data, and there is only one-way communication.

Communication with suppliers

Second tier suppliers are divided according to plant location, with Web EDI or portal use is adopted for contact with overseas suppliers, while email, fax and telephone are the main approaches to contact domestic suppliers. With the increasing of the domestic content rate (Thru, 2006), electronic means are the common approaches to communicate with second tier suppliers. Generally, the use of IS for communication with suppliers and OEMs is limited, as presented in Figure 3.

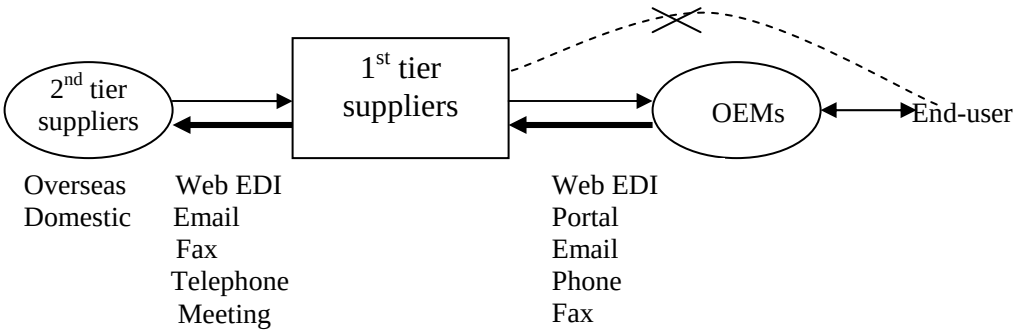

Figure 3 Communications with upstream/downstream

4.2 Critical factors of IS integration

All interviewees agreed that data consistency is the basic requirement for information flow across the departments, and with other partners. Specifically, common data definition was set up between OEMs and first tier suppliers, such as car models, and between first and second tier suppliers, such as auto parts.

The study shows that the cross-functional application systems integration did not take place as the literature suggests. Instead portals and web EDI are commonly used to link partners. Another factor that emerged from the interviews is data accuracy, which is considered as the correct and accurate data input within and across organizations. '*The first step is to make sure that your data is accurate….we are actually experiencing that problem with one of our plants in India right now. They did not keep their eye on the data using the system. Eventually the system literally died, and they were running the business on Excel spreadsheets…The biggest challenge in the organization facing with the information systems is keeping their data clean and keeping their people trained and letting them understand the importance of good data*' (General manager from company A).

Cost is still a main concern in the process of integrating IS from the interviews, as many HQs concern how much they should invest for IS and how much benefits they can

gain. ‘We planned to build a portal to communicate with our suppliers, After consulting the third party provider, it is really expensive, and we started thinking whether it is necessary to implement one’ (General manager from company D).

4.3 Achieving supply chain agility

Customer sensitivity

Companies are seeking to enrich their customers by having the customer-oriented business processes, such as collaborative product design, just in time (JIT) delivery and build to order (BTO) manufacturing, assigning coordinators at the OEM shop floor. Many organizations have intention to implement BTO to fast respond to customers.

The interviews indicate that suppliers still have to respond to volatile OEM schedules changed at the last minutes and with relatively little adherence to the original plans, which also discussed by Harrison (1997). This leads to problems for BTO, ‘if operations are executed only based on BTO, without order confirmation, the production line will cease. The worst scenario is to stop the production line, partially because of the cost issue’ (Senior manager from plant B). Hence plants put weight on build to forecast.

IS integration plays a dominant role in these processes to satisfy the customers, to realize ‘the right product, the right place, the right quantity with the right sequence’. In a manufacturing environment, plants are connected with the customer requirements through sales systems as well as other systems to understand what customers’ changes are, what their expected product design. Integrated IS helps to gather and analyze available information on existing and potential customers to plan more effectively through synchronizing data across supply chains. The OEM’s role is critical in supply chains because their forecast or manufacturing long/short time planning influences

suppliers. JIT delivery is supported by the extensive use of information and communication technology which is made for intra-company data transfer so as to minimize the inventory management of OEMs, and fast responsiveness to customers.

Process integration

The literatures define process integration as the extent of mastering uncertainties to maximize immediate responses (Christopher, 2005; van Hoek et al., 2001). The interviews suggest two perspectives of reacting to uncertainties and changes, which are organization changes and products changes.

Interviewees gave examples of their reactions to change. Because KIA had the second shop floor for assembling vehicles, plant C have to double their manufacturing capacity, and the analysis has been carried out for approximately two years in terms of manpower, inbound/outbound logistics, machine and space. It has been driven by organizational maturity, which is the organizational structure having been in place for many years, and being well defined with very efficient processes. This leads to the introduction of a new aspect of the research. However, the interviewees disagree that IS integration facilitates process integration, such as the changes of organizational structure. In particular, Chinese market is still immature, only ten to twenty year's development, so it changes rapidly. Firms can not purely rely on systems to react to changes due to its rigid design and incapability to deal with uncertainty (Ketikidis et al., 2008). '*When we spited into two plants, the most difficult part is to separate our IS and we spend a lot of time and put efforts on IS separation in procurement, logistics, manufacturing as well as finance*' (Senior manager from plant A). IS integration is not a pre-requisite in mastering changes at the organizational level and may prohibit processes.

For some interviewees, IS integration has a positive impact on reacting quickly to changes due to real time information communication, as well as well coordinated activities. On the other hand, some interviewees disagree as IS integration may prohibit the changes which are made within a short notice. '*I do not think IS should involve too much in mastering uncertainties. For example, when customer changes their orders, it indicates that all our processes will be different starting from BOMs. However, within such a short notice, we can not do anything in our systems…customers will not just wait there until you can re-schedule the processes weeks later*'.

The inconsistent results suggest that a 'productivity paradox' exits, as discussed by Lim et al. (2004) and Sanders (2007). The possible reason to the difference might be organization flexibility, which has influence on IS design and integration. '*If you have developed the systems for almost one piece flow, we can respond very quickly…if you develop your system to build the same part in very large bathes, you will not have that flexibility*' (General manager from company A).

Network integration

Network integration is about the collaboration with suppliers to improve competitiveness. All interviewees agreed that suppliers are important in gaining their competitive advantages. Four ways of coordination were intensively discussed during interviews:

- Training suppliers to let them know the expectations
- Sending experts, working with them on site
- Meeting with suppliers to discuss current problems and the layout
- Outsourcing product design

'*Our suppliers usually try their best to meet our requirements; however, some of them being smaller suppliers, they may not have the resources or capital available to invest*' (General manager from company A).

There have been various studies on supply chains in terms of the relationship among partners (Frohlich and Westbrook, 2001; Sanders, 2007). In today's manufacturing environment, having partner collaboration is critical for success, enabling real time information to travel immediately up and down the supply chain and well coordinated inventory management (Sanders, 2007). However, the research shows the differences- there has been no IS integration between first to second tier suppliers. One reason is that automotive industry is mainly cost-driven, with vehicles depreciating annually (Senior manager from plant B). As a consequence, more and more local suppliers are chosen which increase the local content rate (Thru, 2006). The other reason is that the current business does not require highly integrated IS for companies to communicate with their suppliers. As the senior manager of plant C expressed, '*Currently we only deal with 400-500 types of raw materials, and we are comfortable of using email or fax to contact our suppliers. In fact, we only have 15 approximately suppliers which are located in a very short distances. Our business does not require IS integration with our suppliers*'.

But despite the lack of advanced IS integration with suppliers, the interviewees still discussed the benefits of applying IS and integrating the plants, stating it improves the traceability or ownership of finished product by keeping the record of product serial number, manufacturing time, the employee number, and raw materials' serial number.

With the capability of being traceable, the following result will be the quality improvement.

Virtual integration

Virtual integration focuses on the leveraging the information within the organization. Therefore, integrating systems are becoming necessary to leverage the information. '*It should link all systems effectively in our plant to realize the management IS. I mean we have SAP, and we should really integrate with our manufacturing management, human resource as well as the systems which is for statistical analysis of machine efficiency, together with the system for profits calculation*' (Senior manager of plant A). Hence, data accuracy and consistency are necessary, and data parameters can also be populated within systems to audit data whether they are incorrect or not complete. Information can be accessed easier in integrated systems rather than fragment ones; consequently, it facilitates information acquisition. Furthermore, '*one thing we do is for when you are tracking the profitability of the business, you can very quickly identify which program are profitable, which are not profitable, which might have too much labor cost*' (Senior manager from plant C).

Currently firms are operating in connected links but not viewing them as a holistic chain. The relationship in the participating companies tend to be based on cost-reduction, even through they intend to build the relationship on value-adding. However, with continuous effort on SCM and on implementing IS, partners are beginning to benefit from IS integration in terms of operational performance compared to the time without integrating IS.

Interviewees brought forward the issue of lack of information. At one hand, there is no direct link between first tier suppliers and end users. Suppliers can only get the historical sales data from OEMs, which does not help much on their forecast considering the rapid market change. On the other hand, there is lack of information from second tier suppliers related to delivery, order confirmation and manufacturing status. Hence, information visibility is lacking at the business front end (demand side) and back end (supply side). First tier supplier management has to work harder to deal with these issues (Childhouse et al., 2003). The findings and discussion lead to the development of a revised framework (Figure 4).

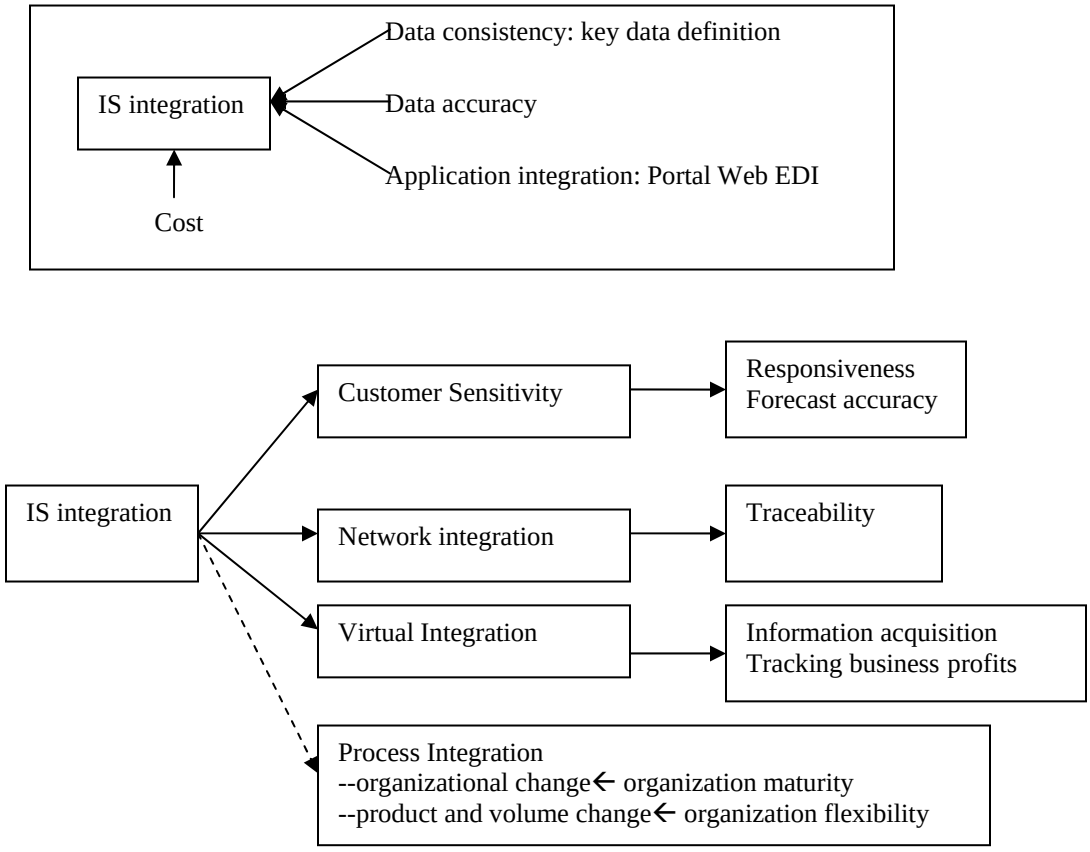

Figure 4 A revised framework

5 Conclusions

In this paper, we investigated indirect links of IS integration and corporate value creation. In doing so, we focused on supply chain agility. Our research is motivated by the importance of IS on supply chain agility in complex manufacturing environments such as Chinese automotive industry, especially from the viewpoint of first tier suppliers. We developed a conceptual model to address the theoretical gap of IS, supply chain agility. The empirical research demonstrated the operational performances that IS integration impact on various integration processes. Although there is a great improvement of information visibility across supply chains, we can still see the pains of suppliers from interviews. Certain levels of data are treated as business secrets for example real time front-end data (demands from car dealers) can not be accessed by suppliers. Hence, transparency of information is still lacking, compounding further inherent upstream problems (Childerhouse et al., 2003). Suppliers expressed that IS integration really helps to obtain data, but they hope, they can get the real time front-end data with further integration, including demand and supply side so that they can have a better product plan and cooperation with regarding to product delivery, inventory management and so on.

The empirical research enhances existing evidence on the impact of IS integration on supply chain agility. The study also recognized that the constraints of achieving operational performances from various integration processes through integrating IS, such as business requirements, cost issue, and organization flexibility. We also provides an in-depth understanding of Chinese automotive industry first tier suppliers in the IS integration and the way of integration various processes and the way to maximize the benefits from IS integration in Chinese business.

Further investigation needs to validate the revised model, along with the emerging concepts pertaining to customer sensitivity, process integration, network integration and virtual integration in achieving agile capabilities of supply chains. As IS plays an increasingly important role in enabling the operations of business, developing such understanding at a theoretical level is critical. In addition, the research only focuses on fist tier suppliers. Therefore, the model and should also be tests on other positions of supply chains.

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