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Information Sharing in Convergent Assembly Supply Chains

Chin-Fu Ho
National Sun Yat-sen University

Yen-Ping Chi
National Cheng Chi University

Yi-Ming Tai
National Cheng Chi University

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Chin-Fu Ho
Department of Information Management, National Sun Yat-Sen University
cfho@mis.nsysu.edu.tw

Yen-Ping Chi
Department of Information Management, National Cheng Chi University
ypchi@mis.nccu.edu.tw

Yi-Ming Tai
Department of Information Management, National Cheng Chi University
ymtai@mis.nccu.edu.tw

Abstract

Implementing information sharing can help supply chain to deal with uncertainty, which lies behind interactions between supply chain participants. The research results suggested that there are three categories must be considered in implementing information sharing in convergent assembly supply chain. The first mandate is associated with planning the mechanism of inter-organizational coordination between factory and channel for coping with demand variation, which includes the channel provides guiding services to the customer as to the selection of equipment combination and the factory transfer the information regarding the assembly of detailed equipment to the channel. The second in line is related to planning inter-organizational coordination between factory and supplier for managing material supply, which includes supplier involvement in new product development and delivery method. The third is the implementation of information sharing based on the mechanism of inter-organizational coordination between supply chain participants. Resolving issues in these three categories are helpful in the execution of SCM, contributing to integrating of supply chain resources and eventually improving the overall supply chain performance.

Keywords: Supply chain management, Information sharing, Inter-organizational coordination

1. Introduction

The thinking of supply chain management (SCM) is the modern paradigm to improve competitiveness through coordination among different companies. SCM expands the scope of the organization being managed beyond the enterprise level to include inter-organizational relationships. On the strength of coordination between suppliers, manufacturers, and distributors, the method of SCM allows the company to achieve the advanced state that the individual company under the resources limitation cannot research. Recent developments in information technology (IT) have helped fuel this trend. Using IT, companies in a supply chain can be connected in real time through continuously shared information and knowledge; relationships among members can be easily maintained, and coordination among partners can be consolidated further (Kauffman and Walden, 2001; Subramaniam and Shaw, 2002; Swaminathan and Tayur, 2003). Although IT is helpful for supply chain to achieve the efficient state of coordination and the resource integration among partners, managing supply chains effectively is harder than the single organization, due to the complexity of partnerships (Davis, 1993; Lee and Billington, 1993; Fisher, 1997; Lee, 2002). The major reason of such difficulty is because that SCM often involves complicated industrial characteristics and interwoven business relationship among supply chain participants. Hence, implementing SCM must consider potential disaster brought by various types of uncertainty embedded in the domain of supply chain (Cooper et al., 1997; Fisher, 1997; Strader et al., 1998; Vickery et al., 1999; Lamming et al., 2000).

Recent research in SCM has studied for supply chain design, supply chain operation, supply chain strategy planning, SC performance measuring, supply chain management model and information sharing in supply chains (Davis, 1993; Cooper et al., 1997; Fisher, 1997; Strader et al., 1998; David et al., 2001). The major problem of supply chain operation proposed in these studies is related to uncertainty and information sharing. For the information management issues of supply chain, most research has concentrated on identifying the information requirements for decision making in the single supply chain node, and the relationship between such information support and supply chain performance. Although these researches have noted that information sharing is an importance solution to deal with uncertainty, they ignored that the diversity of supply chain operating structures leads to different uncertainty issues, and such difference might call for a calibrated design of information sharing scheme. In light of the domain dependent nature of supply chain uncertainty, this research attempts to address the mechanism of SCM and associated information sharing scheme to reduce the impact of uncertainty in convergent assembly supply chain.

The term of convergent assembly is applied to these supply chains because their structure converges from relatively huge number of suppliers to a narrow range of assembles. The features of such supply chain are performing convergent assembly, early product differentiation, multitudinous materials, numerous suppliers, few product models and an assembly process concentrating at the manufacturing stages (Lin and Shaw, 1998). It is important to study these supply chains because they are seen in a number of industries, including many types of vehicle firms, and involve manifold materials, a large range of supply sources, early differentiation of product models, and a primary objective is lean production.

For studying information sharing in convergent assembly supply chain, the remainder of the paper is divided into four sections. Section 2 reviews two streams of literature with one focusing on the factors of supply chain uncertainty and the other describing the important issues of supply chain management. In Section 3, this study describes the research method employed in this paper to investigate the information sharing in convergent assembly supply chain. Section 4 includes two parts. In first part, this study explores uncertainty problems that influence the operation of convergent assembly supply chain and probes into the sources of uncertainty by looking into the real cases of convergent assembly supply chain. In second part, this study investigates how to plan the mechanism of supply chain management and associated information sharing to reduce the interference of uncertainty. The findings will lead to an integrated model of supply chain management mechanism and information sharing. Concluding remarks are given in Section 5.

2. Theoretical Foundations

2.1 Supply chain uncertainty

The supply chain spans the value delivery cycles of the manufacturer, its suppliers, and its downstream channel members. This value-adding process is complex because it is composed of several activities, executed by different functional entities, and heavily interdependent among the tasks and resources involved in the process. The real problem of such a confusing network is the uncertainty that plagues it (Davis, 1993). Previous research has contributed significantly to understanding the issue of uncertainty, identifying many of its sources. In light of the complexity of the interactions among upstream and downstream companies in the order fulfillment process, Davis (1993) suggested that demand uncertainty, manufacturing uncertainty and supply uncertainty were the main sources that plague the management of order fulfillment. To understand fully the impact on order fulfillment process and to be able to improve performance, this study addressed supply chain uncertain problem.

The variation in customer demand is one source of supply chain uncertainty. Forecasting errors may follow from the irregularity of customer orders in terms of time and quantity, or changes of consumer preferences (Davis, 1993). Demand uncertainty involves unknowns associated with product characteristics or environmental factors, and causes difficulties in predicting and controlling the demand for a final product. Fisher (1997) thought that the critical point in analyzing demand uncertainty is to consider the nature of the demand for the products that one's company supplies. Many aspects are important, such as rate of new product introduction (Davis, 1993; Chopra and Meindl, 2001), product life cycle (Miller and Droge, 1986; Fisher, 1997; Vickery et al., 1999), product variety (Fisher, 1997; Chopra and Meindl, 2001), lead time from design to production (Davis, 1993; Fisher, 1997; Chopra and Meindl, 2001), variation of marketing product mix (Lee and Billigton, 1993), number of sales channels(Chopra and Meindl, 2001), accuracy of demand forecast (Whybark and Williams, 1976; Davis, 1993; Fisher, 1997), and predictability of product demand (Davis, 1993; Gerwin, 1993; Fisher, 1997; Vickery et al., 1999; Chopra and Meindl, 2001).

Failure to deliver according to the customers' demands is another source of supply chain uncertainty. Such failure may be caused by a malfunctioning production process at the supplier, late delivery due to unexpected weather conditions, or unacceptable quality of the delivered products (Davis, 1993). Davis (1993) proposed that supply uncertainty is related to unpredictable and uncontrollable factors in material supply. For the problems, Malone et al. (1987) thought that the characteristic of purchasing process was also the influence for the degree of supply uncertainty. Many aspects are important, such as frequency of replacement of critical material supplier (Duncan, 1972; Ellram, 2002), complexity of critical material (Malone et al., 1987; Van der Vaart et al., 1996; Lau et al., 1999), complexity of procurement technology for critical material (Reve and Johansen, 1982; Novack and Simco, 1991; Subramaniam and Shaw, 2002), time specificity of material procurement (Malone et al., 1987; Subramaniam and Shaw, 2002), delivery frequency of critical material (Reve and Johansen, 1982; Novack and Simco, 1991), delay of critical material delivery (Davis, 1993; Dickson, 1996; Zhu and Soh, 1999), and fluctuation in selling price of critical material (Dickson, 1996).

Problems with the manufacturing process are another source of supply chain uncertainty. They may be caused by a production standstill due to a machine breakdown, process disorder due to a computer crash, or a production bottleneck because of improper workflow design (Davis, 1993). Manufacturing uncertainty is related to unpredictable and uncontrollable factors in the manufacturing process. Davis (1993) proposed that the variance of manufacturing lead time was the major source of manufacturing uncertainty. Engineering redesign was also the influence for manufacturing uncertainty. For the problems come from these situations, Duncan (1972) thought that ability of production was one of the factors. Miller and Dorge (1986) argued that the change of producing technology might cause uncertainty. Li et al. (1993) suggested that machine breakdowns, emergency order, problem of producing quality, error of processing time, order cancellation, and change of delivery time were the source of problem. Calinescu et al. (1998) thought that structure of product, structure of shop or plant, function of schedule, information flow, and change of environment were the influence of uncertainty.

2.2 Important issues of supply chain management

Supply chain structure is strongly dependent on the managements' ability to create the necessary inter-organizational relations (Lambert et al., 1996; Barut et al., 2002; Kotzab et al., 2003). This also means that the supply chain participants must agree on which business processes to coordinate and consequently, which information categories should be shared between the actors. It is extremely difficult to overcome in real world supply chain integration with many supply chain participants, since each company has its own strategy and participate in many supply chains. The formulation of inter-organizational coordination and the establishment of information sharing mechanism are the important issues in supply chain management (Cooper and Ellram, 1993; Lee and Whang, 2000; Chopra and Meindl, 2000; David et al., 2000).

SCM is the integration of key business processes among the network of interdependent companies in order to improve the flow of goods, services, and information from original suppliers to final customers (Cooper et al., 1997; Lamming et al., 2000; Chopra and Meindl, 2001; David et al., 2001). Successful SCM can result in lower system inventories, the network of firms that responds more quickly to market changes, and products that more closely match customer expectations. To accomplish this, tightly integrated supply chain is critical and the activities of inter-organizational coordination (IOC) play an important role in the development of SCM strategies for achieving the goal of quick response to customer requirement (Lee, 2000; Zeng and Pathak, 2003).

Quick response, a time-based competitive strategy, involves the development of a holistic approach to managing the supply chain partners for high performance in order to gain competitive advantage in the consumer market. One of the key concerns for companies that want to achieve the purpose of quick response in their supply chain is the development of a structure that facilitates inter-organization integration, superior levels of coordination and the synchronization of the activities of the chains. For designing and managing a tightly coordinated supply chain, the literature suggests that there are two interrelated forms of integration need to be considered (Cooper et al., 1997; Trent and Monczka, 1999; Handfield and Nichols, 1999; Perry et al., 1999). The first type of integration involves coordinating and integrating the upstream and downstream flows of products. The other prevalent type of integration involves the coordination of information among partners.

Many factors influence the performance of a supply chain. The most important factor is uncertainties happened in the processes of IOC. The reason for uncertainties is that perfect information about the system cannot be secured. While every single member has perfect information about itself, uncertainties arise due to a lack of perfect information about other members. To reduce uncertainties, the supply chain member should obtain more information about other members. If the members are willing to share information, each of them will have more information about others. Therefore, the whole system's performance will be improved because each member can gain improvement from information sharing. This cooperation mode for increasing information sharing among supply chain members can reduce bullwhip effect on a supply chain, because it can help the supply chain members share more information to reduce uncertainties (Fisher, 1997; Lee, 2002).

Recently, there are many applications of information technologies developed to support information sharing among supply chain partners. Such as for lowering the total inventory level in the supply chain, Continuous Replenishment Programs (CRP) and Vendor-Managed Inventory (VMI) were employed by two neighboring partners in supply chain to support inventory information sharing. In a typical CRP relationship, the buyer shares his inventory data with vendor and asks the vendor to manage his inventory within guidelines. VMI system let the manufacturer maintain the retailer's inventory levels. The manufacturer has access to the retailer's inventory data and is responsible for generating purchase orders. Moreover, for eliminating the bullwhip effect and avoiding independent multiple forecasts, Collaborative Planning, Forecasting, and Replenishment (CPFR) was employed to support sales and sales forecast information.

2.3 Summary of uncertainty factors

In accordance with the previous literatures of supply chain uncertainties and supply chain management, this study thought that analyzing the uncertainties generate inefficiency in the supply chain and making strategies stand on the characteristics of supply chain structure are important to SCM. Therefore, this study proposed three supply chain uncertainty dimensions including demand, supply and manufacturing, and summarized critical issues for the mechanism of supply chain management based on this framework in Table 1.

Table 1 Analyzing framework of supply chain uncertainty

Dimension	Critical Issue	Critical Factor
(A) Demand uncertainty	(A1)Channel characteristics	heterogeneity of channel; number of sales channels; frequency of channel replacement (Chopra and Meindl, 2001)
	(A2)Product characteristics	rate of new product introduction (Davis, 1993; Chopra and Meindl, 2001); product life cycle (Gerwin, 1993; Fisher, 1997); product variety (Fisher, 1997; Chopra and Meindl, 2001)

	(A3)Demand forecast	predictability of product demand (Lee and Billigton, 1992; Davis, 1993; Gerwin, 1993; Fisher, 1997; Chopra and Meindl, 2001); sharing demand forecast with the customer (Fisher, 1997; Lin and Shaw, 1998)
	(A4)Demand change	frequency of order expedition (Li et al., 1993; Zhu and Soh, 1999); frequency of change in order content (Li et al., 1993; Zhu and Soh, 1999)
(B) Supply uncertainty	(B1)Material supply	delay of critical material delivery (Davis, 1993; Zhu and Soh, 1999); stability of quality of critical material (Lee and Billigton, 1992; Davis, 1993); variance of material supply lead time (Whybark and Williams, 1976)
	(B2)Procurement structuralization	complexity of procurement technology for critical material (Malone et al., 1987; Lau et al., 1999; Subramaniam and Shaw, 2002); time specificity in material procurement (Reve and Johansen, 1982; Kotteaku et al., 1995; Subramaniam and Shaw, 2002); complexity of critical material (Malone et al., 1987; Subramaniam and Shaw, 2002)
	(B3)Supplier relationship	number of critical material suppliers (Duncan, 1972); requency of replacement of critical material supplier (Duncan, 1972)
	(B4)Procurement planning	degree of impact imposed by on-time delivery (Davis, 1993; Dickson, 1996; Zhu and Soh, 1999); delivery frequency of critical material (Reve and Johansen, 1982; Novack and Simco, 1991)
(C) Manufacturing uncertainty	(C1)Product complexity	degree of a product decomposable to simpler components (Calinescu et al., 1998; Khurana, 1999); degree of modularization of the product (Calinescu et al., 1998; Khurana, 1999)
	(C2)Process complexity	impact of pre-process output on post-process performance (Khurana, 1999); impact of change in pre-process on post-process (Khurana, 1999)
	(C3)Engineering change	number of items changed per redesign (Gerwin, 1993; Calinescu et al., 1998; Zhu and Soh, 1999); frequency of redesigns (Gerwin, 1993; Calinescu et al., 1998; Zhu and Soh, 1999)

3. Research Method

3.1 Research framework

Due to the complexity of supply chain structure, it is important to plan the mechanism of supply chain management and information sharing to deal with uncertain problems embedded in the interactions between supply chain partners. Hence, focusing only on single process or partial construct of the environment will be not adequate to address the problems of supply chains. In addition, the characteristics of supply chains will also affect the nature of supply chain uncertainty and the proposed solution mechanism for the supply chain. Hence, this study analyzes uncertainty problems in demand, supply, and manufacturing processes to investigate methods of supply chain management and information sharing for convergent assembly supply chain.

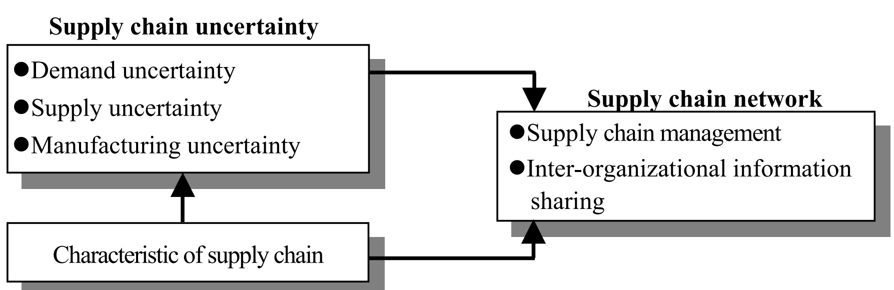

Figure 1 Research Framework

The research framework shown in Fig. 1 addressed three important issues in this study, including supply chain uncertainty, characteristic of supply chain, and innovation in supply chain network to improve its efficiency and efficacy. Based on this research framework, the study adopted a case study approach to investigate how the enterprise in convergent assembly supply chain can address the impact of uncertainty through managerial approaches towards supply chains and implementation of information technology.

3.2 Case study method

Currently, researches on information sharing of supply chain remains in its infancy. Both mature theory development and support from empirical studies continue to be required. The analogy of falling short of theoretical support can also be applied to Taiwan, since there are few cases of SCM and subsequent information sharing that have been practiced successfully. Moreover, given the consideration that analyzing supply chain uncertainty requires a large set of variables to address related problems. This study employed the case study approach to explore the usage of information sharing to reduce supply chain uncertainty.

This study conducted the investigation at two levels: (1) the automaker (demand, supply, and manufacturing uncertainty); (2) the supplier (supply uncertainty). Notice that the automaker has control over the channel of its products; hence, it inevitably has to face the uncertainty from the automobile market. While an embedded design is complex, it provides greater richness and multiple perspectives in explaining behavior. The framework proposed by Eisenhardt (1989) for building theory from case research has been adopted as a basis for organizing the design of the research.

In case selection, this study adopted the classification of Lin and Shaw (1998). Lin and Shaw (1998) suggested that the supply chain network in the automobile and aerospace industries could be classified as the type of convergent assembly supply chain. According to this suggestion, the subject of this case research is Taiwanese automobile industry. Since the management emphasis of convergent assembly supply chain is often placed upon reduction of inventory cost, close integration between upstream and downstream companies is important. Therefore, how to integrate numerous supply chain partners to reduce overall supply chain risk in inventory cost is their major concern. In view of the generalizing capability of case research methodology, two automotive supply chains were selected; each consists of an automaker and two suppliers of automotive material.

4. Case Discussion and Analysis

4.1 Introduction and discussion of the case study

Automobile manufacturing is a synthetic industry with intensive capital and precision technology. With longer product development time and numerous components, lean production and close industrial relationship are the major characteristics of automotive industry. In the Taiwan automotive industry, the manufacturers have their own foreign technical supporters, and their products, on the other hand, are focused in domestic market. The component suppliers have about 30% products for export and 70% for local market. The supplier plays an important position during the whole production process. A large part of the cost of designing, engineering and manufacturing a car is shifted to the suppliers. In this way, the integration between the automakers and the suppliers has become seamless for data, information and knowledge. Integrated analysis for the case of this study is listed as bellow.

(1) China Motor Corporation (CMC)

A1: For managerial efficiency of channel, CMC reduced number of sales channel and maintained the joint venture relation with dealers.

A2: Product life cycle of business van is longer and product variety is smaller. Product life cycle of sedan is shorter and product variety is larger.

A3: The demand pattern for most products can be predicted, but the forecast of equipment combination for demand in sedan is difficult. Based on the sales data, finished products inventory, and sales goal, CMC makes the production plan for the next six months, but the revision of plan is often required.

A4: The frequency of change in order content is lower.
B1: Since CMC requires that the supplier must pass the quality certification of ISO9000 and QS9000, most of material quality can fit the requirement of the company.
B2: Since the number of critical material is large and each has its own particular specifics, the procurement for them is a complex task and requires a lot of manpower to handle the work. To match the work sequence in the manufacturing process, components with low commonality often have time specification set for their delivery.
B3: Since the material is numerous and most of them purchased from the different supplier, the number of supplier is huge. The frequency of replacing critical material supplier is lower.
B4: A sequential delivery method is developed for receiving components with low commonality. This method calls for just-in-time and frequent delivery from suppliers.
C1: The product can be decomposed to simpler components. Automobile manufacturing requires numerous components and each has its own standardized specifics.
C2: Since the product differentiation happens in the early stage of production and the automobile manufacturing process cannot be rebuilt, it is difficult for CMC in dealing with customer demand for the diversification of equipment combination.
C3: For maintaining competitiveness in the market, the style of sedan is frequently modified, and this always leads to engineering redesign in a series of activities from product design to after-sales support.
(2) Ford Lio-Ho Motor Corporation (FMC)
A1: For managerial efficiency of channel, FMC reduced number of sales channel and maintained the agent relation with dealers.
A2: Product life cycle of business van is longer and product variety is smaller. Product life cycle of sedan is shorter and product variety is larger.
A3: The demand pattern for the most products can be predicted, but the forecast of equipment combination for demand in sedan is difficult. After discussing with deals, the department of sales proposes the next month estimating production. Based on this estimate, FMC makes the production plan for the next months, but the revision of plan is often required.
A4: The frequency of change in order content is lower.
B1: Since FMC requires that the supplier must pass the quality certification of QS9000 and Ford Q1, most of material quality can fit the requirement of the company.
B2: Since the number of critical material is large and each has its own particular specifics, the procurement for them is a complex task and requires a lot of work force to handle the work. To match the work sequence in the manufacturing process, components with low commonality often have time specification set for their delivery.
B3: Since the material is numerous and most of them purchased from the different supplier, the number of supplier is huge. Each critical material is only supplied by one supplier, and the frequency of replacing critical material supplier is lower.
B4: A sequential delivery method is developed for receiving components with low commonality. This method calls for just-in-time and frequent delivery from suppliers.
C1: The product can be decomposed to simpler components. Automobile manufacturing requires numerous components and each has its own standardized specifics.
C2: Since the product differentiation happens in the early stage of production and the automobile manufacturing process cannot be rebuilt, it is difficult for FMC in dealing with customer demand for the diversification of equipment combination.
C3: For maintaining competitiveness in the market, the style of sedan is frequently modified, and this always leads to engineering redesign in a series of activities from product design to after-sales support.
(3) Ta-Yih Industrial Corporation (TIC)
A1: TIC provides lamps and electroplating molds for automobile, motorcycle, and airplane.

A2: The lamp is the component of low commonality in automobile. The product life cycle depends on the product of the automaker. In light of the comparability with the product of the automaker, new product development requires close collaboration with the automaker.
A3: Although automakers share information in demand forecast with TIC, the forecast is often inconsistent with the final order.
A4: Since the automaker often redeploys the production scheduling, the frequency of order expedition is high.
(4) Tong-Yang Group Corporation (TGC)
A1: TGC provides plastics for automobile and motorcycle.
A2: Since the plastics that TGC provides are the outward appearance parts of automobile, they are the components of low commonality in automobile. The product life cycle depends on the product of the automaker. In light of the comparability with the product of the automaker, new product development requires close collaboration with the automaker.
A3: Although automakers share information in demand forecast with TIC, the forecast is often inconsistent with the final order.
A4: Since the automaker often redeploys the production scheduling, the frequency of order expedition is high.

4.2 Synthesis
After analyzing the data from these four cases, this study will probe into the cause of the uncertainty and attempts to propose the adaptation methods of supply chain management.

4.2.1 Analysis of uncertainty problem
4.2.1.1 Supply chain uncertainties
(1) The sources of demand uncertainty: The causes of demand uncertainty come from the factors in the dimension of product characteristics and demand forecast. In the dimension of product characteristics, the choice of product variety has been increasing to meet the trend of customization. Although the numerous combination of equipment option can improve customer satisfaction, it adds to the difficulty of managing product demand. In the dimension of demand forecast, due to the possibility of equipment combination and the product complexity, the forecast of detailed product demand became difficult. The difficulty in predicting detailed product specification leads to troubles for automakers in setting their production plans to meet customer demand.
(2) The sources of supply uncertainty: The causes of supply uncertainty come from the factors in the dimension of procurement structuralization, supplier relationship, and procurement planning. In the dimension of procurement structuralization, since there are various material types and most of them are specific to the products, the automaker must spend extra effort in the process of procurement. And this complexity of material procurement requires intensive human intervention, increasing the incidence of errors. In the dimension of supplier relationship, since there are numerous suppliers and each of them plays a different role in the material supply, the automaker must spend extra effort to coordinate with them. And this complexity of inter-organization coordination requires paying more attention to maintaining partnership, increasing the difficulty of supplier management. In the dimension of procurement planning, since components with low commonality have time specification in delivery and the most of them have higher frequency of delivery, the automaker must spend extra effort to avoid this material type accident. And this time specification of material delivery requires additional efforts in controlling quality, increasing the difficulty of material supply.
(3) The sources of manufacturing uncertainty: The causes of manufacturing uncertainty come from the factors in the dimension of process complexity and engineering change. In the

dimension of process complexity, given the MTS production strategy product differentiation happens in the early stage of production because of the characteristics of automobile manufacturing process. This rigidity of manufacturing process suggests difficulty for the automaker in dealing with customer demand for the diversification of equipment combination. In the dimension of engineering change, modification of the outlook and inner component design is often necessary to remain competitive in the market. And this redesign entails a series of activities from product design to after-sales support, in which efforts are made to compensate for changes in the specification of products.

4.2.1.2 Supply chain problems

(1) The problems with demand variation: There are three problems with demand variation. The first problem is difficulty in predicting detailed product specification. Since the automotive product belongs to the category of consumer goods, the selectiveness of equipment combination has been increasing to meet the trend of customization. Numerous combination of equipment option makes it difficult to manage product demand. The second problem is MTS production strategy cannot meet the diversification of customer demand in the channel. Since the product differentiation happens in the early stage of production and the product in the automobile manufacturing process cannot be rebuilt, the demand forecast became important for the company using MTS production strategy. Unfortunately, the detailed product demand information is often not provided by extant forecasting methods. Such rigidity of manufacturing process and the lower predictability of detailed product demand make it difficult to satisfy customer specific demands using the MTS production strategy. These lead to unfulfilled customer demand, increased inventory cost and loss of revenue.

(2) The problems with material supply: There are two problems with material supply. The first problem is the difficulty in managing material delivery. Due to the complexity of manufacturing process and the high cost of components of the product, the automaker plans the multiple delivery models depending on the degree of component commonality. Such complexity of the multiple delivery models and the complexity of critical material make implementation of automaker's material delivery planning a rather difficult task. The second problem is the difficulty in controlling material quality. Since the manufacturing processes rely on a large number and variety of materials for different products, the kinds of supplier are numerous and each of them plays a different role in the material supply. Such complexity of material, limitation of supplier's technology ability and coordination difficulty due to the number of suppliers involved have contributed to the uncertainty in controlling material quality.

4.2.2 Adaptation methods of supply chain management

Analyzing the uncertain problems of supply chain from these four cases reveals the following adaptation methods:

(1) Coordination between factory and channel to solve demand side problems: In automotive industry, since the manufacturing processes rely on capital-intensive equipment and a large number and variety of parts for different products, the final products are generated at the assembly stage and the manufacturing process is irreversible. Hence, early differentiation of product models and the rigidity process have rendered MTS production strategy incapable of meeting customer specific demand in the channel. The customer diversification problem can be addressed by the employment of MTO production strategy. While MTO can meet the demand of customization, the drawback is that the lengthening lead time may reduce the customer's satisfaction (Kotler, 1994; Hill, 2000; Aitken et al., 2003). Therefore, the main issue of implementing MTO is how to shorten the lead time so that the customer's satisfaction can be

improved. Coordination between factory and channel is the key to solve this problem. Working under the framework of MTO, the channel can provide guiding services to the customer as to the selection of equipment combination, and can subsequently send back the relevant information of customer order back to the factory. In response, the factory can transfer the information regarding the assembly of detailed equipment to the channel. This coordination mechanism not only can help the factory to catch the customer detailed product demand but also can help the channel to provide better services and reduce waiting time of customers.

(2) Coordination between factory and suppler to solve supply side problems: In automotive industry, since the manufacturing process is a complex set of activities involving many suppliers and many components are outsourced, the running of production depends on the quality of material and the effectiveness of material delivery. Hence, how to improve suppliers' technology and delivery capability becomes critical in the factory. Supplier involvement in new product development and delivery method can help the suppliers to gain advanced knowledge about the product design and to gain more delivery skills in the collaboration process. For achieving the benefit of supplier involvement in new product development and delivery method, the previous research emphasized that supplier involvement should be managed carefully (Birou, 1994; Hartley, 1994; Wynstra, 1998; Wynstra and Pierick, 2000). Especially in the case of final products consisting of parts from many different suppliers, supplier involvement may increase the complexity of managing development projects. The key issue in such situation is to determine which type of supplier involved and what strategic impact to the coordination between factory and supplier. Differentiation between several forms and phases of supplier involvement may help to set priorities so that the involvement of suppliers becomes more manageable and economical.

(3) Deployment of IT infrastructure to facilitate information sharing in support of coordination between supply chain participants: The importance of information sharing comes from the rationale that the whole system's performance depends on each member can gain suitable information for improving their ability of decision-making and can reduce uncertainties during their coordinating processes. For achieving the effects of information sharing, this study suggested that the deployment of IT infrastructure to support the execution of information sharing is important. Currently there are many information technologies developed to support information sharing among supply chain partners. Before applying these information technologies to support the execution of information sharing, companies must classify the types of information that wants to be shared. The types of information can be categorized into product information (includes equipment assembly information and product developing technology information), shop flow information (includes production schedules information and capacity information), customer demand and transaction information (includes sales information, sales forecast information, and order information), and inventory information (includes material inventory information and finished goods inventory information). For these types of information, companies can deploy the suitable IT infrastructure to support it for sharing among partners. Such as in the type of product information, companies can apply the information systems of product data management (PDM) or collaborative product development (CPD) to facilitate inter-organizational information sharing. In the type of shop flow information, companies can apply the information systems of advance planning system (APS), available to promise (ATP), master planning system module (MPS), or integrated shop floor control system (ISCF) to facilitate inter-organizational information sharing. In the type of customer demand and transaction information, companies can apply the information systems of internet EDI or collaborative planning, forecasting, and replenishment (CPFR) to facilitate inter-organizational information sharing. In the type of inventory information, companies can apply the information systems of continuous replenishment programs (CRP) or vendor-managed inventory (VMI) to facilitate inter-organizational information sharing.

5. Conclusion and suggestion

The uncertainty problems observed in the case analysis can be attributed to imperfect coordination between supply chain participants in demand side and supply side because of the coordination complexity for which the participants has not experienced yet, and the lack of information sharing mechanism. Moreover, these two factors are often intertwined together. Effective SCM requires management skills in the process of coordination, and implementation of IT platform to facilitate information sharing. This implies that mutual trust between supply chain participants is important for inter-organizational coordination to be successful. In addition, implementation success of B2B platform depends on BPR in an inter-organization scale. The research suggested that there are four issues must be considered in implementing information sharing in convergent assembly supply chain.

(1) Effective management of convergent assembly supply chain requires inter-organizational coordination and information sharing between supply chain participants; in particular, inter-organizational coordination must precede information sharing.

(2) Effective management of convergent assembly supply chain must address problems associated with demand variation. The coordination mechanism between factory and channel is important to address problems associated with demand variation. And effective deployment of IT infrastructure to facilitate information sharing is important to support coordination between factory and channel.

(3) Effective management of convergent assembly supply chain must address problems associated with material supply. The coordination mechanism between factory and supplier is important to address problems associated with material supply. And effective deployment IT infrastructure to facilitate information sharing is important to support coordination between factory and supplier.

(4) Inter-organizational coordination and information sharing in convergent assembly supply chain can reduce inventory cost, manufacturing cycle time, and improve customer satisfaction. In short, inter-organizational coordination and information sharing can help integration of supply chain resources, leading to overall supply chain performance.

Accordingly, an essential part of managing convergent assembly supply chain to achieve supply chain integration lies in solving the problems of uncertainties, which calls considering the problems in demand side and supply side. Effective management of convergent assembly supply chain should be combined with mechanism of inter-organizational coordination and information sharing to develop strategies for addressing problems with demand variation and material supply. Combining both mechanism of inter-organizational coordination and information sharing helps to form a holistic approach in the execution of SCM, contributing to integration of supply chain resources and eventually improving the overall supply chain performance. The relationship between the mechanism of inter-organizational coordination and inter-organizational information sharing should be considered. Strategies for convergent assembly supply chain can be based upon the propositions and hypotheses developed in this research, which are presented in Fig. 2.

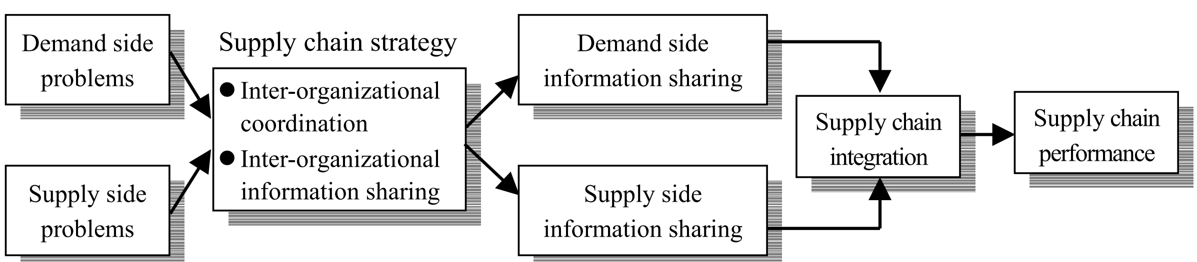

Figure 2 Strategies for convergent assembly supply chain

References

Carpano, C., Chrisman, J., and Roth, K. "International Strategy and Environment: An Assessment of the Performance Relationship," Journal of International Business Studies (25:3), 1994, pp.639-656.

Chopra, S. and Meindl, P. Supply Chain Management: Strategy, Planning, and Operation, Prentice-Hall, New Jersey, 2001.

David, L., Philip, K. and Edith, L. Designing and Managing the Supply Chain: Concepts, Strategies and Case study, McGraw-Hill, New York, 2001.

Davis, T. "Effective Supply Chain Management," Sloan Management Review (33:3), 1993, pp.35-46.

Duncan, B. "Characteristics of Organizational Environmental and Perceived Environmental Uncertainty," Administrative Science Quarterly (17), 1972, pp.313-327.

Eisenhardt, "Building Theories from Case Study Research," Academy of Management Review (14:4), 1989, pp. 532-550.

Ellarm, L. "Supply Chain Management: The Industrial Organization Perspective," International Journal of Physical distribution and Logistics (21:1), 1991, pp. 13-22.

Fisher, M., "What is the Right Supply Chain for Your Product," Harvard Business Review (75:2), 1997, pp.105-116.

Gerwin, D. "Manufacturing Flexibility：A Strategic Perspective," Management Science (39:4), 1993, pp.395-410.

Ghalayini, M., Noble, S. and Crowe, J. "An Integrated Dynamic Performance Measurement System for Improving Manufacturing Competitiveness," International Journal of Production Economics (48:3), 1997, pp.207-225.

Handfield, B., and Nichols, E. Introduction to Supply Chain Management, Prentice-Hall, New Jersey, 1999.

Harland, C. "Supply Chain Operational Performance Roles," Integrated Manufacturing Systems (8:2), 1998, pp.70-78.

Ho, C. "A Contingency Theoretical Model of Manufacturing Strategy," International Journal of Operations and Production Management (16:5), 1996, pp.74-98.

Kauffman, J., and Walden, A. "Economics and Electronic Commerce: Survey and Directions for Research," International Journal of Electronic Commerce (5:4), 2001, pp.5-116.

Khurana, A. "Managing Complex Production Processes," Sloan Management Review (40:2), 1999, pp.85-97.

Lambert, M. and Cooper, C. "Issues in Supply Chain Management", Industrial Marketing Management (29:1), 2000, pp. 65-83.

Lamming, C., Caldwell, D., Harrison, A., and Wendy P. "Transparency in Supply Relationships: Concept and Practice," The Journal of Supply Chain Management (37:4), 2001, pp.4-10.

Lee, L. "Creating value through supply chain integration,'' Supply Chain Management Review (September/October), 2000, pp.30-36.

Lee, L. "Aligning Supply Chain Strategies with Product Uncertainties," California Management Review (44:3), 2002, pp.105-119.

Lee, L. and Billington, C. "Managing Supply Chain Inventory: Pitfalls and Opportunities," Sloan Management Review (33:3), 1993, pp.65-73.

Lin, F.R., and Shaw, M. "Reengineering the Order Fulfillment process in Supply Chain Networks," The Information Journal of Flexible Manufacturing Systems (10), 1998, pp.197-229.

Malone, W., Yates, J. and Benjamin, I. "Electronic Markets and Electronic Hierarchies," Communications of the ACM (30:6), 1987, pp.484-497.

Maloni, I., and Benton, C. "Supply Chain Partnerships: Opportunities for operations research," European Journal of Operational Research (101:3), 1997, pp.419-429.

Mentzer, T., Min, S., and Zacharia, G. "The Nature of Inter-Firm Partnering in Supply Chain Management", Journal of Retailing, (76:4), 2000, pp.549-568.

Mintzberg, T., "Patterns in Strategy Formation," Management Science (24), 1978, pp.934-948.

Novack, A., and Simco, W. "The Industrial Procurement Process: A Supply Chain Perspective," Journal of Business Logistics (12:1), 1991, pp.145-167.

Perry, M., Sohal, S., and Rumpf, P. "Quick Response Supply Chain Alliances in the Australian Textiles, Clothing and Footwear Industry," International Journal of Production Economics (62:2), 1999, pp.119-132.

Strader, T., Lin, F. and Shaw, M. "The Impact of Information Sharing on Order Fulfillment in Divergent Differentiation Supply Chains," Journal of Global Information Management (17:1), 1998, pp.16-24.

Subramaniam, C., and Shaw, M. "A Study of the Value and the Impact of B2B E-Commerce: The Case of Web-Based Procurement," International Journal of Electronic Commerce (6:4), 2002, pp.19-40.

Swamidass, M., and Newell, T. "Manufacturing Strategy, Environment Uncertainty and Performance: A Path Analytic Model," Management Science (33:4), 1987, pp.509-524.

Trent, J. and Monczka, M. "Achieving World-Class Supplier Quality," Total Quality Management (10:6), 1999, pp.927-938.

Vickery, V., Roger, C. and Cornelia, D. "Supply Chain Flexibility: An Empirical Study," Journal of Supply Chain Management (35:3), 1999, pp.16-24.

Whybark, C., and William, J. "Material Requirement Planning under Uncertainty," Decision Science (7:4), 1976, pp.595-606.

Wynstra, F., and Pierick, E. "Managing Supplier Involvement in New Product Development: A Portfolio Approach," European Journal of Purchasing and Supply Management (6:1), 2000, pp. 49-67.

Zeng, Z., and Pathak, K. "Achieving Information Integration in Supply Chain Management through B2B e-Hubs: Concepts and Analyses," Industrial Management and Data Systems (103:9), 2003, pp.657-665.