

# Inter-Organizational Coordination, IT Support, and Environment

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**Abstract:** Manufacturing organizations must know how to deal with uncertainty, manage environmental impact, effectively coordinate with suppliers, and use information technology (IT) to support coordination. Applying cybernetics and information processing theories, this study explores the relationship between organizational environment, inter-organizational coordination, IT support, and the effectiveness of inter-organizational coordination. Using the case study method, data was collected from six manufacturing firms in China. The results show that inter-organizational system adoption is affected by organizational environment and is related to the management of inter-organizational coordination. Coordination and IT application affect the performance of inter-organizational coordination.

**Key words:** cybernetics; information processing theory; information technology (IT) application; inter-organizational coordination

## Introduction

Globalization and consumer demands have forced many business organizations to operate in complex and dynamic environments. For many manufacturing organizations, they must maintain close relationships with the suppliers to respond to changes effectively and to acquire necessary production inputs. Inter-organizational systems (IOS) are important information technology (IT) tools that can support business transactions. Inter-organizational systems promise the benefits of rapid information exchange, low cost, and high efficiency<sup>[1]</sup>. The studies of these issues are the domain of social and system science research. Using social and system theories, we can better understand the relationships between business environments, the dominant coordination mechanisms, and IT support to identify the guiding principles relevant to an

organization when it decides to choose the best coordination mechanisms and to select, design, and implement inter-organizational systems. The purpose of this paper is to find potential solutions for these issues. We formulate our theoretical models using the viable system model (VSM)<sup>[2,3]</sup> (derived from cybernetics) and information processing theory (IPT)<sup>[4,5]</sup>.

## 1 Literature Review

There are two main thoughts that deal with the impact of environment on organization and the use of information systems: system theories and organizational theories. System theories regard an organization as an element in a group of organizations. They deal with organization's survival and evolution in an environment. Organizational environment is measured by complexity to reflect the quantity of the elements, the relationships among the elements, and the dynamics of the elements and overall system. Organizational theories focus on the relationships between environment and organizational design issues, such as organizational

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structure and organizational information processing requirement and capability. Traditionally, organizational theorists focused primarily on the issues internal to the organizations. Recently, particularly as a result of the Internet and e-commerce, attention has been paid more and more to the issues external to the organizations, such as inter-organizational coordination and inter-organizational system support, e.g., institutional theory<sup>[6]</sup>.

### 1.1 System theory

The focus of system theories is on the complexities of environment. These address the issue of how an organization adapts to its environment. System theories originated from Holism Theory and Gestalt after World War I and Cybernetics after World War II. They emphasize coordination, regulation, and control of systems<sup>[7,8]</sup>. Cybernetics and general system theory are the main streams in system science. General system theory focuses more on system structure and system modeling. Cybernetics deals more with system functions. It pays more attention to the coordination and control of its subsystems, or system elements, as well as the communications among subsystems. The applications of cybernetics principles in business and management are represented by two theories: Ashby's law of requisite variety (Ashby's Law) and Beer's viable system theory. According to Ashby, the higher the "variety" possessed by the system, the higher the capability of the system in handling its environment. From information perspective, the amount of information in control system determines the degree of system's controllability. Beer applied Ashby's Law into enterprise management, and proposed the VSM to study the balance relationship between a system and its environment<sup>[2]</sup>. Ashby's Law has been widely accepted<sup>[9,10]</sup>. The VSM has also been applied in organizational diagnoses, management and control, and project management<sup>[11-13]</sup>.

### 1.2 Research in organizational theories

The focuses of organization studies are the organizational environment and its impacts on organizational structure and strategy. The main stream theories are resource-based theory, organizational economics, and organizational design theories. These studies have been verified by empirical evidence<sup>[14-19]</sup>. Among many

theories, IPT is particularly useful for current study. IPT originated from the studies by Simon<sup>[20]</sup>, Thompson<sup>[21]</sup>, Galbraith<sup>[4,5]</sup>, and Tushman and Nadle<sup>[22]</sup>. There are two main concepts: information processing needs (IPN) and information processing capability (IPC). An organization must acquire the necessary information processing capability to deal with information processing needs. In other words, if IPC fits IPN, i.e., there is a balance between information processing needs and information processing capability, the organization will perform well. According to Galbraith, when facing uncertain environment, it's difficult for organization to pre-plan its tasks. Therefore, decision makers must coordinate frequently with related parties and seek more information in order to make the right decisions. Therefore, an uncertain environment increases the needs for information processing. An organization can design its structure and implement information processing mechanisms to handle the needs. A few studies have applied the information processing theory to organizational design and information system studies. Some used the theory to study the coordination issues within the sub-units of an organization and inter-organizational coordination among a group of organizations such as enterprises within a supply chain<sup>[23-26]</sup>. According to IPT, there are two ways to deal with uncertainty: either reducing the needs for processing information through reducing "environment uncertainty" or through increasing information processing capability. There are a number of ways to reduce information processing needs. These ways include actively managing uncertain environment by reducing the uncertainty factors such as forming strategic alliances, increasing slack capacity (i.e., inventory), and designing independent tasks. The way to increase information processing capability includes investment in IT and the creation of lateral coordinating mechanisms.

### 1.3 Inter-organizational coordination and IT support

Assume that we can apply the two theories to inter-organizational coordination and IT support research. The application of cybernetics and the law of requisite variety in management will shed a light in our understanding about how organizations coordinate to achieve their goals. Organizational theories, such as

information IPT, enable us to understand how organizations coordinate from the perspective of information and information processing. Inter-organizational system is a tool that supports the coordination. The role of IOS is to facilitate and support the business transactions among organizations.

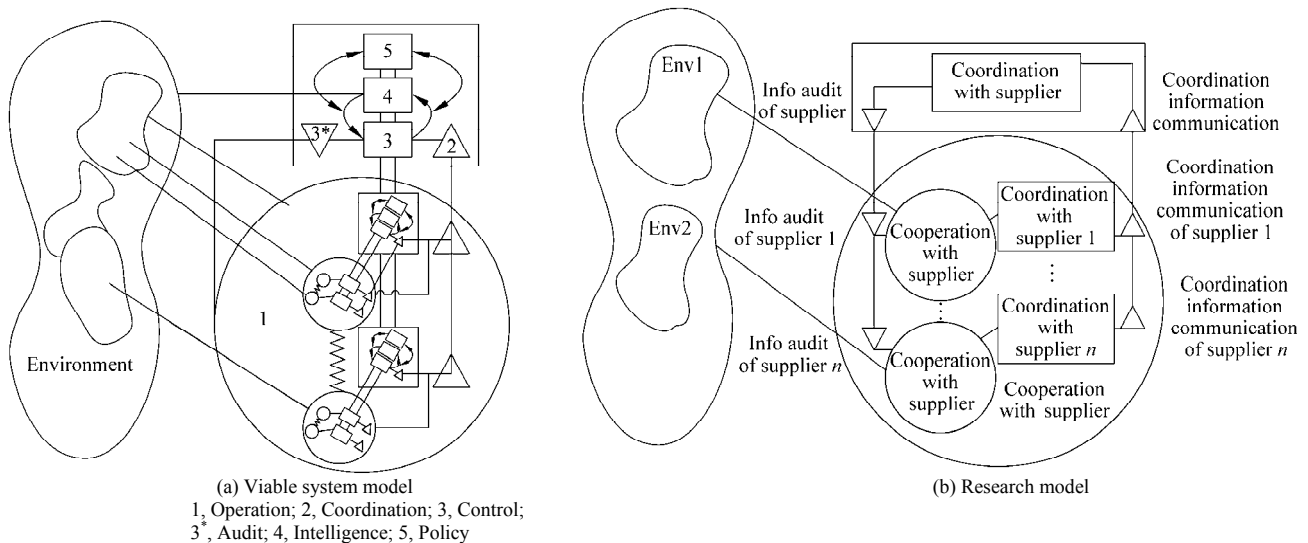
## 2 Research Design

### 2.1 Questions, model, sample, and method

The purpose of this study is to examine organizational environment and its relationships with inter-organizational coordination and IT support. We intended to answer the following research questions: (1) How environment affect inter-organizational coordination mechanisms and inter-organizational IT adoption; (2) how organization uses coordinating mechanisms and IT to handle environment uncertainty; (3) what are the relationships between environment, coordinating mechanisms, IT application, and coordination performance. According to VSM, we can describe the coordination relationships between core organization and its suppliers (as shown in Fig. 1). The core organization's management system can be further divided into elements. Each element consists of a one-to-one relationship between the core organization and its supplier for a particular product or a group of similar products. The viable system model is used to define the management system functions with related organizational theories are applied to define functional

elements. We can further analyze the environment of organizational coordination, management coordination with the suppliers, operational coordination with the suppliers, and the use of IT to support management coordination and operation coordination.

This research adopts the case study method to verify the research questions. There are four reasons for using the case study method. First, there is a lack of applied research and evidence for selected theories in the proposed domain of study. Since the study is exploratory in nature, case study method is more appropriate<sup>[27]</sup>. Second, our preliminary findings indicated no clear evidences of coordination and IT support for many organizations. Case study allows us to conduct interviews and identify the organizations that fit our requirements. Third, case method enables us to conduct in-depth analysis of the selected organizations and is useful for model formulation and data analysis. After careful consideration and initial data analysis, it was decided to select manufacturing organizations in automobile and ship-building industries in our sample. Both industries employ complex production processes with high degree of capital investment and both require a large number of component suppliers. In addition, organizations in both industries need to coordinate closely with various types of component suppliers. Finally, organizations in both industries, comparatively speaking, have well developed information systems. The use of information systems (IS) and IT support for coordination with suppliers is prominent and frequent.



**Fig. 1** Viable system model and research model

## 2.2 Variables and measurement

### 2.2.1 Environment uncertainty

There is no standard definition<sup>[28]</sup> about environment uncertainty. Within organizational theories, uncertainty refers to dynamics, complexity, and munificence<sup>[29]</sup>. Information processing theory views complexity and dynamics as two important factors that affect organizational structure. Complexity is caused by the components, i.e., sub-systems and their relationships. The number of components in the systems and the relationships of these components determine the amount of information required for processing. Dynamics refers to the state of the components. Frequent changes will require the decision makers to process more information<sup>[30]</sup>. This research adopts the definitions and categorizations of information processing theory. Specifically, uncertainty is measured by demand uncertainty and technological uncertainty.

### 2.2.2 Inter-organizational coordination

It refers to inter-organizational management coordination and operational coordination. According to IPT, an organization is considered as an entity of an information processor. Therefore, the way the organization is designed will affect the organization's information processing capability<sup>[6]</sup>. Traditional organizational design deals with internal rules, policies, and procedures, departmentalization and integration, formalization, and centralization. These parameters deal with two fundamental concepts, differentiation and integration. In order to perform certain task, e.g., making product or providing service, an organization must divide the tasks and then integrate them. These parameters can also be applied to inter-organizational coordination. Essentially, inter-organizational structure defines the relationships and power structures among a group of organizations. On a supply chain, buyers and suppliers perform different roles and different tasks. To be effective, the divided tasks must be integrated, and coordination and information exchange and processing are thus required. For the purpose of this research, we measured the information exchange between the core organization and its suppliers on product supplies and quality assurance. It includes the way that core organization controls and coordinates with the suppliers, and the mutual support between core organization and its suppliers. These constructs are measured by

information exchanges and the standardization of operation between the buyers and the suppliers.

### 2.2.3 Inter-organizational IT support

IT support refers to the use of electronic information exchange tools, i.e., information and communication technologies, between the core organization and its suppliers. This research measures the degree of IT support in procurement, quality management, and management information.

### 2.2.4 Coordination performance

Coordination performance refers to how about the coordination between the core organization and its suppliers in accomplishing its goals. It is measured by management process optimization, decision support information, and the efficiency of procurement quality management. In essence, it measures the fit between information processing needs and information processing capability.

## 3 Case Description

We selected a total of six manufacturing organizations in this study, including four automobile and two ship-building companies.

All the companies are well-known large scale manufacturing companies in China. For each organization, we chose two departments that are closely related to the suppliers: procurement and supplier quality management. Data was collected by unstructured interviews, archival and document reviews, and structured interviews via questionnaires. The data collected through personal interviews and document reviews was categorized according to each variable. Structured interviews were conducted using questionnaires. The questionnaires were given to multiple individuals who deal with suppliers (one individual for each supplier/product) within each department of each organization. The questionnaire was designed to measure the four constructs. A total of 221 questionnaires were sent to the four automobile companies and 63 were sent to the two ship-building companies. Table 1 shows the summary of the interviews and structured interviews.

### 3.1 Automobile manufacturing companies

The automobile manufacturing industry in China is in its rapid development stage. It is a highly competitive

**Table 1** Summary of interviews and samples

Automobile		Ship-building	
Interview department	Number of interviews	Interview department	Number of interviews
Procurement	5	Material supplies	3
Quality management	4	Quality management	3
Information management	4	Information management	3

market. As a result, many companies are pursuing new products and low cost strategies. Such strategies require the manufacturers to establish close relationships with their suppliers to ensure quality and timely delivery of required supplies. Supplier relationship management is an important business activity for automobile organizations. Of the four automobile companies included in this study, three have included a formal “partnership” relationship with their suppliers in their business strategies and core values. For smooth production, automobile manufacturers need to maintain close relationships with its suppliers, sometime with several suppliers for the same components. At the same time, the core (i.e., the buyer) organization needs to communicate and coordinate with the suppliers on a number of production and management issues including production planning, component design, and technical support. For critical and high technological content components, the frequency of coordination and communication is even higher. Suppliers also need to communicate and coordinate frequently with the buyers on product delivery and warehousing matters. To ensure that the quality and quantity of the components meet requirements, buyers often need to review suppliers regularly. To shorten the production cycle and reduce inventory level, many automobile companies implemented so-called just-in-time production method, which adds additional constraints to the suppliers. Hence, many suppliers have to follow the standards and procedures specified by the buyers. For IT support, none of them have reached the level of computerized integration and data processing between organizations.

The dominant technology for inter-organizational integration is the use of web-based technology. The common use of web technology is for information exchange such as data entry and data submission. E-mail is often used for document exchanges. Cost saving is the main reason for using this form of IT. There is not much investment needed. All needed is the standardization of information exchange behavior. Significant

gaps still exist among different organizations in IT applications. Often there are requirements for human involvement through face-to-face communication and coordination. Most suppliers with relatively high IT applications are those critical components organizations. They maintain close business relationships with the buyers, standardized work processes, and standardized information exchange protocols. The benefits of maintaining close relationships with the suppliers include low inventory, reducing product procurement cost, high quality, and management process optimization. IT adoption between organizations increases the efficiency of data exchange and information sharing between buyers and suppliers.

### 3.2 Ship-building companies

Compared with mass production organizations, such as automobile manufacturing companies, ship-building manufacturing companies are single production organizations. Typically, single and small product manufacturing companies will organize their production only after production orders are in place. Ship-building companies often focus on body and main component design and outsourcing the manufacturing of most of their components. Because of the nature of the product, i.e., high technology content and high degree of customization, and the nature of the production, i.e., quick response to customer order and high demand for meeting production schedule and delivery date, ship-building companies must maintain good relationships with their suppliers. Unlike automobile manufacturing companies that keeping continuous production is one of the most tasks, ship-building companies must deal with hundreds, if not thousands, suppliers since a typical ship consists of more than ten thousand components and they are typically specialized products and provided by specialized suppliers. Although ship-building companies typically do not need to maintain frequent electronic data transmissions compared with automobile manufacturers, they do need to obtain

detailed product information from their suppliers for certain components. For example, for diesel engine, ship-building companies typically post the product requirement on the web for contract tendering. After winning the bid, diesel engine manufacturers need to digitize diesel engine model. The designers will take the digitized diesel model and integrate it in its ship's virtual design and virtual assembly model. Due to a large number of components and high degree of complexity, ship-building companies need to establish formal coordination channels and rules with their suppliers so as to ensure quality, clarity, and smooth procurement process. Although the use of IT for document transmissions between ship-building companies and their suppliers is relatively low compared with automobile companies, this type of organizations will benefit through the use IT for inter-organizational coordination to reduce inventory, increase delivery efficiency,

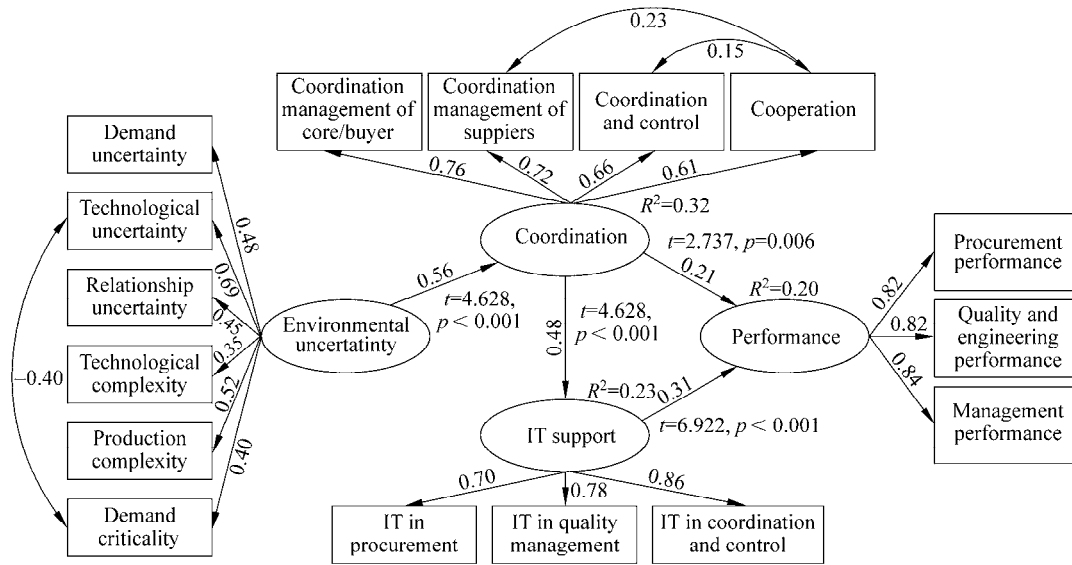
reduce transaction cost for product tendering, and optimize capital utilization.

### 4 Results

Table 2 includes the results of main variables, interview, and document review. Figure 2 shows the results of variable goodness of fit for main variables using structural equation modeling. The use of structural equation model is based on a one-to-one relationship between the buyer and supplier for product procurement (Fig. 2). It forms the basic unit of analysis in coordination. The results showed that environment is related to inter-organizational coordination. IT support for inter-organizational coordination is related to the ways of management coordination between organizations. Coordination performance is related to inter-organizational coordination and IT support.

**Table 2 Case description of automobile and ship-building companies**

Factor	Automobile		Ship-building		t
	Case description	Mean	Case description	Mean	
<b>Environment</b>					
Technological characteristics	High technology content and frequent technological changes.	3.29	High technology content and frequent technological changes.	3.41	0.769
Market demand characteristics	Mass production and continuous procurement.	3.74	Single production and procurement, infrequent order.	3.19	0.002
<b>Inter-organizational coordination</b>					
Inter-organizational coordination behavior: buyers to suppliers	Frequent communication and coordination with suppliers on production, components design, and machinery procurement; frequent negotiations with suppliers prices and dealing with emergencies and crisis.	2.97	Need to coordinate with suppliers for technical matters; frequent communication and coordination with suppliers for components prices.	2.79	0.054
Inter-organizational coordination behavior: suppliers to buyers	Frequent communication and coordination with buyers to understand buyers' requirements and to make necessary investment.	3.66	Need to know buyers' requirements and to provide product and technological information to buyers.	3.40	0.000
Coordination and control	Buyers often inspect and monitor suppliers for their products and productions.	3.61	Buyers rarely inspect and monitor suppliers' products and production.	3.06	0.013
Operational coordination	Work processes and scopes are mutually determined.	3.17	Work processes and scopes are mutually determined.	3.52	0.074
<b>Inter-organizational IT support</b>	Web-based transmissions of purchasing, production, and technical information exchanges.	3.52	Web-based transmissions of technical information exchanges.	2.98	0.000
<b>Coordination performance</b>	Inventory reduction, on time delivery; continuous product supplies, components' quality assurance, operation and management efficiency and effectiveness.	3.58	Improving technological management capability, timely acquisition of suppliers' components information, and better components' pricing.	3.60	0.779



**Fig. 2 Result of structural equation model**

$\chi^2=245.40$ ,  $df=97$ ,  $p<0.001$ ,  $RMSEA=0.069$ ,  $NFI=0.860$ ,  $RFI=0.827$ ,  $IFI=0.911$ ,  $CFI=0.909$ ,  $GFI=0.915$ ,  $AGFI=0.881$ .\*\*,  $p<0.01$ ; \*\*\*,  $p<0.001$

**4.1 Environment, inter-organizational coordination, and IT support**

Organizational environment is significantly related to inter-organizational coordination and indirectly to IT support. For both automobile and ship-building companies, environment shows high scores for both technological and market uncertainty with 3.29 and 3.74 on five point scale (Table 2).

Our findings through personal interviews confirmed that both industries and buyer organizations maintain close relationships with key components' suppliers. Compared to ship-building organizations, automobile companies showed clearly close relationships with their suppliers for continuous production and product improvement. Therefore, they show more active roles in procurement and component quality control and assurance. These characteristics are confirmed by the data from all the measures of inter-organizational coordination, which are significant. The data showed that the use of IT support for inter-organizational coordination was significantly more for automobile companies than for ship-building companies. This can be explained by both IPT and VSM theories. According to information processing theory, the need to process information and the need to coordinate with their suppliers will increase when organizations face environment's uncertain growing up. Organizations

can handle the uncertainty by either increasing IPC by using IT or reducing IPN. To reduce the information processing needs, organizations can actively manage environmental uncertainty by closely coordinating with their suppliers. This is reflected by the coordination mechanisms employed the organizations. From the view of VSM, inter-organizational coordination can handle uncertainty. The higher the uncertainty of the environment, the higher the environmental "variety" is. Organizations must have equal number of "variety" to handle environmental "variety". The frequent use of coordination mechanisms and IT is a way for an organization to increase its own "variety".

**4.2 IT adoption and the management of inter-organizational coordination**

The use of IT for inter-organizational coordination is related to the ways of management coordination between organizations. For example, the use of IT for automobile companies is clearly higher than that of ship-building companies. Buyers in automobile industry show higher degree of control over their suppliers as compared to that of ship-building industry. This requires these companies to exercise different ways of coordination. They keep monitoring their components' suppliers to ensure product quality and delivery. Information technology can be useful and economical for the control and monitoring. In terms of the type of

information systems and IT used by the organizations, we found that the predominant tool is the web and web related technologies. Organizations typically make their decision of whether to use IT for inter-organizational coordination or if there is a need for such coordination. The higher the coordination activities, such as work processes and information exchanges, the higher the frequency of using IT is. For the organizations that did not use IT for inter-organizational coordination, the frequency of coordination is much lower compared to those with higher frequency. Based on IPT, the lateral coordination mechanisms and the information systems can help an organization to handle the uncertainty as in the case of automobile companies. From VSM viewpoint, VSM regards IS as the means of information processing and feedback. Timely feedback and control are a critical step in management control. From this aspect, it is understandable that the use of IT is related to the management of coordination.

#### 4.3 Coordination performance, environment, and IT support

Our data confirmed that coordination performance, as measured by reduced inventory, on-time delivery, product quality, the continuation of product supply, the operational efficiency, and the management effectiveness, is determined by the fit between environment, inter-organizational coordination, and the use of IT. Compared to ship-building industry, automobile industry has higher environmental uncertainty. Also, the IT use in automobile companies is significantly higher. However, there is no significant difference in the coordination performances between the two kinds of companies. This shows that the “fit” between environment, coordination, and IT support matters to the performance. In other words, when dealing with low environment uncertainty as in the case of ship-building companies, less coordination and information processing is needed. As argued by IPT, organization will perform well when there is a “fit” between IPN and IPC. Ship-building companies are in, relatively speaking, less uncertain environment with less coordination efforts. Therefore, they have less need for IPN and IPC. It can also be explained by VSM, which means that the subsystems are connected by communication and control information to treat uncertainty. When the system

has more varieties, the system can absorb more environment variety. This will lead to better performance, as the output of control is better.

## 5 Discussion and Conclusions

Using case study method, we tested the applicability of the cybernetics and information processing theories in inter-organizational coordination and IT support. Specifically, we explored the relationships between organizational environment, inter-organizational coordination, inter-organizational IT support, and coordination performance. Our results show that inter-organizational IT adoption is affected by environment and is related to the management of inter-organizational coordination. The management of coordination and the use of inter-organizational system impact on the performance of inter-organizational coordination. Based on VSM’s systematic method, this study applied Ashby’s Law of Requisite Variety and VSM’s application in inter-organizational management coordination. The present study also confirmed and extended the information processing theory in the context of inter-organizational and IT support setting. The findings are useful not only for theoretical discussion but also for practice. The manufacturing organizations in uncertain environment need to establish close relationship with their suppliers and manage the coordination well. The use of IS and IT is beneficial for organizations to manage coordination, and handle uncertainty. On the other hand, it is important for organizations to be aware that the fit between environment, coordination, and IT support is important for its performance. In other words, organizations should consider their environment, i.e., the degree of uncertainty, the nature of the coordination, and the coordination mechanism, before they decide to invest information technology.

This study is limited by the sample, research method, and measurement instrument. Due to the limitation of time and resources of the researchers, we could not include as many cases as we had hoped. An in-depth case analysis was not conducted as desired. Furthermore, due to the limitation of the research method, the generalization of the findings is limited to our selected samples. For example, all the six cases included in this study are leading and large automobile and ship-building manufacturing companies in China. The findings may



not be applicable to medium and small companies in the two industries we studied and the companies in other industries. Finally, the present study is limited by its measurement instrument. Although the measurement instrument used in the study was developed and used in previous studies<sup>[23,25]</sup>, efforts should be made to develop the measurement instrument that are more suitable for the context organizations and industries in China.

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