

Accessing Antecedents of Supply Chain Flexibility and Supply Chain Integration

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Abstract: This paper empirically examines the impact of environmental uncertainty, IT enablers and inter-organizational relationships on supply chain flexibility and supply chain integration. Based on the data collected from 196 organizations, multiple regression analyses are used to test the factors impacting supply chain flexibility and supply chain integration respectively. It was found that commitment of supply chain partners and shared vision between supply chain partners positively impact both customization flexibility, and volume and launch flexibility. In addition, volume and launch flexibility are also positively impacted by customer uncertainty and technology uncertainty. It was also found that supply chain integration is positively impacted by supply chain management tools and shared vision, and negatively impacted by supplier uncertainty. The results also show that supply chain flexibility and supply chain integration are not impacted by communication tools, enterprise resource planning tools and trust in supply chain partners. The implications of the findings were discussed at the end.

Keywords: Supply Chain Flexibility, Supply Chain Integration, IT Enablers, Supply Chain Management

I. Introduction

Supply chain flexibility has been consistently identified as a key measure for supply chain performance [2] [26] and a major determinant of competitiveness in an increasingly dynamic marketplace [10]. Improved supply chain flexibility results in reduced supply chain risk [25], higher supply chain agility and ultimately higher competitive advantage [24]. In addition to supply chain flexibility, supply chain integration is also a key ingredient for an effective and efficient supply chain. Higher levels of supply chain integration are characterized by increased communication, greater coordination of the firm's activities with those of its suppliers and customers, and more blurred organizational distinctions between the activities of the firm and those of its suppliers and customers [5]. Supply chain integration leads to increased operational and business performance [7].

This paper first identifies a set of factors, including environmental uncertainty (customer uncertainty, supplier uncertainty, and technology uncertainty), IT enablers (communication tools, resource planning tools and SCM

tools), and inter-organizational relationships (trust in supply chain partners, commitment of supply chain partners, and shared vision between supply chain partners), that may impact supply chain flexibility and integration. Based on the data collected from 196 organizations of various sizes and industries, multiple regression analyses are used to test the factors impacting supply chain flexibility and supply chain integration. It is found that environmental uncertainty and inter-organizational relationships are most critical factors in determining the level of supply chain flexibility and supply chain integration.

II. Theoretical Framework and Hypothesis Development

Figure 1 presents a framework displaying the factors impacting supply chain flexibility and supply chain integration. This section will discuss each variable in the framework and the hypothesized relationships briefly.

Supply Chain Flexibility and Supply Chain Integration

Supply chain flexibility can be measured by the following five dimensions: product (customization) flexibility, volume flexibility, launch (new product introduction) flexibility, access flexibility, and responsiveness to target markets [26]. Product flexibility refers to the ability to handle difficult, nonstandard orders, to meet special customer specifications, and to produce products characterized by numerous features, options, sizes, and colors; volume flexibility is the ability to effectively increase or decrease production in response to customer demands; launch flexibility refers to the ability to rapidly introduce many new products and product varieties; access flexibility is the ability to produce widespread or intensive distribution coverage; and the final flexibility, responsiveness to target markets, captures the overall ability of the organization to respond to the needs of its target markets.

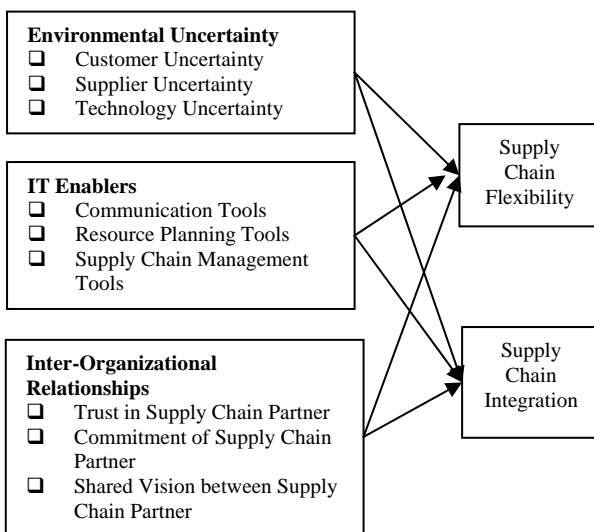


Figure 1. Research Framework

Supply Chain Integration is defined as the extent of all activities within a firm, and the activities that integrated together its suppliers, customers, and other supply chain members [18]. Supply chain integration includes three stages: functional integration, internal integration, and external integration. Functional integration establishes close relationships between functions such as shipping and inventory or purchasing and raw material management [17]. Internal integration involves the integration of all internal functions from raw material management through production, shipping, and sales [18]. External integration extends the scope of integration outside the organization to embrace suppliers and customers [18].

Environmental Uncertainty

Environmental uncertainty is defined as including the uncertainty from customers, suppliers, and technology. *Customer Uncertainty* is defined as the extent of the change and unpredictability of the customer's demands and tastes [3]. *Supplier Uncertainty* is defined as the extent of change and unpredictability of the suppliers' product quality and delivery performance. [12]. *Technology Uncertainty* is defined as the extent of change and unpredictability of technology development in an organization's industry. The development of IT not only provides numerous opportunities for organizations [6] but also creates threats for them [21].

The Impact of Environmental Uncertainty on Supply Chain Flexibility and Supply Chain Integration

Many researchers have considered environmental uncertainty an important driver for supply chain flexibility and integration [4]. In a highly uncertain environment with changing markets, organizations tend to build strategic partnership with their supply chain members to share information, to increase organizational flexibility, and to reduce the risk associated with the uncertainty. Lambe and

Spekman [11] suggest that uncertain industry structure and market environment encourage the formation of strategic supplier partnership. The threat from competitors will impel organizations to increase customer satisfactions and loyalty by sharing timely information with customers. Vickery et al. [26] found that volume flexibility and launch flexibility are key responses to environmental uncertainty. The above arguments lead to:

Hypothesis 1a: The higher the level of environmental uncertainty, the higher the level of supply chain flexibility.

Hypothesis 1b: The higher the level of environmental uncertainty, the higher the level of supply chain integration.

IT enablers

IT enablers are defined as the information technology used to facilitate information sharing and information quality in SCM. By reviewing relevant literature, fourteen IT tools are identified. These IT tools are further divided into three groups in terms of their primary purpose: 1) Communication Tools, 2) Resource Planning Tools, and 3) Supply Chain Management Tools. *Communication Tools* refer to the IT used to facilitate data transfer and communication between trading partners, which include Electronic Data Interchange (EDI), Electronic Fund Transfer (EFT), Internet, Intranet, and Extranet; *Resource Planning Tools* refer to the IT used to integrate the resource planning processes in an organization, which include Material Requirement Planning (MRP), Manufacturing Resources Planning (MRPII) and Enterprise Resource Planning (ERP). *Supply Chain Management Tools* are identified as the IT used to manage the various processes and relationships in the entire supply chain, which include Distribution Requirement Planning (DRP), Customer Relationship Management (CRM), Supplier Relationship Management (SRM), Vendor Managed Inventory (VMI), Data Warehouse (DW), and SCM software.

The Impact of IT Enables on supply chain flexibility and supply chain integration

Many researchers consider IT a great enabler for improving supply chain flexibility and integration [6] [23]. IT enhances supply chain efficiency by providing real-time information regarding product availability, inventory level, shipment status, and production requirements. Skipper and Hanna [22] and Swafford et al. [24] found that the use of IT enablers lead to increased supply chain flexibility. In addition, Information sharing enabled by IT also creates opportunities for increased supply chain agility/integration [24]. Li et al. [15] found that the implementation of IT leads to supply chain integration that in turn leads to enhanced supply chain performance. Therefore, it is hypothesized that:

Hypothesis 2a: The higher the level of the usage of IT enablers, the higher the level of supply chain flexibility.

Hypothesis 2b: The higher the level of the usage of IT enablers, the higher the level of supply chain integration.

Inter-organizational Relationships

This study considers inter-organizational relationship as including three sub-dimensions: trust in trading partners, commitment of trading partners, and shared vision between trading partners. *Trust in Trading Partners* is defined as the willingness to rely on a trading partner in whom one has confidence [16] [23]. Trust is conveyed through faith, reliance, belief, or confidence in the supply chain partner, viewed as a willingness to forego opportunistic behavior [23]. *Commitment of Trading Partners* refers to the willingness of buyers and suppliers to exert effort on behalf of the relationship [23]. Commitment incorporates each party's intention and expectation of continuity of the relationship, and willingness to invest resources in SCM. *Shared Vision between Trading Partners* is defined as the degree of similarity of the pattern of shared values and beliefs between trading partners [13]. Shared vision is therefore the extent to which partners have beliefs in common about what behaviors, goals, and policies are important or unimportant, appropriate or inappropriate, and right or wrong [1].

The Impact of Inter-organizational Relationships on Supply Chain Flexibility and Supply chain Integration

Without good inter-organizational relationships based on such intangibles as trust, commitment, and shared vision, organizations will be reluctant to share information with their supply chain partners, which is a key factor for building a flexible and lean supply chain. Handfield and Bechtel [9] found that building trust improves supply chain responsiveness. The empirical result of Nyage et al. [19] indicated that trust and commitment lead to improved supply chain performance and satisfaction with supply chain relationship. Panayides and Lun [20] found that trust leads to innovativeness and higher performance in the supply chain. The above arguments lead to:

Hypothesis 3a: The higher the level of inter-organizational relationship, the higher the level of supply chain flexibility.

Hypothesis 3b: The higher the level of inter-organizational relationship, the higher the level of supply chain integration.

III. Research Methodology

Empirical data for testing the research framework was collected via a field survey. Five constructs were measured in this study: supply chain flexibility, supply chain integration, environmental uncertainty, IT enablers, and inter-organizational relationships. All construct were developed and tested using four phases: (1) item generation,

(2) pre-pilot study, (3) pilot study, and (4) large-scale data analysis. The items for each construct were generated through a comprehensive literature review. In the pre-pilot study, these items were reviewed by six academicians and re-evaluated through structured interviews with three practitioners who were asked to comment on the appropriateness of the research constructs. Based on the feedback from the academicians and practitioners, redundant and ambiguous items were either modified or eliminated. New items were added wherever deemed necessary. In the pilot study stage, the three round Q-sort method was used to pre-assess the convergent and discriminant validity of the scales.

Large-scale Methods

Mailing lists were obtained from two sources: the Society of Manufacturing Engineers (SME) and the attendees at the Council of Logistics Management (CLM) conference in New Orleans, 2000. The final version of the questionnaire was administered to 3137 target respondents. The survey was sent in three waves. There were 196 complete and usable responses, representing a response rate of approximately 6.3%. Among the respondents, almost 20% of the respondents are CEO/President/Vice President /Director. About half of the respondents are managers, some identified them as supply chain manager, plant manager, logistics manager or IT manager in the questionnaire. The areas of expertise were 30% purchasing, 47% manufacturing production, and 30% distribution/transportation/sales. Moreover, about 30% of the respondents are responsible for more than one job function, and they are expected to have a broad view of SCM practice in their organization.

Based on 196 responses, all construct were validated with the following objectives in mind: purification, unidimensionality, reliability, convergent and discriminant validity. After the validation, supply chain flexibility is split into two constructs: customization flexibility and volume and launch flexibility. The final list of items for each construct is listed in Appendix A.

IV. Data Analysis and Discussion of Results

Three linear regression analyses are conducted, using the nine influencing factors as independent variables and customization flexibility, volume and launch flexibility, and supply chain integration as dependent variable respectively. The results are shown in Table 1.

Table 1 Regression Analysis of Supply Chain Flexibility and Supply Chain Integration

Independent Variables	Dependent Variables					
	CF		VLF		SCI	
	Standardized Coefficients	Sig.	Standardized Coefficients	Sig.	Standardized Coefficients	Sig.
Customer Uncertainty	.11	.12	.15	.04	.09	.20
Supplier Uncertainty	.05	.45	-.07	.36	-.15	.04
Technology Uncertainty	-.02	.75	.17	.02	.02	.78
Communication Tools	-.04	.69	.07	.40	.06	.47
Enterprise Resourcing Planning Tools	.10	.25	-.12	.15	-.10	.23
SCM Tools	-.08	.38	-.03	.74	.15	.05
Trust in Supply Chain Partners	-.15	.08	-.02	.78	.12	.15
Commitment of Supply Chain Partners	.31	.00	.22	.01	-.07	.46
Shared Vision between Supply Chain Partners	.23	.01	.22	.01	.30	.00
R	.44		.44		.42	
R ²	.19		.19		.18	
F-statistics	4.90		4.93		4.45	
Significance	.00		.00		.00	

It can be seen that customization flexibility is influenced by commitment of supply chain partners and shared vision between supply chain partners. Environmental uncertainty and IT enablers have no impact on customization flexibility. This finding indicates the importance of inter-organizational relationship on improving customization flexibility, the ability of the supply chain to handle difficult orders and to meet special customer specification.

The results also show that volume and launch flexibility is influenced not only by commitment of supply chain partners and shared vision between supply chain partners, but also by customer uncertainty and technology uncertainty. This result demonstrates the importance of external environment in driving supply chain flexibility. High uncertainty from customers and technology will force an organization to increase the flexibility of its supply chain to respond to customers' changing needs better. Moreover, the results also show that a good supply chain relationships based on commitment and shared vision are necessary for improving supply chain flexibility.

Surprisingly, the results did not find any significant impact of IT enablers on supply chain flexibility. The insignificant relationship may be caused by low level of IT usage in surveyed organization. Another possibility may be the impact of IT enablers on supply chain flexibility is not direct, but indirect. This can be a direction for future research.

Table 1 also shows that supply chain integration is negatively impacted by supplier uncertainty, and positively impacted by SCM tools and shared vision between supply chain partners. The higher the level of SCM tools and shared vision between supply chain partners, the lower the level of

supplier uncertainty, the higher the level of supply chain integration. In one hand, the results indicate the importance of IT enablers and inter-organizational relationships in supply chain integration. On the other hand, the results reveal that a low level of supplier uncertainty is associated with high levels of supply chain integration. This can be true since organizations may find it too difficult to integrate with suppliers with high uncertainty, such as unpredictable engineering level, product quality and delivery time.

V. Conclusions and Future Research

The goal of this paper was to assess the antecedents of supply chain flexibility and supply chain integration. The results partially support the hypotheses. It is found that both customization flexibility and volume and launch flexibility are impacted positively by commitment of supply chain partners and shared vision between supply chain partners. Volume and launch flexibility is also positively influenced by customer uncertainty and technology uncertainty. Those findings partially support hypothesis 1a and 3a. Hypothesis 2b is disapproved since no significant relationship is found between IT enablers and both customization flexibility, and volume and launch flexibility. The results also show that supply chain integration is impacted positively by SCM tools and shared vision between supply chain partners, which partially support hypothesis 2b and 3b. Moreover, we initially hypothesized a positive relationship between environmental uncertainty and supply chain integration (hypothesis 1b) but found a negative relationship between

one of environmental uncertainty dimension (supplier uncertainty) and supply chain integration.

The results of this study have the important implications for practitioners. First, the results of regression analysis highlight the importance of inter-organizational relationships in improving supply chain flexibility and supply chain integration. Frequently, organizations have tended to focus on the applications of IT on SCM; they have not given enough attention to the development of inter-organizational relationships. This phenomenon may reflect the nature of IT and inter-organizational relationships. Compared with inter-organizational relationships, IT can be more easily implemented, and its benefits are more tangible and measurable. While the establishment of good inter-organizational relationships (such as trust, commitment, and shared vision) is much more difficult and time-consuming than the installation of SCM software, its impact on overall performance is mostly invisible.

Second, the findings indicate a low level of supplier uncertainty is associated with high level of supply chain integration. To ensure the integration of the supply chain, an organization must select its suppliers with caution. In addition, the research also shows that uncertainty from customer and technology will drive an organization to improve volume and launch flexibility to respond to the changing environment. In addition, it is also found that supplier uncertainty will lead to decreased supply chain integration. Those findings show the impact of each of sub-dimensions of environmental uncertainties (from customers, suppliers, technology) on supply chain performance may be different.

Appendix A: Items for the Constructs

Supply Chain Flexibility and Supply Chain Integration

Customization Flexibility: Our supply chain is able to handle difficult nonstandard orders; our supply chain is able to meet special customer specification; our supply chain is able to produce products characterized by numerous features options, sizes and colors. **Volume and Launch Flexibility:** our supply chain is able to rapidly adjust capacity so as to accelerate or decelerate production in Response to changes in customer demand; our supply chain is able to rapidly introduce large numbers of product improvements/variation; our supply chain is able to handle rapid introduction of new products. **Supply Chain Integration:** there is a high level of communication and coordination between all functions in our firm; cross-functional teams are frequently used for process design and improvement in our firm; there is a high level of integration of information systems in our firm; there is a great amount of cross-over of the activities of our firm and our trading partners.

Environmental Uncertainty

Customer Uncertainty: customers order different product combinations over the year; customers' product preferences change over the year. **Supplier Uncertainty:** the properties of materials from suppliers can vary greatly within the same batch; suppliers' engineering level is unpredictable; Suppliers' product quality is unpredictable; suppliers' delivery time can easily go wrong. **Technology Uncertainty:** technological changes provide opportunities for enhancing competitive advantage in our industry; technological breakthrough results in many new product ideas in our industry; improving technology generates new products frequently in our industry.

IT Enablers

Communication Tools: the extent of the usage of EDI in your firm to facilitate supply chain management; the extent of the usage of EFT in your firm to facilitate supply chain management; the extent of the usage of intranet in your firm to facilitate supply chain management; the extent of the usage of extranet in your firm to facilitate supply chain management. **Resource Planning Tools:** the extent of the usage of MRP in your firm to facilitate supply chain management; the extent of the usage of MRPII in your firm to facilitate supply chain management; the extent of the usage of ERP in your firm to facilitate supply chain management. **Supply Chain Management Tools:** the extent of the usage of DRP in your firm to facilitate supply chain management; the extent of the usage of CRM in your firm to facilitate supply chain management; the extent of the usage of SRM in your firm to facilitate supply chain management; the extent of the usage of VMI in your firm to facilitate supply chain management; the extent of the usage of DW in your firm to facilitate supply chain management; the extent of the usage of SCM Software in your firm.

Inter-organizational Relationships

Trust in Trading Partners: our trading partners have been open and honest in dealing with us; our trading partners respect the confidentiality of the information they receive from us; our transactions with trading partners do not have to be closely supervised. **Commitment of Trading Partners:** our trading partners have made sacrifices for us in the past; we have invested a lot of effort in our relationship with trading partners; our trading partners abide by agreements very well; we and our trading partners always try to keep each others' promises. **Shared Vision Between Trading Partners:** we and our trading partners have a similar understanding about the aims and objectives of the supply chain; we and our trading partners have a similar understanding about the importance of collaboration across the supply chain; we and our trading partners have a similar understanding about the importance of improvements that benefit the supply chain as a whole.

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