

The Impact of Supply Chain Strategy and Integration on Supply Chain Performance: Supply Chain Vulnerability as a Moderator

Yi-Chun Kuo, Jo-Chieh Lin

I. INTRODUCTION

Abstract—The objective of a supply chain strategy is to reduce waste and increase efficiency to attain cost benefits, and to guarantee supply chain flexibility when facing the ever-changing market environment in order to meet customer requirements. Strategy implementation aims to fulfill common goals and attain benefits by integrating upstream and downstream enterprises, sharing information, conducting common planning, and taking part in decision making, so as to enhance the overall performance of the supply chain. With the rise of outsourcing and globalization, the increasing dependence on suppliers and customers and the rapid development of information technology, the complexity and uncertainty of the supply chain have intensified, and supply chain vulnerability has surged, resulting in adverse effects on supply chain performance. Thus, this study aims to use supply chain vulnerability as a moderating variable and apply structural equation modeling (SEM) to determine the relationships among supply chain strategy, supply chain integration, and supply chain performance, as well as the moderating effect of supply chain vulnerability on supply chain performance. The data investigation of this study was questionnaires which were collected from the management level of enterprises in Taiwan and China, 149 questionnaires were received. The result of confirmatory factor analysis shows that the path coefficients of supply chain strategy on supply chain integration and supply chain performance are positive (0.497, $t = 4.914$; 0.748, $t = 5.919$), having a significantly positive effect. Supply chain integration is also significantly positively correlated to supply chain performance (0.192, $t = 2.273$). The moderating effects of supply chain vulnerability on supply chain strategy and supply chain integration to supply chain performance are significant (7.407; 4.687). In Taiwan, 97.73% of enterprises are small- and medium-sized enterprises (SMEs) focusing on receiving original equipment manufacturer (OEM) and original design manufacturer (ODM) orders. In order to meet the needs of customers and to respond to market changes, these enterprises especially focus on supply chain flexibility and their integration with the upstream and downstream enterprises. According to the observation of this research, the effect of supply chain vulnerability on supply chain performance is significant, and so enterprises need to attach great importance to the management of supply chain risk and conduct risk analysis on their suppliers in order to formulate response strategies when facing emergency situations. At the same time, risk management is incorporated into the supply chain so as to reduce the effect of supply chain vulnerability on the overall supply chain performance.

Keywords—Supply chain integration, supply chain performance, supply chain vulnerability, structural equation modeling.

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MAJOR in receiving OEM and ODM orders, Taiwanese enterprises play an important role in the global supply chain [35]. In 2017, Apple Inc., a renowned leader in technology, announced a list of its top 200 suppliers. 39 Taiwanese enterprises made up close to one fifth of the list, signifying that on this list, The Foxconn Technology Group ranked 98th in the 2017 Fortune Global 2000 listed companies. From an examination of the supply chain strategy of Foxconn Technology Group, we can find that, through supply chain integration, the Company can effectively dominate downstream marketing channels, increase bargaining power with upstream suppliers, and strengthen the connection with clients, thereby creating synergistic benefits that are unachievable by a single organization and, moreover, enhancing overall supply chain performance.

Changes in the market environment are intensifying. In addition to using their own resources, companies must cooperate with suppliers to create greater benefits. In order to achieve common goals and interests among partners in the supply chain, companies must adopt appropriate supply chain management. Strategy is seen as a concrete implementation of supply chain management decisions [19]. Reference [22] indicates that the supply chain strategies adopted by different product types will differ; they are divided into two main categories. The first type is the lean supply chain strategy, which aims to create cost-effectiveness and concentrates on reducing inventory, delivery time, and waste [33], [34]. The second is the agile supply chain strategy where the goal is to achieve rapid and continuous response to achieve supply chain flexibility when faced with changing customer needs in a competitive environment. Reference [25] states that lean supply chain strategy and agile supply chain strategy both emphasize a supply chain integration's importance in terms of reducing waste and compressing time; [7] shows that although the two strategies of lean and agile have different developments, both have a positive impact on supply chain integration.

Reference [2] points out that supply chain integration is a cooperative progress whereby companies plan to implement and operate the entire supply chain to improve competitiveness and delivery performance, ultimately achieving a mutually beneficial and common goal, and also improving the overall performance of the supply chain. Reference [17] also illustrates that enterprises can achieve greater supply chain performance through supply chain integration.

In the progress made in improving supply chain

performance, market uncertainty and complexity have increased, and supply chain risks also have increased due to globalization and the rapid development of technology. For example, due to forecast errors of market demand, overstocking will increase storage costs; changes in international circumstances will cause raw material prices to fluctuate and increase purchasing costs; natural or man-made disasters will affect production and cause supply chain disruptions. Negative events in any part of the supply chain may cause companies to face unprecedented changes. Taiwan's enterprises have played an important role in the global supply chain of many industries through their foundations of OEM and ODM [35]; therefore, they must pay particular attention to supply chain risk management.

References [6] and [32] point out that supply chain vulnerability is considered as a characteristic of supply chain risk. Reference [24] states that the main causes of supply chain vulnerability may be the outsourcing of enterprises, the emerging of the global market, the increasing dependence on suppliers and customers, and the rapid development of information technology.

Based on the above observations, this study aims to explore 1. The relationship between supply chain strategy and supply chain integration, 2. The impact of supply chain strategy on supply chain performance and 3. The impact of supply chain integration on supply chain performance. It also aims to use supply chain vulnerability as a moderator to test whether the impact of supply chain strategy and supply chain integration on supply chain performance is significant.

II. THEORETICAL FRAMEWORK AND HYPOTHESES

A. The Relationship between Supply Chain Strategy and Integration

Reference [28] indicates that a lean supply chain strategy aims to eliminate waste, improve efficiency and reduce cost. The promotion of establishing close partner relationships with suppliers and customers is considered as a fundamental driver of integration. An agile supply chain adapts to rapidly changing and increasing market segmentation; the assurance of flexibility and product availability may be taken as the driving force for integration. Reference [7] considers that lean and agile supply chain strategies are closely related concepts and can affect supply chain integration. Accordingly, this study proposes that:

- H1: Supply chain strategy is positively related to supply chain integration.

B. The Relationship between Supply Chain Integration and Performance

Reference [1] states that the higher the level of supply chain integration, the better the supply chain performance is. Other research results indicate that supply chain integration can improve performance [15]. Integration with supplier and customer can improve operating plans and solve the problems together that can reduce production costs and improves production flexibility. Therefore, enterprises with a higher level of supply chain integration demonstrate better supply chain

performance [9]. Furthermore, [20] suggests that enterprises should invest in plans to enhance supply chain integration. Therefore, this study proposes that:

- H2: Supply chain integration is positively related to supply chain performance.

C. The Relationship between Supply Chain Strategy and Performance

References [34] and [33] indicate that through a lean supply chain strategy, excess inventory can be eliminated and the set-up time of the supply chain reduces to adjust production ability, thus improving the quality of product in response to customers' needs, and enhancing supply chain performance. Reference [30] also implies that an agile supply chain strategy does help to improve supply chain performance, and has a significant effect on supply chain performance, perhaps because of its ability to provide a variety of products to meet changing market demands. Reference [14] found that the effects of lean and agile supply chain strategy on supply chain performance are positively significant. Therefore, this study proposes that:

- H3: Supply chain strategy is positively related to supply chain performance.

D. The Relationship between Supply Chain Strategy and Supply Chain Performance with the Moderating Effect of Supply Chain Vulnerability

The lean supply chain strategy aims to reduce waste [5], [12], [21], which means that under its strategy, there is less inventory under any process of production, and the buffering ability of any production chain is also small [23]. Currently, the market is unpredictable and unstable. A lean supply chain strategy will result in sub-optimal supply chain performance because it is unable to quickly respond to the needs and changes in the market [27].

The agile supply chain strategy emphasizes the ability to quickly respond to customer needs and market changes [3], [29], [36]. However, it requires more stock space to guarantee flexibility, in this situation, in regard to a poor supply chain performance due to the risk of a stock up.

In summary, [13] points out that while implanting this strategy is a means of improving supply chain performance, it also may be seen as increasing potential risk of a supply chain. In mathematics, vulnerability can be a measure of risk, in terms of it being a combination of the likelihood of an event and its potential severity. Therefore, this study proposes that:

- H4: Supply chain vulnerability will have a moderating effect on the relationship between supply chain strategy and performance.

E. The Relationship between Supply Chain Integration and Supply Chain Performance with the Moderating Effect of Supply Chain Vulnerability

References [8] and [18] state that enterprises tend to cooperate with the upstream and the downstream to achieve excellent synergies; however, [13] points out that with self-expansion and the tendency to integrate with different regions, the supply chain will be exposed to greater risks,

resulting in sub-optimal supply chain performance.

Reference [26] indicate that strong supply chain integration is more susceptible to uncertainties and accidents of other chains in the supply chain, such as after the terrorist attacks of September 11, 2001; the delay in delivery of components from abroad forced Ford and Toyota to stop production in the US [31]. Once this chain was interrupted, supply at the downstream was unstable and was unable to immediately respond to customers' needs, and was unable to optimize supply chain performance.

In summary, most literature points out that supply chain risk not only makes for effective supply chain integration, but also makes for a decline in supply chain performance. Furthermore, supply chain risk is a measure of the supply chain vulnerability [4]. Therefore, this study proposes that:

- H5: Supply chain vulnerability will have a moderating effect on the relationship between supply chain integration and performance.

III. RESEARCH METHODOLOGY

A. Data Collection

In this study, data were collected from management in various enterprises, mainly through the Internet and electronic questionnaires. We sent out 500 questionnaires and received 193 responses, for a receiving rate of 38.6%. A total of 149 questionnaires were valid, with a further 44 being incomplete. The response rate was 77%. Descriptive statistics for the respondents are given in Table I.

TABLE I
 DESCRIPTIVE STATISTICS FOR THE RESPONDENT ENTERPRISE PROFILES
 (N=149)

Information Characteristics		Samples	Percent
Founded time	Less than 2 years	13	8.7%
	2-5 years	16	10.7%
	6-10 years	19	12.8%
	More than 10 years	101	67.8%
Fixed Assets(NTD)(10 Thousand)	Less than 500	20	13.4%
	500 -999	19	12.8%
	1000-1999	24	16.1%
	2000-2999	15	10.1%
	More than 3000	71	47.7%
Employee	Less than 50	83	55.7%
	50-99	20	13.4%
	100 -199	11	7.4%
	200-299	4	2.7%
Industry	More than 300	31	20.8%
	Manufacturing	40	26.8%
	Construction	26	17.4%
	Wholesale and Retail Trade	28	18.8%
	Transportation and Storage	7	4.7%
	Electronics industry	17	11.4%
	Electro-Optical Industry	5	3.4%
	Textiles Mills	1	0.7%
	Medical Materials and Supplies	1	0.7%
	Manufacturing	1	0.7%
Others	24	16.1%	

B. Psychometric Properties

In order to confirm the consistency and reliability of the received questionnaires, a reliability and validity analysis was conducted using SPSS statistic 22 and AMOS 21.0. Cronbach's α was used as a measure according to [16], [10]. Component reliability (CR) was greater than 0.6, Average Variance Extracted (AVE) was greater than 0.5 as principle, and factor loading was greater than 0.5. CR and AVE met the criteria and at the same time exhibited convergent validity.

In Table II, we can find that the CR of a supply chain strategy is moderate and has convergent validity; CR of supply chain integration, supply chain performance and supply chain vulnerability are great and exhibit convergent validity. In addition, based on the study of [11], the correlation coefficient between two different contracts should be less than the square root of the AVE, signifying that it has a discriminant validity. Table III shows that supply chain strategy and supply chain integration, and supply chain integration and supply chain performance all have discriminant validity.

TABLE II
 RELIABILITY AND VALIDITY ANALYSIS

Latent variables	item	Mean	Standard error	Factor loading	CR	AVE	Cronbach's α
Supply chain strategy	X_3	4.20	0.726	0.734	0.773	0.531	0.770
	X_4	4.06	0.864	0.763			
	X_5	4.14	0.745	0.688			
Supply chain integration	Y_1	3.57	1.028	0.746	0.896	0.685	0.893
	Y_4	3.93	0.803	0.769			
	Y_5	3.65	0.900	0.872			
Supply chain performance	Y_6	3.70	0.868	0.911	0.858	0.602	0.855
	Y_7	4.10	0.760	0.712			
	Y_8	4.03	0.762	0.825			
Supply chain vulnerability	Y_9	3.91	0.825	0.786	0.825	0.613	0.824
	Y_{10}	4.06	0.764	0.776			
	M_4	3.62	0.835	0.834			
	M_5	3.62	0.819	0.796			
	M_6	3.83	0.844	0.713			

TABLE III
 RESULTS OF CORRELATIONS BETWEEN LATENT VARIABLES

Latent variables	Correlations (Square)		
	Supply chain strategy	Supply chain integration	Supply chain performance
Supply chain strategy	0.531		
Supply chain integration	0.247	0.685	
Supply chain performance	0.710	0.318	0.602

In this model, the model fit indices are CMIN/DF=2.082, RMR=0.043, GFI=0.909, AGFI=0.853, NFI=0.911, NNFI=0.935, IFI=0.952, PNFI=0.679, PGFI=0.564, which show that this model is acceptable.

After an analysis of SEM, the results are as shown in Fig. 1: The path coefficient of H₁ is 0.497, t-value is 4.914 which achieves a level of significance (>1.96), meaning that a supply chain strategy has a positive effect on supply chain integration; thus, Hypothesis 1 is supported. The path coefficient of H₂ is 0.192, t-value is 2.273 which achieves a level of significance (>1.96), meaning that supply chain integration has a positive

effect on supply chain performance, so Hypothesis 2 is supported. The path coefficient of H_3 is 0.748, t-value is 5.919, which achieves a level of significance (>1.96), meaning that supply chain strategy has a positive effect on supply chain performance. So Hypothesis 3 is supported.

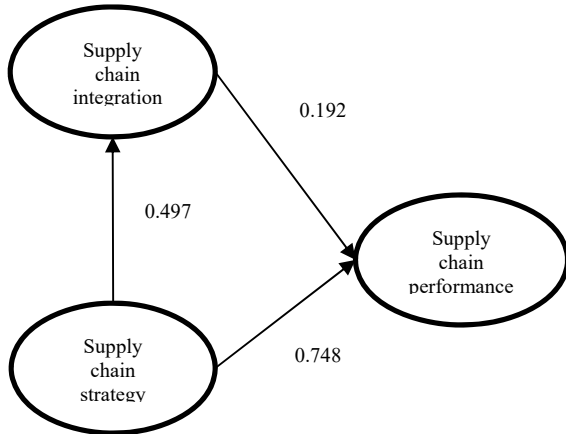


Fig. 1 The SEM result for the conceptual model

This study used AMOS 21.0 to examine the moderating effect of supply chain vulnerability. The results are shown in Figs. 2 and 3.

In Fig. 2, we can see that the path coefficient of “Strategy X Vulnerability” is 0.615, and t-value is 7.407, reaching significant level. Therefore, supply chain vulnerability has a moderating effect on the relationship of supply chain strategy and supply chain performance, so Hypothesis 4 is supported. Fig. 3 indicates that the path coefficient of “Integration X Vulnerability” is 0.761, and t-value is 4.687, reaching the significant level; therefore, supply chain vulnerability has a moderating effect on the relationship between supply chain integration and supply chain performance, so Hypothesis 5 is supported.

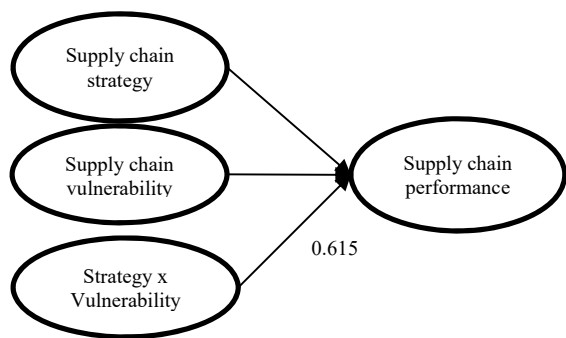


Fig. 2 Estimate model for Hypothesis 4

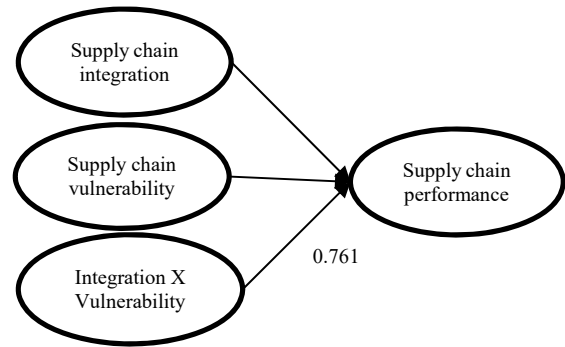


Fig. 3 Estimate model for Hypothesis 5

IV. CONCLUSIONS

The goal of an enterprise’s implementation of a supply chain strategy is to increase customer satisfaction. In order to achieve this goal, the integration of a supply chain in cooperation with supply chain partners for purposes of higher-level planning, communication and decision-making is important.

Currently, the maturity of advanced technologies such as Internet of Things, cloud computing, and big data help enterprises to forecast market trends, control and manage entire supply chains, take more accurate preventive actions, increase the degree of supply chain integration, reliability and effectiveness, and ultimately improve supply chain performance.

As a result of the empirical analysis of this study, we find that Taiwanese enterprises that adopt appropriate supply chain strategies and efficiently integrate with upstream and downstream enterprises positively affect supply chain performance.

The upstream and downstream enterprises in a supply chain are closely related. Mistakes in any part of these chains may cause considerable risk of losses to the entire supply chain. Therefore, supply chain risk cannot be ignored.

According to a 2016 report by the British Standards Institution (BSI) [2], the increase in terrorist attacks on the global supply chain will continue to impact supply chains. If the upstream side cannot supply in time, it will cause downstream shipments to be interrupted, resulting in the disruption of an entire supply chain.

The 2018 the Global Risk Report released by the World Economic Forum (WEF) [36] points out that the first ranked risk is that of extreme weather events and the second is that of natural disasters. These risks, such as changes in rainfall types, water shortages, extreme weather, etc., will affect supply chains that depend on natural resources, as well as impact the logistics of supply chains. Therefore, the issue of environmental climate change cannot be ignored. The third-ranked risk is cyberattacks, and the fourth is data fraud or theft; the risk of Internet information security is serious.

The impact of supply chain risk is becoming ever more of great concern, so enterprises should pay more attention to this issue. Supply chain vulnerability is regarded as the characteristic of the supply chain risk [6], [32]. Therefore, enterprises should analyze the vulnerability of their supply

chain in advance. This study uses supply chain vulnerability as a moderator. The questions for measuring the vulnerability of a supply chain include whether an enterprise adopts an outsourcing strategy, whether most of its materials come from global sources, and whether it relies on a single or small number of suppliers.

The questionnaire of this study were used to understand the supply chain vulnerability of Taiwanese enterprises, and to analyze whether or not supply chain vulnerability is a significant variable that affects the performance of a supply chain. The results of the study show that supply chain vulnerability will affect supply chain strategy, supply chain integration and supply chain performance. They also indicate that when enterprises conduct risk analyses, establish response strategies in the face of emergencies, and regard supply chain risk management as an important corporate action, they will effectively improve their overall supply chain performance.

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