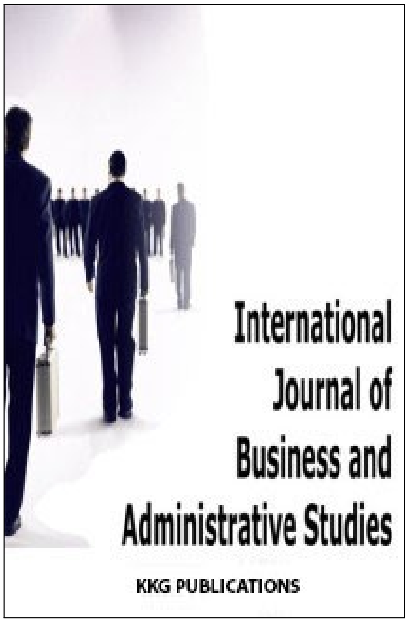

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VULNERABILITY OF MULTINATIONAL RETAILING DELIVERY SERVICE: A CASE STUDY OF TAOBAO

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Abstract. With fast growth of broadband internet connection, online shopping has become a popular channel for young people. It is necessary for e-retail to provide a reliable, efficient and powerful delivery system in order to send goods to customer fast and safely. For the past few years, TAOBAO is more and more important e-commerce for China and Taiwan. Risk management is regarded as the important issue in supply chain management, and the vulnerability is the new concept of risk analysis. From the point of view of risk management, the multinational delivery plays an important role more in the field of e-commerce, and logistics process is complicated and has a lot of risks. However, there are fewer studies focused on the vulnerability issue of the logistics process, especially for the case of TAOBAO. If managers understand the most vulnerable parts in all businesses, they could take actions and know how to allocate resources to avoid risks from happening. The objective of this study is to develop an evaluation model and discuss the risk of logistic delivery system via the Fuzzy Cognitive Map (FCM) and Sensitivity Model (SM). This study focuses on a theoretical model intended to capture the dynamic operation process of the multinational retailing delivery service system of TAOBAO. We establish an evaluation model to analyze and describe the vulnerability using the Fuzzy Cognitive Maps and different scenarios are implemented, observed, and appraised. Finally, we will provide some discussion and build management strategy to help managers reduce the risks proactively as well.

INTRODUCTION

Under the objective of maximizing efficiency, economic activity can form characteristics of globalization or regional integration, such as the EU or ASEAN, through rapid logistics development and information technology advances. Globalization refers to connecting production and consumption around the world through an effective supply chain. Take for example riding boots in Wal-Mart in the United States. The orders are taken in Taiwan, and the manufacturing is done in China. Leather and zippers, which are the raw materials, come from China and Japan, respectively. The finished products are distributed to Hong Kong via land transportation, and Japan's international freight forwarders look after the international transport and clearance operations. The products are transported in Singapore's container vessels to the United States by sea, and then trucks distribute the products to the retail stores. To reach high efficiency and low cost targets, designs of supply chain systems are increasingly seeking lower inventory levels for smaller buffer spaces. The most efficient logistics method can be used to produce, distribute, and sell products in the globalization model; however, constantly adopting the most efficient method causes supply chain disruptions and hazardous events, which gradually complicate the supply chain structure. Supply chain members must collaborate closely across countries in order to prevent supply chain disruptions (Sheffi & Rice, 2005).

It can be known from the literature review that vulnerability is generally divided into three dimensions for discussion (Wagner & Bode, 2009; Peck, 2007; Oren & Longo, 2008; Aven, 2015): I. Natural dimension: The emphasis is on the influence of nature or disasters; II. Response dimension: The emphasis is on the social structure, including history, culture, society, economy, and other forces; III. Local dimension: Disasters are products operating in specific regions or under natural and social structure dimensions. In the exploration of vulnerability, two characteristics of the system, exposure and adaptive capacity, must be carefully studied. Exposure refers to the risk of experiencing hazardous events (Tsadiras, Kouskouvelis & Margaritis, 2003; Cutter, Boruff & Shirley, 2003). Adaptive capacity includes the ability to withstand shocks and continue operations. After reviewing the definitions of supply chain vulnerability, we decided to use Wagner and Bode's (2009) definition as reference. We defined delivery vulnerability as follows: The risk of the multinational delivery system is constructed by the system's vulnerability and recovery.

To clarify which factors are important variables in analyzing the multinational retailing delivery risk, we adopted the perspective of multinational stores with logistical service providers and used management thinking to explore the factors influencing the vulnerability of multinational stores with

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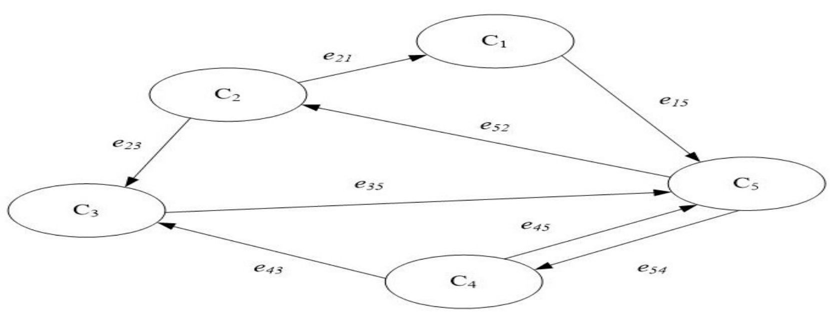
a logistics service system and the relationships between the factors (Tierney & Bruneau, 2007). The study also proposes a management strategy for the risks of supply chain disruptions to improve the considerations of businesses facing supply chain risk management topics.

METHODOLOGY

Cognitive Maps (CM) have been deemed as a useful tool in problem-solving. However, one major limitation exists in CMs, that is, the restriction of quantifying relations among variables. In order to overcome the weakness embedded in the cognitive maps, fuzzy numbers were incorporated to form a new technique called Fuzzy Cognitive Map. Fuzzy Cognitive Map (FCM) is a symbolic method for modeling and controlling a system which relies on expert experience and follows the principle of decreasing precision with increasing intelligence. FCM is an extension of cognitive maps, and it is useful in modeling complex systems.

FCM is comparatively easier to quantify, and then foretells state transitions through a simple matrix calculation. Due to the advantage, FCM has been applied to not only social science such as investment analysis problems (Lau, Jiang, Ip & Wang, 2010), political problems, and critical success factors modeling for an IT project process, but also to engineering such as behavioral analysis of electronic circuit and knowledge modeling for urban design (Bueno & Salmeron, 2008; Lee, Kim, Chung & Kwon, 2002; Rodriguez-Repiso, Setchi & Salmeron, 2007). A FCM model is a dynamic complex system as a collection of concepts and causal relations between concepts. Nodes of the graph stand for the concepts that are used to describe the behavior of the system and they are connected by signed and weighted interconnections representing the causal relationships existing between the concepts. The graphical illustration of FCM is similar to the cognitive map. FCM also consists of nodes, signs but the additional element, directional and weighted arcs, are incorporated into the map. Nodes in the graph stand for the concepts that describe the behaviors in the objective environment and they are connected by signed and weighted interconnections that represent the causal relationships among the concepts, as shown in fig.1.

FIGURE 1
Cognitive Map with Concepts and Weighted Causal Relationship



Further in calculation, FCM uses a fuzzy value between -1 and 1. FCM can be represented as equation 1 by a $n \times n$ adjacency matrix (E), while n is the number of nodes. By values within [1, 1], each e_{ij} means the strength of causal relationship between the i and j concepts. Consequently, three types of relationships can be seen: (a) e_{ij}>0, indicating a positive relationship, (b) e_{ij}<0, indicating a negative relationship, and (c) $e_{ij} = 0$, where no relationship exists.

$$\text{E} = \begin{matrix} e_{11} & \cdots & e_{1n} \\ \vdots & e_{ij} & \vdots \\ e_{n1} & \cdots & e_{nn} \end{matrix} \qquad (1)$$

When an expert assigns an eij value, three issues must be kept in mind (Schneider, Shnaider, Kandel & Chew, 1998). First, the e_{ij} indicates how strong a causal influence the i concept casts on j. Second, the strength of relationship precedes a fuzzy weight with a positive or negative sign, representing whether that relationship is direct or inverse respectively. Last but not least, the causal relationship needs to be shown to establish if the i concept is a cause of j or vice-versa. However, to have a consensus among the experts with FCM is relatively difficult because every expert may have their own opinions, leading to the difficulty in explanation.

Once the adjacency matrix is available, a new value for each concept that is calculated according to the following equation could be acquired:

$$C_i = (t_{n+1}) = S[\sum e_{ki}(t_n)C_k(t_n)] \qquad (2)$$

Namely, $C_i(t_{n+1})$ is the value of concept C_i at step $tn + 1$, $C_k(t_n)$ is the value of concept C_k at step t_n, and $e_{ki}(t_n)$ is the strength of causal relationship from concept C_j to concept C_i and $S(x)$ is a bounded signal function that transforms the result of the multiplication in the interval [0,1].

$S(x)$ is a threshold function that squashes the result of the multiplication in the interval [0, 1]. The logistics signal function has been used to transform to an S-shaped curve as the following eq. (3).

$$S(x) = \frac{1}{(1+e^{-ax})} \quad (3)$$

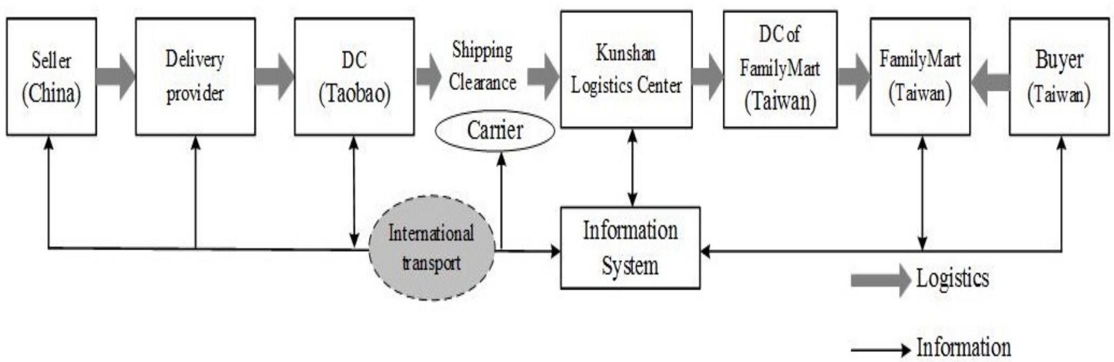
The fundamental ideas of SM and FCM, which make them different from other planning approaches, include system thinking, and the use of fuzzy set theory. The Sensitivity model was by no means used for the first time in logistics, and here the use of SM is to make sure if all these problems are included. The study applies the methodology Fuzzy Cognitive Maps to model and explore the operation for multinational retailing delivery system.

RESEARCH CASE

Multinational Store Retailing Delivery of TAOBAO

The Retailing Delivery (RD) system is playing a very important role of logistics system in Taiwan. Retail delivery of e-commerce in Taiwan is more than 16, in 2014, Family Mart (Taiwan) and TAOBAO have integrated their information system and logistics system, providing a new RD model: multinational store retailing delivery service. Based on the logistics service, online seller (Taobao.com) can provide their service for their customers in China, the Taiwan's buyers can choose products through the online auction in Taiwan, and pick up their products in Family Mart (Taiwan). Fig. 2 explains the integrated supply chain management model of the case study. From fig. 2, it can be known that the main members making up the multinational convenience stores and logistics service system can be divided into supermarkets, logistics, information, and multinational transportation businesses.

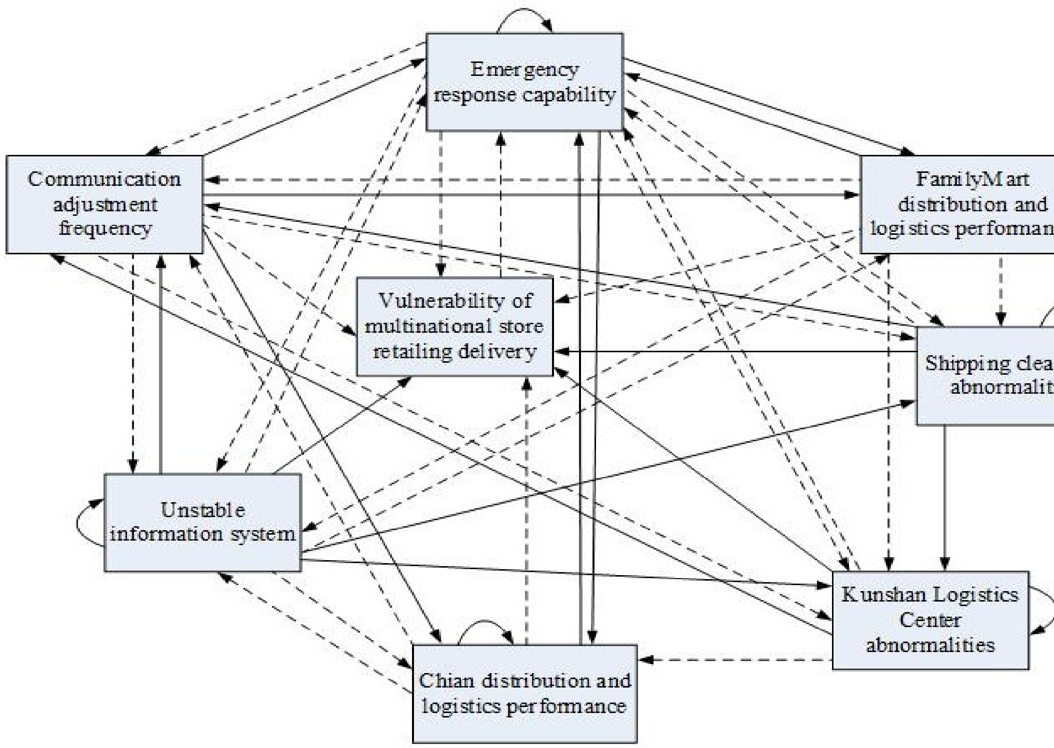
FIGURE 2
Basic Concept of Multinational Store Retailing Delivery Service



Multinational Store-to-Store Retailing Delivery FCM is a fuzzy cognitive map in which the relations between the concepts can be used to compute the "strength of relationship" for these elements. It helps demonstrate or simulate how experts deliberate upon a particular issue. In addition, it puts causal relationships in use and provides functionalities of feedbacks. The Fuzzy Cognitive Map combines the cognitive maps of psychology and the fuzzy relationship to explore the system association model. Little literature has been published on the multinational retailing delivery approach with FCM model, the study is more like an exploratory research.

In order to build up the fuzzy cognitive maps to capture the insightful characteristics on the problems, the construction of concepts is primarily based on: (1) The literature and (2) In-depth interviews with experts within the multinational retailing delivery service. From the in-depth interviews and literature review (Verhulst, 2014; Tokar, Aloysius, Waller & Williams, 2011; Lado, Paulraj & Chen, 2011; Hartmann & de Grahl, 2012; Lambert, GarciaDastugue & Croxton, 2005), this study constructed factors influencing the vulnerability of multinational stores and logistics service system and conducted a data collection through the expert questionnaire. This paper conducted a survey on practicing experts with relevant experience in managing multinational stores and logistics service system. The questionnaire survey design was set up through Taiwan FamilyMart's delivery service and Taobao's pickup services. According to the in-depth interviews and literature review, this study constructed eight variables that influence the case study's logistics vulnerability: Taiwan FamilyMart distribution and logistics performance, shipping clearance abnormalities, Kunshan Logistics Center abnormalities, and logistics performance, unstable information system, communication coordination frequency, and emergency response capability. Table 1 explains the definitions of the variables in the fuzzy recognition map. The proposed fuzzy cognitive map (fig. 3) is constructed according to the defined system scope and problems they encounter. The structure uses the cognitive map concept to connect the positive and negative relationships between variables. In the proposed FCM, directional arc represents the causal relationship.

FIGURE 3
An Example of a Fuzzy Cognitive Map with Concepts and Causal Relationship



EMPIRICAL ANALYSIS AND RESULTS

Sample Source and Input

For the questionnaire respondents, this paper chose nine supply chain members who were experts with managerial positions or higher. In the study's questionnaire format, these experts were invited to write the status of each variable, and the degree of influence each variable has on the other variables. According to the data collection and processing, the data gathered and operated are as in table 1. Thus, the following weight matrix for the FCM could be produced: Showing the negative impact, no impact, or positive impact, and revealing the strength of impact to concepts in the column on those in the row.

Table 1 shows the nine experts' geometric means of variables affecting the weight matrix (the advantage of Geometric mean is more stable even if extreme value exists). The values range between 0 and 1. The closer they are to 1, the higher the degree of influence. Positive values represent that the influence is positive, and negative values represent that the influence is negative. The value interval of the status variable is 0-1. The closer the value of the status variable is to 0, the worse the system status is (or better depending on the definitions of the variables). When the value of the status variable is 1, this represents that the status of the variable is the better (or worse depending on the definitions of the variables).

TABLE 1
The Input Data

	X1	X2	X3	X4	X5	X6	X7	X8	Stage
X1	0.8	-0.3	-0.3	0	-0.4	-0.2	0.2	-0.5	0.80
X2	0	0.85	0.3	0	0	0.26	-0.74	0.78	0.55
X3	0	0	0.35	-0.7	0.45	0.4	-0.4	0.65	0.48
X4	0	0	0	0.83	-0.4	-0.53	0.78	-0.73	0.43
X5	-0.3	0.1	0.66	-0.74	0.15	0.65	-0.73	0.84	0.52
X6	0.24	-0.16	-0.45	0.3	-0.24	0	0.5	-0.5	0.15
X7	0.41	-0.23	-0.4	0.25	-0.35	-0.56	0.3	-0.74	0.33
X8	0	0	0	0	0	0.7	0	0	0.70

Results

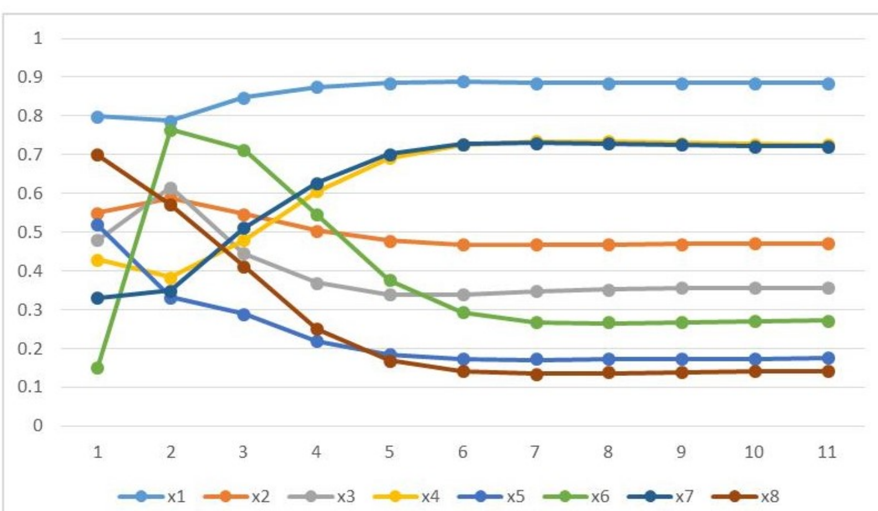
In equation (4), $x_{i(t)}$ represents the status of period t in variable i; the values of x_i range between 0 and 1. The closer variable x_i is to 1, the better the status of variable xi (or worse according to the variable's definition and differences). The variable w_{ji} is the weight value of variable $j's$ influence on variable i; the values of w_{ji} will be less than 1, positively representing that variable j has a positive influence on variable i and negatively representing that variable j has a negative influence on variable i. The higher is the value of w_{ji}, the higher the degree of influence. In Equation (4), the status of period $t+1$ in variable X_i is determined by the status of all the variables at period t influencing variable X_i. The conversion function f makes sure every iteration of the fuzzy cognitive map converges the variable range to the initial range set, and converts the value of $x_{i(t)}$ to a value between 0 and 1. This paper chose the logistical signal function as the conversion function. The common range setting of parameter λ is 0.2-5. The setting of λ is related to variable amounts in the fuzzy cognitive map and the complexity between variables. According to the characteristics setting in the fuzzy cognitive map, this study's λ value is set as 2.

$$x_i(t) = f \cdot (\sum_{\substack{j=1 \\ j \neq i}}^{n} x_j(t-1) w_{ji}),\ f = \frac{1}{1+e^{-\lambda x}} \tag{4}$$

According to the starting values of status variables and the weight matrix of influences between variables, the analysis steps for equation (4) were done to conduct the iteration calculations. Changes that occurred at any time in the system variables could be found. The interviewed experts expressed that when the multinational logistics system encountered external environment changes and needed to change, the time needed to prepare and change the results was about a week. A week's time includes (1) holding a meeting to determine the contents of operations that need to be repaired, (2) relevant unit making operation adjustments, and (3) announcing the changes to all units and starting to implement new operations. In addition, in a research on logistics operations, Huang, Feng, Wang and Jeng (2010) set each iteration of the Fuzzy cognitive map to a week as the managers implied. Therefore, in referring to the interviewed experts and the study's literature review of definitions, this paper set each iteration calculation to a week as the managers implied.

Fig. 4 explains the dynamic changes of the system variables and the final state of the status variables. As fig. 3 shows, this research constructed 8 variables of the fuzzy cognitive map and iterated up to 8 times. The majority of results reached stability. The definition is when the logistics service produced problems, each member of the supply chain could hold a meeting to resolve the problem. Therefore, this dynamic change map shows it takes approximately 2 months for the logistics service system to stabilize. The pattern analysis results can reveal the factors influencing the vulnerability of multinational stores and distribution logistics. After the eighth week of operation, each variable showed improvement. "FamilyMart distribution and logistics performance" increased from 0.8 to 0.88; "shipping clearance abnormalities" decreased from 0.55 to 0.47; "Chain distribution and logistics performance" increased from 0.43 to 0.73; "unstable information system" decreased from 0.52 to 0.17; "communication coordination frequency" increased from 0.15 to 0.27; "emergency response capability" increased from 0.33 to 0.72; and "system vulnerability" decreased from 0.7 to 0.13.

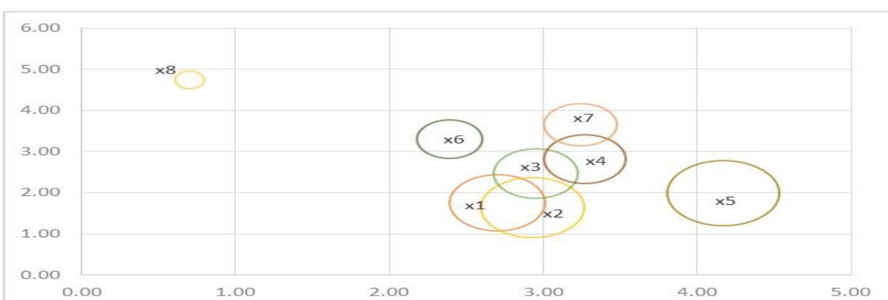
FIGURE 4
The Output of Proposed FCM



Then, this paper explored the Fuzzy cognitive map through the sensitivity model. The variables act as key influencing factors. In the influence weight matrix, AS is the Active Sum, which represents the sum of variables that influence other variables. The greater is the AS value of variables, the greater the degree to which a variable influences other variables. PS is the Passive Sum, which represents the degree to which a variable receives the influence of other variables. The variable Q is the ratio of AS/PS. The greater is the Q value, more difficult it is for the variable to influence other variables and to receive the influence of other variables. According to AS and PS, sensitivity can be obtained in the Fuzzy cognitive map (fig. 5). The further the variable is from the original point, the more is the size of the Q value that can represent the area size of the variable in fig. 5.

From fig. 5 it can be seen that among the factors that influenced the system's vulnerability, "unstable information system", "Taiwan FamilyMart's distribution and logistics performance" and "shipping clearance abnormalities" are the three most important variables. Because these factors more easily influence other factors and are not easily influenced by other factors, when the performances of the three variables worsen, the vulnerability of the multinational store distribution and logistics system will also receive a bigger attack. Take the information system for example. After supply chain members complete every logistics operation, they must return the logistics status, benefitting other members to complete subsequent logistics operations. Therefore, when the information system is unstable (instability may be that other supply chain members did not in the provisioned time upload the correct logistics information in the stable format), this will produce an immediate impact on the multinational store and distribution and logistics system. Because Taiwan FamilyMart's distribution and logistics factor belongs to the most upstream part of the whole multinational distribution and logistics system, once a problem occurs, it will have a chain reaction on subsequent logistics operations. Shipping clearance abnormalities are the least controllable by supply chain members because clearance operations often control entrance operations more severely than exits. Therefore, once clearance operations in Fuzhou, China, are delayed by factors, it will produce an immediate impact on the subsequent logistics and distribution operations.

FIGURE 5
Result of Sensitivity Model



CONCLUSION

China is already one of the world's most important markets. In recent years, in addition to playing the role of world's manufacturer, China has noticeably developed e-commerce. Along with the cross-strait signing of the Economic Cooperation Framework Agreement (ECFA), the mutual trade and economic cooperation cannot avoid being increasingly close. The supply chain is facing more and more risks. Therefore, the supply chain managers must further clarify which internal or external hazard events will influence the supply chain system, and make sure the supply chain can rapidly recover operation after receiving these hazard events. This study used the multinational distribution and logistics service as the case study and constructed the vulnerability factors influencing the multinational store distribution and logistics service system. The factors are Family Mart's distribution and logistics performance, shipping clearance abnormalities, Kushan Logistics Centre abnormalities, China distribution and logistics performance, unstable information system, communication coordination frequency, and emergency response capability. The analysis results show that the system's factors after 8 weeks of operation reached a stable status, and the three most important factors that influenced the system's vulnerability were unstable information system, FamilyMart's distribution and logistics system, and shipping clearance abnormalities.

In the future, all industry supply chain systems will face many challenges. Along with the development of related technologies in logistics and distribution, the derived logistics service patterns are also becoming increasingly diverse. The logistics industry cannot avoid encountering more cross-industry competition. In facing these external environment changes, each industry's supply chain management personnel must develop the industry's supply chain risk identification and evaluation indicators. Through each industry's characteristics, the prevention strategies and risk mitigation mechanisms are studied. Management employees must build a robust supply chain system and build an anti-fragile logistics and supply chain system, to achieve the objective of reducing the supply chain system vulnerability and enhancing the system's recovery ability.

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