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# ON-JOB COURSE TRAINING FOR SUPPLY CHAIN DISRUPTIONS SUPPORT IN THE ELECTRONICS INDUSTRY

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## Abstract

Most supply chain management personnel exhibit weak capabilities in response to supply chain disruptions. This might be because such personnel have not received comprehensive supply chain training, which results in insufficient responses in an emergency. According to the case studies used in this research, the proposed course package not only enhanced supply chain staff members' capabilities of emergency responses. This procedure facilitated relatively efficient responses from all staff members in relevant departments together with upstream clients and downstream clients in the occurrence of emergency. Therefore, these on-job training courses can enhance their emergency responses to supply chain disruptions.

Key Words: Analysis Study on Supply Chain Disruptions, Experts Weighting, QFD Analysis, Training Courses Training

## Introduction

Because of temporal and spatial changes occurring in external supply chains have increased the possibility of supply chain disruptions. Such a condition could lead to severe supply chain and material disruptions, thereby creating substantial manufacturer losses.

Therefore, the present study designed a course package that fulfills the needs of supply chain managers and could serve as a reference for employers to introduce relevant training courses to equip staff members with the abilities to solve problems of supply chain disruptions efficiently. According to the identified factors and solution strategies of supply chain disruptions from a litera-

ture review, this study combined a questionnaire and interviews with experts in the industry to obtain their opinions on what the most essential expertise and strategies are for supply chain managers. Subsequently, this study calculated the weight of each expert using an expert-weighting method and identified courses in academia that corresponded with the expert-suggested strategies. A quality function deployment (QFD) analysis was used to understand the correlation between learning courses and their corresponding strategies, and the correlation results were subsequently combined with the weights of experts to obtain the importance ranking of all courses. Finally, this study used the ranking to design a course package that as well as explained and verified the course package with a case study.

## Literature Review

### *Supply chain disruption analysis and corresponding strategies*

Based on a study of the bullwhip effect (Lee, 1997), incidents occurring in any nodes within a supply chain are enlarged, which considerably hinders the operation of the entire supply chain. Chuang (2012) stated that in an entire supply chain system, the relationships between upstream and downstream firms are critical to disruption management. Zhang et al. (2014) noted that numerous unpredictable catastrophes had occurred in the previous few years and natural disasters, indicating a rise in uncertainty and vulnerability in the global supply chain system. Li et al. (2013) explained the damages, namely financial losses and operation failures, caused by supply disruptions. For example, in 2007, Land Rover laid off 1400 of their employees because its main supplier failed to pay their own debts. Li et al. (2013) proposed various approaches to manage supply disruptions, including a safety inventory, flexible supply, self-production, outsourcing, postponement strategy, and dual source. Ivanov et al. (2014) compiled numerous historical events that contributed to supply chain disruptions, including the earthquake and tsunami in Japan on March 11, 2011, the influence of which was instantly disseminated worldwide (Marsh et al., 2011; Roh, 2013). After this incident, Toyota reduced its production volume and lost its leading position among automobile manufacturers. Chopra and Sodhi (2004) divided the potential risks of supply chains into nine categories. Other studies have researched supply chain disruption risks caused by reduced corporate responsibilities (Cruz, 2013) and established comprehensive recycling systems (Bloemhof et al., 1995; Hill, 1997). Fabian (2000) suggested that poor corporate social responsibility performance in all stages within a supply chain could damage the most instrumental asset of a company. (Emmelhainz & Adams, 1999; Kolk & Tudder, 2002).

Various scholars have conducted empirical studies on the relationships among corporate social responsibility, risk, and profit (Clarkson, 1991; Kotter & Heskett, 1992; Collins & Porras, 1995; Waddock & Graves, 1997; Berman et al., 1999; Roman et al., 1999; Dowling, 2001; Fombrun, 2001). Pang et al. (2014) developed a three-level supply chain contract, which was based on the concepts of revenue sharing and price-

dependent demand and facilitated supply chain disruption management. Sawik (2013) introduced a new method of stochastic-mixed-integer programming to integrate the selection of suppliers. Chang and Cheng (2013) compiled studies and categorized disasters affecting a supply chain into natural disasters (i. e., earthquakes, windstorms, tsunami, SARS, bird flu, and wildfires), and manmade disasters (specifically terrorist attacks and strikes) (Kleindorfer & Saas, 2005). Stecke and Kumar (2009) proposed corresponding strategies for supply chain disruptions, including substitute vendors, substitute materials, diverse outsourcing, replication strategies (Chris, 1998), flexible transportation, and transparent information. Blackhurst (2005) suggested that increased global procurement has created supply chain disruption risks.

Tsai et al. (2009) proposed a postponement strategy that reduced the lead time in the supply chain and facilitated more flexible production capacity. Wang (2008) acknowledged the positive influence of radio-frequency identification (RFID) technology on the performance of a supply chain. Other studies have explored the supply chains of modular products, which exhibit substitutability, and suggested that multisource procurement (Wagner & Bode, 2006) and standardized components (Sheffi, 2005) reduced the recovery time from supply chain disruptions to normal operation. Other systems related to inventory and transportation management are the just-in-time inventory (JIT) system (Ohno, 1995), cross-dock management (Apte, 2000), strategic inventory and transportation, and collaborative production (Chung, 2004). The present study adopted the supply chain classification proposed by Sheffi (2005) and the three supply chain disruption types categorized by Chang et al. (2013). Subsequently, these generated strategies were used to design a questionnaire and interview surveys for experts, and the results were analyzed using an expert-weighting method to determine the weight of each corresponding strategy.

### *Expert-weighting*

The first and most prominent expert-weighting method is the Delphi method, which was developed by Helmer and Gordon in the twentieth century and modified by Murry and Hommons in 1995. The Likert scale was developed by psychologist Rensis Likert (1932); it is predominantly used in questionnaire design, and is the most widely used instrument among researchers. For example, Fare and Hunsaker (1986) proposed a method of weight restriction; Shang and Sueyoshi (1995) applied weight restriction to a flexible production system and obtained a more favorable evaluation result; and Kao (1997) developed an efficiency evaluation method using average weights and self-defined weights. Cheng (2005) noted that criteria weights influence the results of weight evaluation methods; specifically, various criteria weights could result in varying evaluation results. To establish an expert-weighting method, Bao et al. (2015) focused on numerous variable weights that were unable to be evaluated accurately and improve the existing weight evaluation method. This approach strengthened the discrimination among originally evaluated weights by using

internal variance to increase the sum of matrix rows, and the results of this approach could be used as weights of expected values and incorporated into subsequent QFD analyses.

### *QFD analysis*

A QFD approach is a type of client-oriented process planning and was first introduced by Akao (1972) in Japan. Chan and Wu (2002) stated that a product design specification determined using a QFD approach was underpinned by client needs and competitive analyses. Studies have also demonstrated other applications of QFD in various critical decision-making processes, including confirming client needs (Stratton, 1989), determining development focus (Han, 1998), establishing annual policies (Philip, 1994), and determining production strategies (Crowe & Cheng, 1996; Jugulum & Sefik, 1998). Chen et al. (2009) suggested that a QFD approach is a method for client-driven product development as well as one for quality assurance in a product design stage. Bossert (1991) proposed the framework of house of quality (HOQ), which facilitated the determination of improvement priorities using a relationship matrix between client expectations and engineering technology. Alireza et al. (2013) suggested an application of HOQ in supplier selection. Therefore, underpinned by the research entailing the incorporation of weights in QFD (Bao et al., 2013).

## Research Methods

First, a questionnaire on supply chain disruption solution strategies for experts was designed. Second, this study calculated the weights of corresponding strategies according to the normalized data and used the calculation results as the weights for subsequent QFD analyses. Third, this study compiled all relevant courses concerning supply chain disruption management in academia, existing strategies for such disruptions, and questionnaires for professionals involved in these courses. Fourth, a QFD analysis, accompanied by the weights of experts and the rated importance of solution strategies, was conducted to obtain a weight ranking list of all courses.

### *Questionnaire for experts*

This study compiled the aforementioned existing solution strategies to design a questionnaire for experts. The questionnaire featured content asking experts how supply chain management staff members can be equipped with the fundamental capabilities to prevent supply chain disruptions and instantly and appropriately manage such incidents when they occur. For preventing or solving supply chain disruptions and rate the score for each strategy.

### *Expert-weighting method*

The interview responses were collected managers in the supply chain-related departments of numerous electronics manufacturers. These experts were asked to provide their perceived importance of each solution strategy based on their experiences of supply chain disruptions. Subsequently, an expert-weighting method was used to calculate the weight of each strategy according to the importance result provided by these experts, and the calcu-

lated weights were used in the following QFD analysis. The expert-weighting method used by this study involved experts rating the importance of each variable. Furthermore, this expert-weighting method increased the discrimination among the originally weighted values. Conventionally, the importance of each questionnaire item is only compared based on the column sums in matrix X; specifically, a higher column sum of a questionnaire item indicates higher importance of this item. However, such a simplified calculation could lead to failure in comparing the importance among questionnaire items when the sum of ratings for each item (each column) is equal to that for other items. Therefore, when comparing the column sums with row sums in matrix TT does not reveal the relative importance of questionnaire items, this matrix should be transposed into matrix TTr. By dividing matrix TT by matrix TTr, the following matrix T' is obtained. This process increases the discrimination among the ratings of questionnaire items and facilitates an evaluation based on each variable. Finally, the row sums in matrix T are normalized, and the weight of each questionnaire item is obtained.

*Supply chain management courses and the questionnaires concerning corresponding strategies*

Regarding the analysis of related courses, this study visited departments that provided courses related to supply chain management in Taiwan. According to the discussion and compilation results, we interviewed managers of electronics companies and recruited staff members to respond to the questionnaire.

In the questionnaire design, each row represents a corresponding strategy, which corresponds to the columns of teaching courses. Respondents were requested to provide a correlation coefficient for the relatedness between each corresponding strategy and the corresponding teaching course according to their operational experiences.

*Course importance ranking based on a QFD method*

The HOQ framework used in this study. Elements of this framework are as follows: (A) This study compiled all strategies that the industry expected to solve or reduce supply chain disruption risks through their use. (B) Expected weights: the weights of the corresponding strategies were incorporated into the framework. (C) Teaching courses: relevant courses of supply chain management are listed. (D) The relationship matrix between client expectations and teaching courses was used to obtain the correlation coefficients between corresponding strategies and teaching courses rated by supply chain managers in the electronics industry. (E) Course planning priorities: the importance rankings of all course planning were calculated. (Figure 1).

The calculation of QFD is shown in Table 1, and the calculation steps for course ranking are as follows:

Calculate the weighted average of each course using the following equation.

$$P_j = \sum_{i=1}^{n} C_i W_{ij}$$

Table 1. *QFD Table*

| | Experts' Weights | | Training Curriculum | | | |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | … | *m* |
| Industry Requirements | $C_1$ | 1 | $W_{11}$ | $W_{12}$ | … | $W_{1m}$ |
| | $C_2$ | 2 | $W_{21}$ | $W_{22}$ | … | $W_{2m}$ |
| | ⋮ | ⋮ | ⋮ | ⋮ | Wij | ⋮ |
| | $C_n$ | n | $W_{n1}$ | $W_{n2}$ | | $W_{nm}$ |
| Weighted Average Pj | | | $P_1$ | $P_2$ | | $P_m$ |
| Course Importance Ranking Tj | | | $T_1$ | $T_2$ | | $T_m$ |

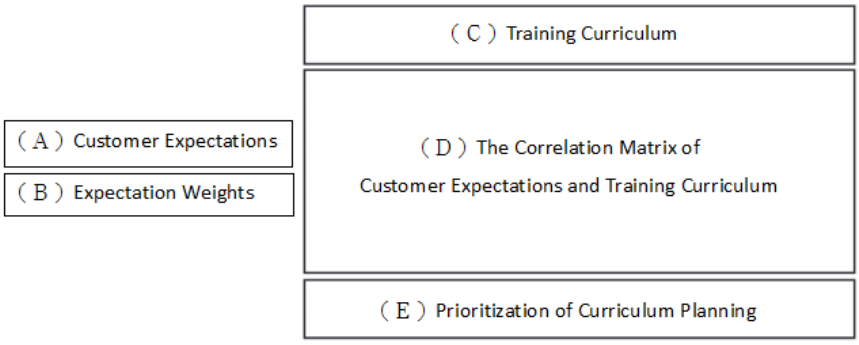


Figure 1. Structure Diagram for House of Quality (HOQ)

where:

Ci: weight of the corresponding strategy in row i ( i=1, 2, …, n )
Wij: weight coefficient of the relationship matrix ( i=1, 2, …, n, j=1, 2, …, m )
m: number of teaching courses
n: number of corresponding strategies
Use Tj for the course importance ranking.

## Case Study

This study interviewed supply chain operations managers, their instant management actions for such incidents, and the instant management actions and performance of their coworkers from the experimental group, who had received training courses in response to supply chain disruptions.

### *Training course planning*

The top 10 crucial courses, their course outlines, and their course objectives are presented. Schedules for these courses are planned by companies, and all courses are scheduled to be 12 hours.

*Performance of operations after training*

All strategies for alleviating supply chain disruptions are developed based on cross-department collaboration, which contributes to improving supply chain efficiency when disruptions occur. These strategies correspond to the aforementioned top 10 crucial learning courses. Based on the aforementioned course content and analyses on actual operations, this study established an SOP for emergency responses. The procedure is briefly explained as follows:

Step 1: All onsite staff members are gathered for announcement and a collective approach is adopted; everyone is notified by a text message to their personal cell phones.

Step 2: Emergency response teams are formulated: a data report team, liaison team, situation management team, and news announcement team.

Step 3: A comprehensive supply chain database of all materials is established and all suppliers are requested to upload their operation progress of WIP; a database is constructed that comprises the place of origin of materials and raw materials; and the suppliers are required to upload their stock level and WIP stock conditions within 1 hour. Such an emergency response procedure is finished when the emergency situation is under control and suppliers are able to deliver on time

Step 4: Meetings are held and situations are reported regularly. Members of each team adjust and implement their response plans according to the reported situations.

Step 5: All available resources are continually examined and exploited, including all departments in a company, and all response mechanisms are activated, such as second suppliers, transportation support, and vendors' responses to emergency.

Step 6: A process report is presented after the emergency is over; cases are recorded and shared.

## Conclusion and Suggestions

The method demonstrated that responses to supply chain disruptions strongly influence companies. However, the questionnaire results suggested that the supply chain management personnel of companies comprised less than one-fifth of staff members who had relevant degrees. Although the companies had established relevant operation procedures and strategies for such incidents, staff members who had not received supply chain-related courses or who were new to the companies only learned the response practices without knowing the causes of the incidents. Accordingly, these staff members were unable to respond adequately or propose more favorable strategic actions. Moreover, large companies exhibit large bodies of supply chain-related personnel, and thus are unable to provide such training to all staff members or determine the appropriate courses for them because of time constraints. Therefore, this study proposed a course package that provided the required professional training for supply chain management personnel. This

course package can serve as a reference for companies' training departments to design the prioritization of courses for staff members was analyzed; specifically, the proposed importance of training courses for the supply chain management department.

The above study planned the training courses with a focus on developing staff members' capabilities for emergency responses to supply chain disruptions. However, future research might develop strategies to prepare for future incidents, specifically forecasting upcoming supply chain disruptions before they occur and preparing extensively in advance.

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