



SUPPLY CHAIN RISKS:
A CASE STUDY OF CAR ASSEMBLED COMPANY

By
NITINON DEJSAKULKRAI

A Final Report of the Six-Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

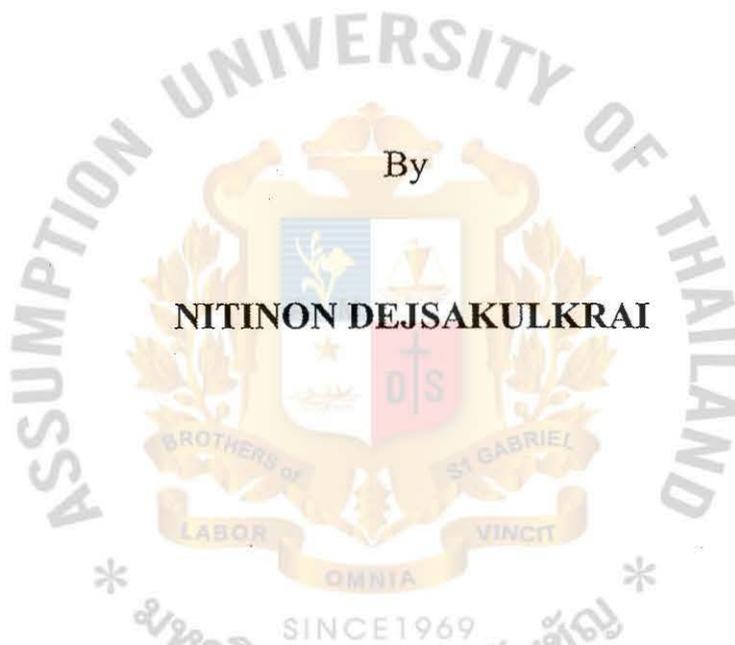
Martin de Tours School of Management
Assumption University
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Assumption University

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Declaration of Authorship Form

I, Nitinon Dejsakulkrai, declare that this thesis/project and the work presented in it are my own and has been generated by me as the result of my own original research.

Supply Chain Risks: A case study of car assembled company

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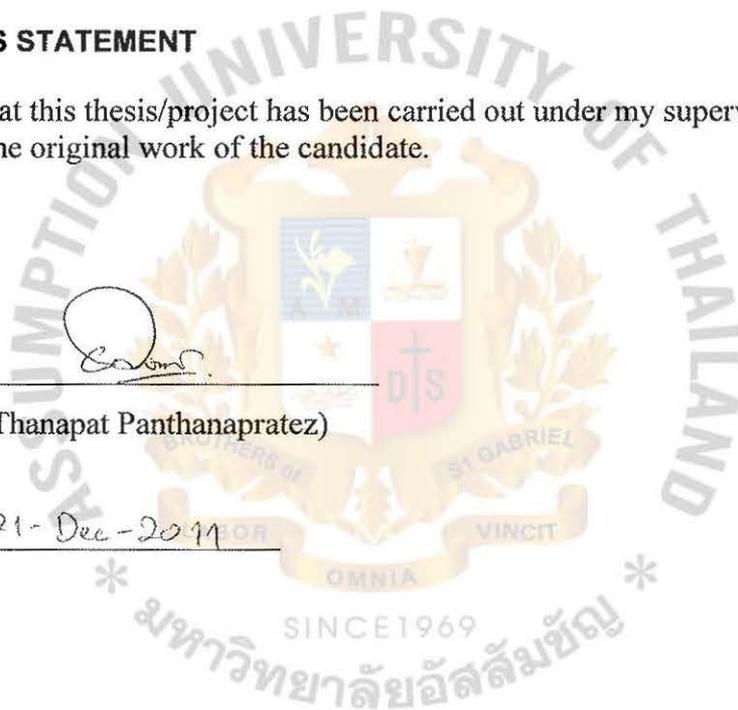
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Mr.Nitinon Dejsakulkrai

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November 2011

ABSTRACT

Supply chain in an automotive industry is quite a complex transactions and flow because of many tier suppliers and a large number of components. In the world of risks, it causes a supply disruption which affects the supply chain flow. A company cannot operate transactions to manufacture products and deliver it to customers. Nevertheless, risks can be managed through efficient risk management. A company needs to prepare to cope with supply chain risks.

The purpose of this study is to present supply chain risks and how to manage those supply chain risks of car assembled company's supplier in Thailand. This study uses a qualitative approach with interview methods to explore supply chain risks and how to manage those risks from top 8 suppliers with high purchasing amount of ABC company. This research focuses on a single case study of ABC company.

This study presents supply chain risks and enhances understanding of supply chain risk management in the automotive industry. This research contributes to supply chain risk management in the specific field of the automotive industry. There are both theoretical and practical contributions. In terms of theory, this research develops integrated models of supply chain risks in the automotive industry. In terms of practice, a manager can understand thoroughly about supply chain risks and supply chain risk management of suppliers and can cooperate with suppliers to conduct supplier development programs to improve their supply chain risk management to prevent those supply chain risks and mitigate effect of those risks.

Due to the small sample size and single case study, there are some constraints on the generalized ability of the study's findings. However, the study also has significant strengths. The findings support the existing literature and enhance more understanding in supply chain risk and supply chain risk management.

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Form signed by Proofreader of the Graduate Project

I, Asst. Prof. Dr. June Bernadette D'Souza, has proofread this Graduate Project entitled
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Mr. Nitinon Dejsakulkrai

and she hereby certifies that the verbiage, spelling and format is commensurate with the quality of internationally acceptable writing standards for a Master Degree in Supply Chain Management.

Signed June B. Souza
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Date: 28th December 2011.

CHAPTER I

GENERALITIES OF THE STUDY

This chapter provides the general information concerning the industry overview and company background. Moreover, the overall purpose will be addressed and some related key words will be explained.

1.1 Background of the Research

The automotive industry is very important industry in Thailand. Export values of the automotive business are the second rank of Thailand's export value. The government obtains a tax from this industry of around 60,000 million baht per year. Currently, The Thai automotive industry is the 15th rank in the world. The Thai government plays an important role to drive and promote this industry ("Thai Automotive", n.d.). The Thai Automotive Institute which was established by the government generated a strategic plan to develop automotive industry in year 2007-2011. It consists of 5 main strategies as below.

1. Strengthen productivity thrust and promote lean supply chain
2. Develop market expansion and integration thrust
3. Develop technology and engineering capability thrust
4. Develop human resources thrust
5. Promote investment and linkage thrust

According to the Office of Industrial Economics Ministry of Industry (2006), Thailand has one of the largest automotive assembling capacity, and possibly the highest quality parts manufacturing capability among ASEAN. These are combined with the market growth potential, good domestic market size, stable political atmosphere, liberal trade and investment policy, absence of ethnic conflicts, and lack of "national car program". This has made Thailand one of the most attractive countries for automotive investments.

In the future, the automotive industry will improve dramatically because of the economic improvement in addition to the government's efforts and private's business strategy adaptation. Therefore, the car assembled company and its supplier have to improve their capability and manage supply chain well in order to deliver product to customer on time.

In a perfect world of supply chain, components would arrive at the assembled company on time for production. Adequate inventory of all components would be available and demand would be deterministically predictable. However, in the practical world, there are uncertainties. Consequently, sales deviate from forecasts, components are damaged in transit, production fails to meet plan and shipments are held up in ports.

For instance in the electronic industry, there was fire at one of the Ericsson's suppliers factory in 2000 that caused Ericsson to the loss about 400 million Euros (Norrman & Jansson, 2004). In automotive industry, one of Land Rover's suppliers experienced insolvency which caused layoff of 14,000 workers in 2001 (Paulsson, 2004). In July 2007, Toyota Motor Corporation paused production in all Japanese factories because of an earthquake that damaged Riken Corporation, the major parts supplier for pistons and seal rings. The damage to Riken affected other automotive manufacturers, Mitsubishi Motor Corporation, Suzuki Motor Corporation and Honda Motor Corporation (Hayashi, Smith, & Chozick, 2007). On March 11, 2011, the magnitude-9.0 earthquake and tsunami destroyed many factories in northeastern Japan, causing severe parts shortages for Toyota and other auto makers (Yuasa, 2011).

Company Background

In this research, the anonymous company is called “ABC company”. This company is a well-known automobile brand in Thailand. For nearly half a century the company has been supplying customers with high-quality cars. ABC company sells both vehicles and parts in Thailand and exports all over the world. According to information as of November 2010, the company profile can be explained as below.

- Registered capital: 7,520 million baht
- Shareholders: Japan 86.4%, Local 13.6%
- Employees: 13,500 persons
- Dealers: 119 dealers (with 319 showrooms)
- Suppliers: 151 suppliers
- Production ratio: Passenger vehicle 44%
Commercial vehicle 56 %
- Production plants: 3 production plants

Plant 1 : Producing commercial vehicle for domestic sell.

Production capacity is around 200,000 vehicles/year.

Plant 2 : Producing passenger vehicle for both domestic and export sell.

Production capacity is around 250,000 vehicles/year.

Plant 3 : Producing commercial vehicle for export sell.

Production capacity is around 100,000 vehicles/year.

- Car Products: Import vehicle 7 models
Domestic production vehicle 9 models

Sharing production plan information

ABC company provides production volume plan to supplier through electronic systems which is an information linkage between supplier and company. Production volume plans are separated into yearly, monthly and daily plans. For yearly plan, the company will send the original annual plan to each supplier in March of each year in order to provide overall of total production and then in August, the revised annual plan will be sent to suppliers for updating the production plan. Monthly plans will be sent to the suppliers every month to provide more accuracy for production planning. It indicates the 3 month forecast volume and 1 month confirmed production volume. For example, in May 2011, the suppliers will receive the confirmed production plan of June 2011 and forecasted production plan of July, August, and September 2011. Confirmed production volume plan will be allocated in the daily plan.

Ordering and logistics

The order of parts from the company will be done by the electronic system to suppliers based on the Just-in-time concept. Supplier prepares parts following the instruction in the electronic ordering sheet. There are two kinds of delivery methods from the suppliers to the ABC company, milk run and direct delivery. Milk run route is divided into five zones to pick up parts from supplier.

Zone A is Saraburi, Ayudhaya and Pathumtani.

Zone B is Bangkok, Samutprakan and Samutsakorn.

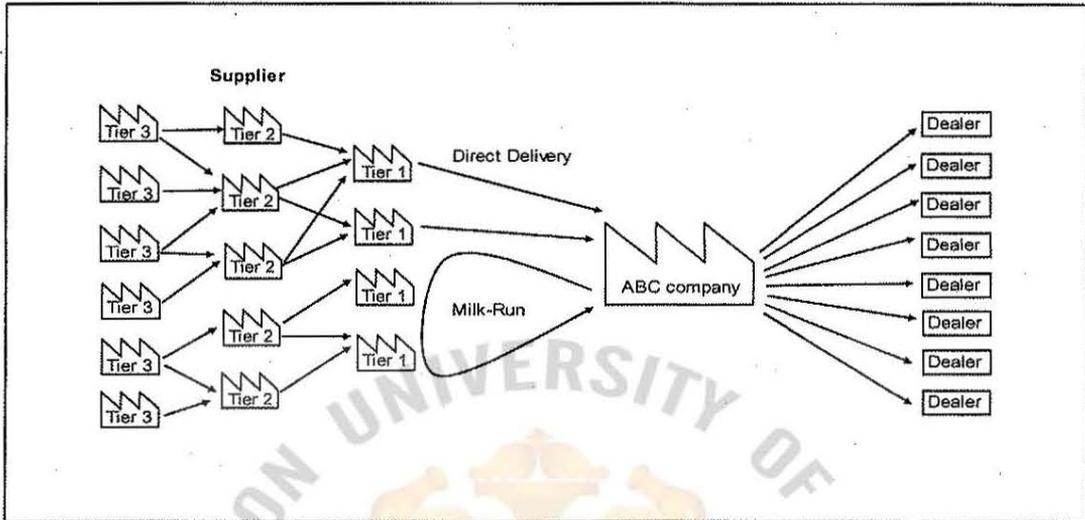
Zone C is Bangpakong.

Zone D is Chonburi and Rayong.

Zone E is Prachinburi, and Chachoengsao.

Currently, 68 percentage of suppliers use milk run method which transportation is controlled by logistics partner of ABC company.

Figure 1.1 ABC Company's Supply Chain



Source : ABC company

The supply chain starts from tier 2 or tier 3 suppliers and goes down the line in the supply chain. Tier 3 supplies to tier 2, tier 2 supplier supplies to tier 1. After this the parts are delivered to ABC company through milk run or direct delivery method. The ABC company will assemble the car as customer demand and then deliver the car to the dealers. Finally, the dealer sells the car to the customer.

1.2 Statement of the Problem

The ABC company has proceeded supply chain risk management to prevent an adverse effect on production. Company has conducted strategies to mitigate supply chain risk from suppliers, for instance, keeping safety stock of component parts, sharing production plan information continuously, and closing communication with supplier by monthly supplier meetings. Nevertheless, due to the complexity of the supply chain in automotive industry, a large number of suppliers supplied a number of component late causing the production line stop. According to company historical records from 2008 to 2010, the production line stopped for around 7,200 minutes. Actually, the business loss includes lost sales cost, cost of unused manufacturing

capacity, holding cost for other component parts etc. It is quite difficult to quantify the true cost. In a simple way, only for lost sales cost which can roughly estimate the impact from formulation are considered. Production line stop time is divided with take time of vehicle production and then multiplies with selling price of the vehicle. The estimated impact of this effect is around 5,760 million baht.

In addition, the recent impact of the earthquake and Tsunami disaster in Japan on March 11, 2011 had an extreme impact for ABC company and global affiliates. This disaster destroyed many tier 2 and 3 suppliers' factories in the northeastern area where automotive, electronic, chemical supplier are located. Some suppliers' factories were completely destroyed and some suppliers' factories were partly damaged. The main affected components and raw materials were electronic parts and raw materials of paint. Supplying components from Japan was not enough quantity to respond to the global demand. Tier 1 suppliers faced difficulty to import component parts from tier 2 in Japan and deliver parts to ABC company on time. Finally, ABC company decided to announce the drastic production cuts in Thailand on April 22nd, 2011. Working days were reduced from 5 days to only 3 days per week without overtime and production ran at half capacity.

According to above mentioned problems, It can be seen that even ABC company has conducted supply chain risk management but there are delay deliveries and shortage of parts from supplier. To prevent this problem, ABC company's supplier should identify supply chain risks and conduct supply chain risk management as well. Therefore, the main research question of this study is "what are supply chain risks and how to manage those supply chain risks of ABC company's supplier?"

Research Questions:

- RQ1. What are the supply chain risks of ABC company's supplier ?
- RQ2. How do supply chain risks influence to ABC company's supplier?
- RQ3. How does ABC company's supplier manage those supply chain risks?
- RQ4. What are the future supply chain risks of ABC company's supplier?

1.3 Research Objectives

According to Chopra and Sodhi (2004), although it is difficult to control uncertainties, it can be managed through efficient contingency planning and risk management. Organizations need to prepare themselves to cope with crisis. To prevent delay of delivery and part shortage from suppliers, ABC company should understand what are the supply chain risks of suppliers and how do suppliers conduct supply chain risk management. Therefore, the objectives of the study are as follows

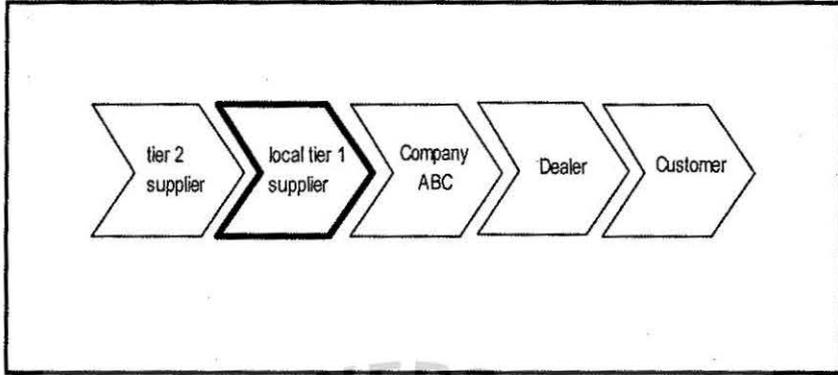
1. To determine the supply chain risks of ABC company's suppliers.
2. To examine each supply risk influencing to ABC company's suppliers.
3. To examine how ABC company's suppliers manage those supply chain risks.
4. To explore future supply chain risks of ABC company's suppliers.

1.4 Scope of the Research

The scope of this study is limited to study of supply chain risks of ABC company's local tier 1 supplier as shown in Figure 1.2. The ABC company is chosen in this study because this company is a leading car assembled company in Thailand which has business transaction with local around 151 suppliers.

According to Saunders, Lewis, & Thornhill (2003), interview is one of the data collection methods that can assist researchers to gather valid and reliable data which are relevant to research questions. In addition, Kvale (1996) also said that interviews are useful for getting the information of interviewee's experiences. The researcher can obtain in-depth information and uncover the meaning of these experiences. Therefore, an interview method is chosen to satisfy the purpose of the study. Local tier 1 suppliers of ABC company are interviewed following the research questions to collect the required information.

Figure 1.2 : Scope of the Study



1.5 Significance of the Research

This study would provide to both theoretical and practical contribution.

1.5.1 Theoretical contributions:

In terms of theory, this research attempts to develop models of supply chain risks in the automotive industry.

1.5.2 Practical contributions:

In term of practice, this study would like to identify the supply chain risks and find out how to manage those supply chain risks of ABC company's supplier. Once the supply chain risks are identified and how those suppliers manage supply chain risks are explored, ABC company can understand thoroughly the insights about supply chain risks of the suppliers. In case that the supply chain risks are not managed well, the ABC company can cooperate with suppliers to conduct supplier development programs to improve their supply chain risk management to prevent those supply risks. In case that the supplier managed those supply risks well, ABC company can use it as a guidance to develop with other suppliers.

1.6 Limitations of the Research

The study in this research is a qualitative research based on one company as a case study. In this research, the single case study conducted interviews with top 8 suppliers. The high purchasing amounts might have specific characteristic that are not relevant to other cases. The interviewee may not disclose information as the information may discredit his company.

1.7 Definition of Terms

| | |
|------------------------------|--|
| Supply chain disruption | Unplanned events that may occur in the supply chain which might affect the normal or expected flow (Svensson, 2000). |
| Supply chain risk | The negative deviation from the expected value of performance measure, causing negative consequences for the company (McCormack, Wilkerson, Marrow, Davey, Shah, & Yee, 2008). |
| Supply chain risk management | Management of supply chain risks through coordination or collaboration among the supply chain partners to ensure profitability and continuity (Christopher, 1992; Tang, 2006). |

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter provides a review of the literature and research related to the study. It presents the overview of the automotive industry, supply chain, supply chain risks and supply chain risk management.

2.1 Defining Thai Automotive Industry.

2.1.1 Structure of industry

The Office of Industrial Economics Ministry of Industry (2006) states that automotive part companies in Thailand can be categorized into three main groups;

Group 1 : a member in Japanese family companies.

Group 2 : a joint venture with Japanese technology owners.

Group 3 : a company having technical assistance or licensing agreements with Japanese companies.

Due to high growth rate in the Thai automotive industry, companies involved in this industry are confronted with high competition, and cost reductions, quality improvements, and shorter delivery time requested by car assemblers. Therefore, part industry has to improve technology level in accordance with the demand from car assemblers. Foreign automotive part companies in Thailand, mostly Japanese, are able to introduce technologies from their parent companies. Technological spillovers from Japanese subsidiaries to Thai companies also play an important role in the improvement of Thai technology (Bongsebandhu-phubhakdi, Saiki, & Osada, 2009). The Thai automotive industry has always depended on the foreign automotive manufacturers, especially Japanese automotive manufacturers (Toyota, Honda, Nissan and Isuzu) who are still the top car manufacturers.

2.1.2 Technology transfer and development

Joint venture companies are able to acquire technology, new management strategy and also financial support from their parent company. The supports are mainly for high technology machines, research activities and development programs to continuously improve products and production quality.

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Some local part companies have technical assistance agreement (TA) with foreign companies. Foreign companies provide technical support in which the agreement will be made on a product-by-product basis. This technical assistance does not cover any funding or management issues. Management costs for this kind of company is quite cheap compares to Joint venture companies.

Pure Thai Companies are Thai manufacturers without any support from any foreign company. Many of the pure Thai companies have transferred into Joint ventures and Technical assistant companies because of the financial crisis and inadequate technical capability. Pure Thai companies are suitable for manufacturing parts for which high technology is not required. Production cost for those companies is quite inexpensive because of the lower expense for production technology which requires cheaper machines and lower salary for workers. Mainly, the weaknesses of pure Thai companies are out of dated technology and management problems. Most of the pure Thai companies are in tier 2 and tier 3 supplier in the supply chain.

(Office of Industrial Economics Ministry of Industry, 2006)

2.1.3 Market access factor

There is no specific measure to block new companies or imported vehicles and components in Thailand. End users are the principal enforcers of products standards. Intensified competition in the market is the forceful obstruction to market entry in Thailand. Nowadays, auto parts in Thailand are increasingly competitive in terms of productivity and quality. Almost auto parts acquire international standards (TS16949) and get approval from developed countries and can prove this by their export to the

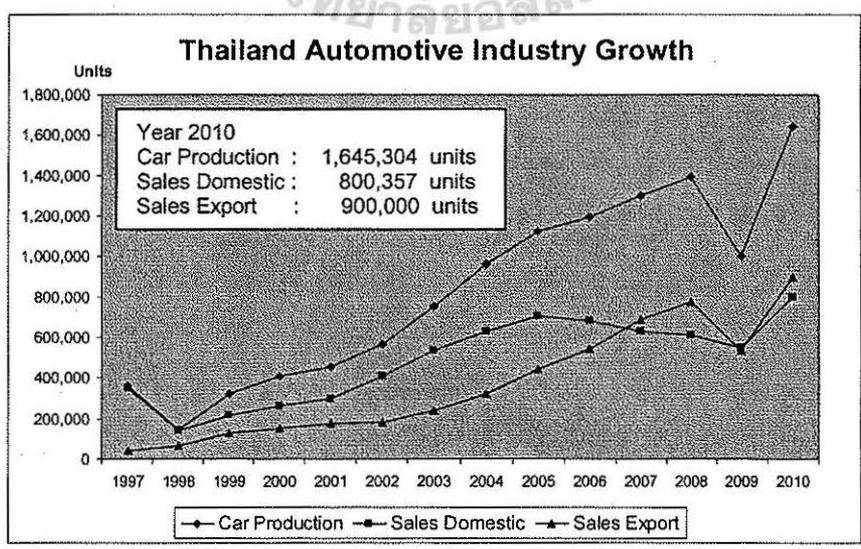
markets like EU, Japan and the North America where quality and standard are rigorous (Office of Industrial Economics Ministry of Industry, 2006).

2.1.4 Current situation of the industry

Information from Thailand Automotive Institute (2010) is shown in Figure 2.1. After the economic crisis of 1997 – 1998, the production of automobile has been growing continuously. This can be proved by the impressive 23% annual production growth rate during 1999 to 2005. Many leading automobile companies, such as Mitsubishi, Ford-Mazda, GM-Isuzu, Toyota had relocated their production to Thailand in order to establish their one ton pickup truck as a global production base for exports. Moreover, the domestic auto market has been expanding because of strategic alliances between auto companies, and partly because of the government’s promotion-and-support policies in the automotive industry.

In year 2009, the production of automotive industries, both domestic and export decreased due to effect from economic crisis in USA. Nevertheless, in 2010, the situation of automotive industry dramatically improved.

Figure 2.1 : Thailand Automotive Industry Growth



Source : Thailand Automotive Institute (2010)

2.1.5 Future production trends

The data from Thailand Automotive Industry is shown in below Figure 2.2. In Thailand, there is new investment for increase in production capacity in the future. In the year 2014, the estimated production capacity in Thailand will be increased around 28% compared to the year 2010 to serve the future demand growth.

Figure 2.2 : Estimate Production Capacity of Thai Automotive Industry

| Estimate Production Capacity | | | |
|------------------------------|------------------|----------------|------------------|
| | 2010 | New Investment | 2014 estimate |
| Toyota | 650,000 | 100,000 | 750,000 |
| Ford & Mazda | 250,000 | 150,000 | 400,000 |
| Mitsubishi | 200,000 | 200,000 | 400,000 |
| Honda | 240,000 | - | 240,000 |
| Nissan | 220,000 | - | 220,000 |
| Isuzu | 220,000 | - | 220,000 |
| GM | 160,000 | - | 160,000 |
| Suzuki | - | 138,000 | 138,000 |
| Others | 139,000 | - | 139,000 |
| TOTAL | 2,079,000 | 588,000 | 2,667,000 |

Source: Thailand Automotive Institute (September 2010)

2.2 Supply Chain in the Automotive Industry

There are many challenges for the supply chain in the automotive industry, both for management and as a subject for research. For example, from Turner (2005) :

1. The complexity of the product: Distinct specification in terms of trimmings, colors, body, engine, etc.
2. The complexity of the supply network: Many supplier locations across the country and multiple stocking locations from the assembled plant to dealers in each major market.

3. Consumer behavior: Willingness to wait for a build-to-order car, and the extent to which customers will compromise on specifications.
4. Demand seasonality: Varying markets, and its effect in combination with manufacturers preference for level production schedules.

Supply chain in automotive industry is large in scale, having many tiers of suppliers, where each supplier of the supply chain provides goods or services to the next level supplier tier in the supply chain.

Inbound-supply in the automotive industry is quite complex because there are many parts, many suppliers located across a country and even some clustered in some areas. Furthermore, according to Wu, Blackhurst and Chidambaram (2006), each tier supplier may have multiple components or members, making a mesh network within the supply chain. They don't only supply directly to car assembly plants but also supply their components to other suppliers to assemble parts who then deliver it to car assembled company.

There are two types of Inbound logistic from suppliers to car assembled company. These are direct delivery and milk run delivery which make multiple pickup parts at different supplier locations on a regular scheduled basis.

2.3 Defining Supply Chain Risks

Supply chain risk is defined as the negative deviation from the expected value of performance measure, causing negative consequences for the company (McCormack, et al., 2008).

Cucchiella and Gastaldi (2006) stated that the sources of complexity inside a network are numerous and their management is more complex. The high number of sources of complexity exposes the network to an increasing level of uncertainty and the uncertainty level exposes the network to an increasing number of risks.

Zsidisin (2003a) explained more details about supply risks in the supply chain as “. . . the probability of an incident associated with inbound supply from individual supplier failures or the supply market occurring, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety.”

Supply risk includes all risk that occurs if the up-stream flow of materials, information, or capital is disturbed (Christopher & Peck, 2004). Supply risks extend beyond the boundaries of a single company with major flow of material, information and cash (Juttner, 2005).

Wu et al. (2006) stated that inbound supply risk is defined as the potential occurrence of an incident associated with inbound supply from supplier failures or the supply market, resulting in the inability of the purchasing company to meet customer demand and as involving the potential occurrence of events associated with inbound supply that can have significant detrimental effects on the purchasing company. These risks or supply chain failures can be costly and lead to significant delays in customer deliveries. Therefore, managing supply risk is a critical component of managing the supply chain. Consequently, it is important to an organization's success to understand the sources of risks and how to best manage them.

Sheffi (2001) studied supply chain management under the threat of international terrorism and proposed some methods such as setting certain operational redundancies. Martha and Subbakrishna (2002) also analyzed supply chains under terrorist attacks and proposed a so-called targeting a just-in-case supply chain strategy to face the inevitable next disaster.

Cucchiella and Gastaldi (2006) divided supply chain risks into categories of internal (involving such issues as capacity variations, regulations, information delays, and organizational factors) and external (market prices, actions of competitors, manufacturing yield and costs, supplier quality, and political issues).

Wu et al. (2006) also divided supply chain risks into internal and external but supply chain risks were defined specifically. Internal risks involve quality, cost, on-time delivery, production capability/capacity, production flexibility, technical/knowledge resources, financial and insurance issues, management related issues, accidents, market strengths, internal legal issues, and continuity of supplies. External risks involve tier 2 suppliers, external legal issues, demand fluctuations, security, nature/man-made disasters, political/economic stability, and market characteristics.

According to Matook, Lashch, and Tamaschke (2009), risks were classified into 10 categories; price, quantity, quality, technology, economic, environmental, process, management, chaos, and inventory.

According to Chopra and Sodhi (2004), there are nine risk categories: disruptions, delays, systems, forecast, intellectual property, procurement, receivables, inventory, and capacity. But their risk assessment framework was general and not specific to the automotive industry.

Based on reviews of above relevant supply chain risk literature, supply chain risks mostly were described in general not specific to the automotive industry. Blackhurst, Scheibe, and Johnsonit, (2008) conducted a study which explained about risks in automotive industry. They expanded and added categories to address the specific risks to cover risks in the automotive industry. They expanded the delay into logistics, supplier dependence and quality. 'Delay' is insufficient to capture the necessary details of risk. In addition, legal category was raised for importing/global sourcing. They also changed the systems category to information systems to remove ambiguity. The last, two new risk categories – management and security – were added for completeness. In summary, the supply chain risks in the automotive industry are disruption/disaster, logistics, supplier dependence, quality, information systems, forecast, legal, intellectual property, procurement, receivables (accounting), inventory, capacity, management and security.

1. Disruptions/Disasters

Risk that relates to disasters such as floods, fires, earthquakes, storms and disruption from labor dispute, wars, terrorism and political issues/unrest.

2. Logistics

Risk that relates to non-delivery issues due to transportation and shipping.

3. Supplier dependence

Risk that concerns with supplier's production and on time delivery. The degree of dependency on the supplier to supply product.

4. Quality

Risk that the product does not meet quality specifications.

5. Information systems

Risk that relates to technology issues leading to uncertainty, e.g. information infrastructure breakdown, incompatible system.

6. Forecast

Risk that relates to inaccurate forecast, lead time variance and product demand variation.

7. Legal

Risk that concerns with legislative action related to importing/global sourcing and restriction relating to use of particular type of material or components.

8. Intellectual property

Risk that relates to intellectual property infringement e.g. unauthorized use, exploitation, manufacture, distribution of protected copyright, trademark, patent or trade secrets misappropriation and purchasing counterfeit products.

9. Procurement

Risk that relates to scarcity and availability of component or raw materials.

10. Receivables (accounting)

Risk that is concerned with financial strength of the customer and ability to pay money of customer.

11. Inventory

Risk that relates to out-dating, spoilage, and carrying cost of inventory.

12. Capacity

Risk that relates to available capacity and capacity flexibility.

13. Management

Risk that relates to company communication and visibility.

14. Security

Risk that is concerned with IS system security.

2.4 Defining Supply Chain Disruption

Supply chain disruptions are unplanned events that may occur in the supply chain which might affect the normal or expected flow (Svensson, 2000).

Gaonkar and Viswanadhum (2004) explained that supply chain disruption can occur at various nodes, on the supply side, demand side, during transport or storage. There could be failure of supply side, transportation, facilities, communication and demand fluctuations.

Supply chain risks result in supply chain disruption of a company which can be costly and lead to significant delays in customer deliveries. If the company handles the

supply risk poorly, disruptions in supply chain could result in costly delays causing poor service levels and high cost (Blackhurst, Craighead, Elkins, & Handfield, 2005).

Blackhurst, et al. (2008) stated that supply chain disruptions can cause various problems such as long lead-times, stock-outs, inability to meet customer demand, and increases in costs.

2.5 Defining Supply Chain Risk Management

The aim of supply chain risk management is to prevent companies from unpredictable events and their adverse effects (Gaudenzi & Borghesi, 2006). Supply chain risk management has been defined as the management of supply chain risks through coordination or collaboration among the supply chain partners to ensure profitability and continuity (Christopher, 1992; Tang, 2006).

Gaonkar and Viswanadhum (2004) explain two approaches of risk management to management uncertainty. The first one is a preventive approach. This approach is to reduce the likelihood of occurrence of disruption. The second one is interceptive approach. It attempts to contain the loss by active intervention subsequent to the occurrence of the event.

According to Srivantaneeyakul (2011), business continuity plan (BCP) is a plan to handle unexpected risks. This plan will help to mitigate risk and continue business. To create and proceed with this plan, top management must fully support it and all critical function of the business unit must be involved. There are eight steps to make BCP.

Step 1 : Project plan

Top management must be involved during the kick-off. Team members and frameworks are identified to proceed BCP.

Step 2 : Risk analysis

Risk analysis workshop is conducted to collate the findings. The results will be presented to the senior management.

Step 3 : Business impact analysis

This is the most difficult and time-taking process. Business impact analysis will be conducted and reported to the senior management.

Step 4 : Recovery strategy

Recovery strategy is created. Development and testing are planned.

Step 5 : Plan develop

BCP plan is developed and evaluated.

Step 6 : Training

BCP table-top exercises will be conducted and observed result will be collated.

Step 7 : Testing

Test plan for table –top BCP exercises will be developed.

Step 8 : Maintenance plan

The plan will be revised to solve a problem during the test. Then, step 3, 4, 5 will be reviewed for the next test.

In general, a supply risk management consists of four processes:

- (1) risk identification;
- (2) risk assessment;
- (3) risk management decisions and implementation; and
- (4) risk monitoring

(Hallikas, Karvonen, Pulkkinen, Virolainen, & Tuominen, 2004)

In the first step, each company is responsible for its own risks and must identify them according to the company's perspective. Once risks are identified, their impact and probability must be assessed. Once the risks are assessed, a number of strategies can be used to manage the risks. The last step, the risks have to be monitored periodically.

Risk identification

Bazelon (1979) explained that risk can be analyzed, categorized and defined objectively and subjectively with reference to social, cultural and scientific disciplines. Each perspective may generate a different result. Cutter (1993) stated that risk is viewed as acceptable in case it is familiar, controllable, and has low catastrophic potential.

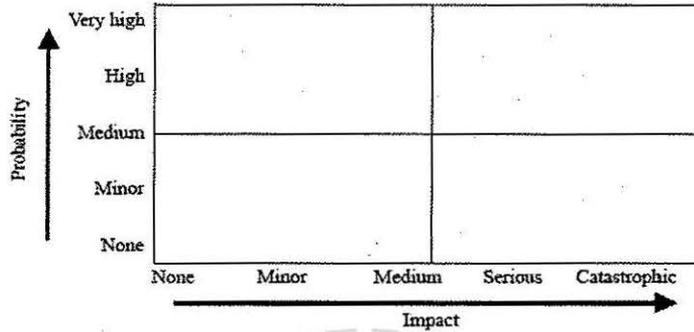
The awareness of risks, and actual or implicit measure of risks, may induce behavioral responses. An unidentified risk is perceived as no risks. Once perceived, a risk can be subjectively assessed, reduced, avoided or hedged (Adam, 1995). Fischhoff said that individual perception of risk subjective and hence variable (Fischhoff, 1994).

The most common practices that have been used is brainstorming with the research team or interviews with the expert from the industry (Zsidisin, 2003b; Norrman & Jansson, 2004; Sinha, Whitman, & Malzahn, 2004; Wu et al., 2006). In addition, the company must select the group of suppliers which will be assessed. The commodity portfolio matrix indicates that suppliers of critical strategic supplies should be considered for the risk management process (Handfield, Krause, Scannell, & Monczka, 2000).

Risk assessment

Once risks are identified, their impact and probability must be assessed. The risk assessment matrix shown in Figure 2.3 can be helpful with this respect (Hallikas et al., 2004).

Figure 2.3 : Risk Assessment Matrix



Source : Hallikas et al. (2004)

Wu et al. (2006) developed an analytic hierarchy process (AHP) based on supplier risk assessment tool to define the relative weights of individual risk factors. These weights and the probability of each risk factor was computed.

In the assessment stage, there are a number of approaches including brainstorming, process mapping, risk impact analysis, and scenario planning. The failure mode and effect analysis (FMEA) is a popular model used in the assessment stage where a priority list to each risk based on the multiplication of the probability of occurrence and the severity of the impact can be defined.

In assessing supply chain risks, there are the different scales used. Some researchers (Norrman & Jansson, 2004) used a 1 – 4 scale, while Hallikas et al. (2004) used a 1 – 5 scale. For example, in indicating the magnitude of impact (severity), the values of 1, 2, 3, 4, and 5 represent low, medium, high, very high, catastrophic impacts respectively.

But Zsidisin (2003b) and Sheffi and Rice (2005) used only two levels, i.e., high and low, to assess the magnitude of risks. In the assessment stage, mapping the risks into a

graph or a matrix could be useful for analysis. Management can use such visualization to communicate risks internally as well as to other parties within the supply chain.

Risk management decisions and implementation

The risk management relates to the course of actions to consider reducing the risks. It can be done by decreasing the probability of occurrence, the severity of impact, or both.

Juttner, Peck, and Christopher (2003) stated that cooperation with supply chain partners is one of the mitigation strategies for supply chain risks. It can be in terms of joint efforts to improve supply chain visibility and understanding, share risk related information, and prepare supply chain continuity plans, dropping specific products.

Moreover, Juttner also said that developing an alternative plan or contingency plan is one major action that can mitigate the supply chain risks. Such an alternative, which is also called as business continuity management is being developed well in the area of supply chain risk management recently.

Kleindorfer and Saad (2005) stated some principles to mitigate risks as follows;

- (1) Diversification can reduce risk –It includes facility locations, sourcing options, logistics, and operational modes;
- (2) Prevention is better than correction
- (3) Backup systems, contingency plans, and maintaining slack can mitigate risks;
- (4) Collaborative information sharing and best practices are needed to identify vulnerabilities in the supply chain;
- (5) Modularity of process and product designs as well as other aspects of agility and flexibility can provide ability to reduce risks, especially those involving raw material availability and component supply; and
- (6) Total quality management principles such as Six-Sigma give leverage in achieving greater supply chain security and reduction of disruptive risks as well as reducing operating costs.

Tang (2006) classified four approaches to mitigate the impact of supply chain risks:

(1) Demand management:

Coordination with downstream partners to influence demand in a beneficial manner.

(2) Product management:

Change in product or process design in order to make more fluent the material flows in the supply chain.

(3) Information management:

Coordination and collaboration among supply chain partners by sharing information.

(4) Supply management:

Collaboration with upstream partners to ensure efficient and effective supply of materials.

Khan and Burnes (2007) proposed some strategies for supply chain risk management; for examples, buffer stock, multiple sources, information sharing, and early supplier involvement.

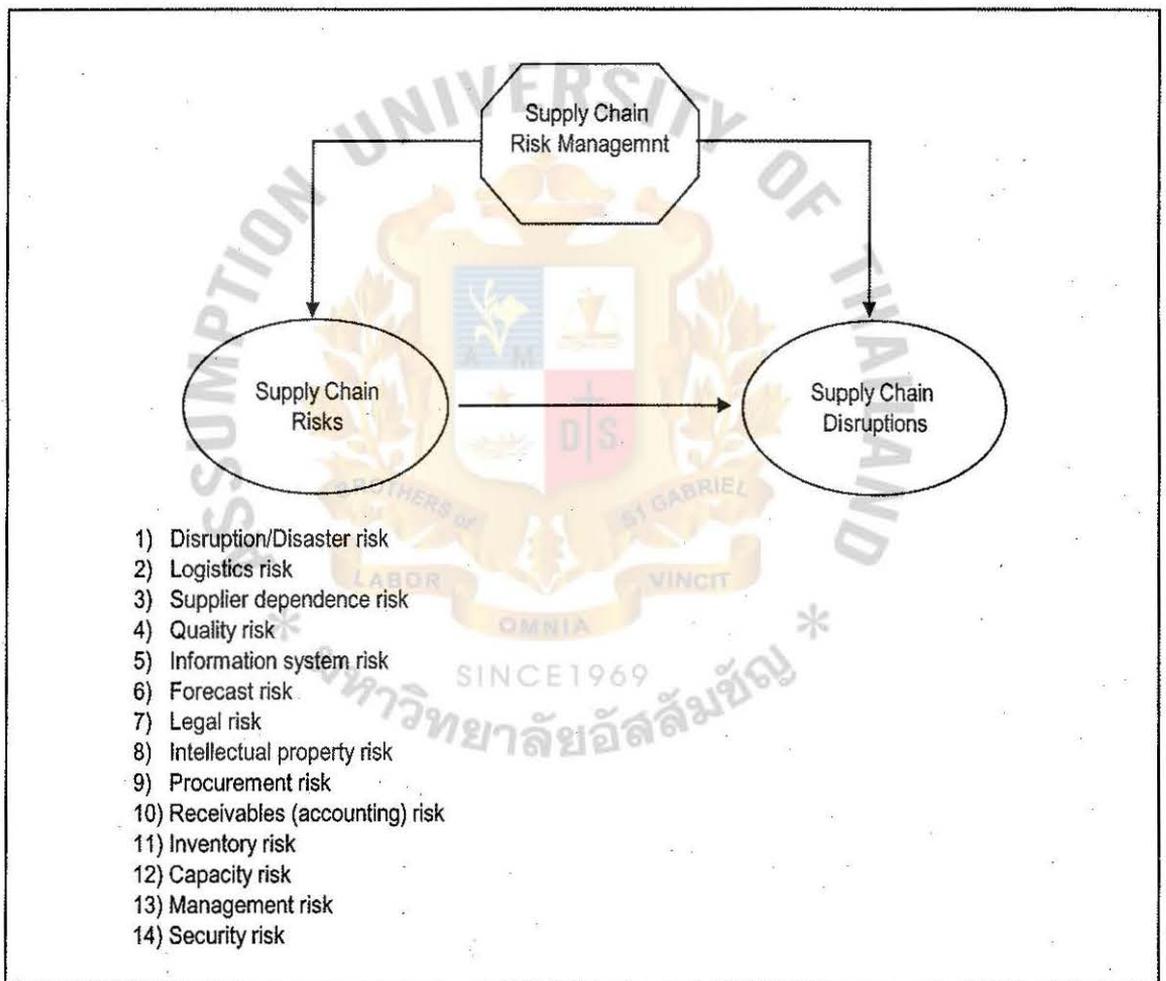
Risk monitoring

There is the least attention to risk monitoring by the researcher and little literature has shown focus on the necessary for risk monitoring. According to Blackhurst et al. (2008), one of the big challenges posed by the auto manufacturer was the need to predict disruptive events prior to their occurrence. The automotive manufacturer wanted to change from a reactive supply risk management to proactive. To do this, risk ratings and/or risk indices must be tracked over time and trends monitored to determine if they are reaching unacceptable levels. In this way, the user can predict a problem before it occurs and offer mitigation strategies.

2.6 Preliminary Framework

According to the literature review, the researcher establishes a preliminary framework. There are 14 risks affecting to supply chain disruption which are given below.

Figure 2.4 : Preliminary Framework



2.7 Previous Studies

Figure 2.5 : Previous Studies

| Author and Year | Concept, Focus, Empirical basis | Finding |
|--|---|---|
| Cucchiella and Gastaldi (2006) | Real option approach allows the flexible level in identification options to reduce company risks. | The real option approach has been individualized to identify possible option to protect company from risks. |
| Wu, Blackhurst and Chidambaram (2006) | Inbound supply chain risk management is reinforced. The study suggests methodology to classify, manage, and assess inbound supply risks. AHP model is used to calculate risk factor. | In general industry, inbound supply chain risks are identified and explain how risk factor is classified by AHP. |
| Matook, Lasch and Tamaschke (2009) | Benchmarking approach in supplier development is focused. The theoretical and practical supplier risk management are pointed out. | The study presented details of management responses stage and explain how to conduct development of supplier. |
| Blackhurst, Scheibe and Johnson (2008) | Literature of supply chain risks is reviewed. The interviews with automotive manufacturer are conducted to identify risks. The identified risk are in the development of risk assessment and monitoring system. | The study present a framework of risk factors and develop a multi-criteria scoring method to identify part and supplier risk. |
| Olson and Wu (2010) | Approaches of supply chain risk management are reviewed and types of risks are indentified. Supply chain concerning China are mentioned. | A generic framework is identified and categorizations of supply chain risks are compared. |
| Pujawan and Geraldin (2009) | Proactive framework enable company to select risk agent and prioritize proactive action to reduce impact of risk events. | The study presents the useful method of House of risk (HOR) framework for supply chain risk management. |

Source : Compiled for this study

Figure 2.5 shows the wide attention that such a topic has received from researchers and the concept of risk has been extensively studied in literature from different perspectives. Most of the researches have focused on supply chain risks in general, not specific with the regard to an automotive industry.



CHAPTER III

RESEARCH METHODOLOGY

This chapter presents the research methodology, research strategy, data collection and data analysis used in this study.

3.1 Methods of Research Used

There are three different classifications of research, exploratory, descriptive, and explanatory. Exploratory research is often conducted because a problem has not been clearly defined, or its real scope is unclear. The researcher can familiarize himself/herself with the problem or concept to be studied, and perhaps initiate hypotheses to be tested. It is the initial research before further conclusive research is undertaken (Exploratory Research, n.d.).

In this study, the research is exploratory because the researcher would like to obtain a better understanding about what are supply chain risks of ABC company's supplier, how those supply chain risks influence supply disruption and how to manage those supply risks. The main reasons that exploratory research is selected because it is quite new area of study in Thailand and data is ambiguous so far for supply chain risks in the automotive industry.

Kent & Flint (1997) stated that logistics and supply chain management research requires a broader set of research approaches including qualitative ones, which can get across logistics and SCM boundaries.

Gummesson (2000) also said that qualitative methodology has been proven to be a useful tool because logistics and supply chain issues need to consider social and human involvement. It's not just mechanistic modeling and simulation.

According to Gordon and Langmaid (1988), qualitative research is best used for problems where the results will increase understanding, expand knowledge, clarify the real issues, generate hypotheses, and provide input for future research or development.

The researcher considered use the qualitative method to conduct this study. By adapting qualitative method, the researcher is able to go to in-depth details of real-life situations and understand how and why certain outcome are achieved (not just what is achieved).

3.2 Case Study

Yin (2003) stated that case study methods allows the investigator to retain the holistic and meaningful characteristics of real life events-such as individual life cycles, organizational a managerial processes, neighborhood change, international relations and maturation of industries. A case study is an empirical inquiry which investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident.

A case study is a strategy to do research which relates to an empirical investigation of particular contemporary phenomenon within it real life context by using multiple source of evidence (Robson, 2002).

One of the most important determinations in conducting any case study is choosing the right case whether a case is of intrinsic value, or seems to be representative of the larger population (Leary, 2004).

The researcher considered that the case study is the best way to conduct this study because the research questions are the contemporary set of events which require investigation in the real-life context. In addition, the case study strategy also uses to explore situations in which the intervention being evaluated is not clear. The

researcher can obtain better understanding and go into deeper details of case study by using the qualitative method.

3.3 Qualitative Sampling

Although collecting and analyzing data from every possible case or group member is the census, in the practical way, there are constraints of time and budget. There are many researchers, for example Henry (1990), argued that using sampling obtains higher accuracy than a census. The smaller number of cases which you need to collect data means that more time can be spent to collect data in details. Then, more time can be devoted to checking and testing the data for accuracy prior to analysis.

Leary (2004) stated that in qualitative research, researchers who want to understand the population are not looking for the representativeness. The goal is rich understanding that comes from the few, rather than many. Such a study is not so much dependent on representativeness and sample size but the ability to explain the relationship of any sample in a broader context.

In this study, ABC company, is a well-known car assembled company in Thailand was carefully selected as a single case study. This company was chosen because it is a leading company in Thailand and also deals with global and local suppliers (151 suppliers). Then, interviews were conducted with the top 8 suppliers with high purchasing amounts from ABC company. This research focuses on the top 8 suppliers because purchasing amount of the rest of the suppliers is quite low. It is only around 1% of total purchasing amount. In addition, there are time limitations to collect information. The research will reconsider the number of suppliers for interviews later if information obtained from interviews is not enough to fulfill the purpose of this study.

Table 3.1 : Top 8 Suppliers with High Purchasing Amount

Unit : million baht

| No | Supplier | Estimated purchasing amount year 2011 (million baht/year) | Percentage of purchasing amount | Accumulation of percentage |
|----|------------|---|---------------------------------|----------------------------|
| 1 | Supplier A | 34,473 | 14.00% | 14.00% |
| 2 | Supplier B | 27,062 | 10.99% | 24.99% |
| 3 | Supplier C | 11,937 | 4.85% | 29.84% |
| 4 | Supplier D | 8,777 | 3.56% | 33.40% |
| 5 | Supplier E | 7,477 | 3.04% | 36.44% |
| 6 | Supplier F | 6,154 | 2.50% | 38.94% |
| 7 | Supplier G | 5,083 | 2.06% | 41.00% |
| 8 | Supplier H | 4,980 | 2.02% | 43.03% |
| 9 | Supplier I | 2,650 | 1.08% | 44.10% |
| 10 | Supplier J | 2,552 | 1.04% | 45.14% |
| 11 | Supplier K | 2,540 | 1.03% | 46.17% |
| 12 | Supplier L | 2,504 | 1.02% | 47.19% |
| 13 | Supplier M | 2,480 | 1.01% | 48.19% |
| 14 | Supplier N | 2,145 | 0.87% | 49.06% |
| 15 | Supplier O | 2,012 | 0.82% | 49.88% |

Source : ABC company

3.4 Data Collection

There are four main methods of data collection which are surveys, interviews, observations and document analysis. Yin (2003) said that no single method has a complete advantage over all the others. Using multiple source of evidence can help to deal with the problems of establishing the construct validity and reliability of the case study evidence.

Document analysis is collection, review, interrogation and analysis of the various forms of the text as a primary source of research data (Leary, 2004). Interviewing is a method of data collection that involves researchers asking respondents basically open-ended questions (Leary, 2004). According to Yin (2003), interviews are of an open-ended nature in which you can ask respondents about facts of the matter, opinions of the events and also his or her own insights into certain occurrences.

In this study, the researcher uses the document analysis and interview methods to collect data. Firstly, the researcher needed to understand the historical data of supply disruption from the recorded documents of company from the year 2007 - 2010. Historical documents can provide the other specific details to corroborate information from other sources but if the documents provide contradictory rather than corroboratory, the researcher needs to pursue the problem by inquiring further.

The researcher choose semi-structured interview method in which the list of questions is prepared but the order of questions may be varied depending on the flow of conversation or additional questions that may be added during the interview to explore more details (Saunders, et al., 2003). Semi-structured interview leaves a room for flexibility to go into in-depth-details with probed questions. (Robson, 1993). Interviews will be conducted on one-to-one basis between the researcher and top 8 suppliers with high purchasing amounts of ABC company, face-to face.

Key Informants

The researcher invites a plant manager of each supplier (total 8 plant managers) for interviewing because of direct responsibility for manufacturing parts for ABC company and knowledge in the filed to response the research questions.

3.5 Interviews

According to Leary (2004), interview is a process that involves the need to: plan for all contingencies; prepare an interview schedule and data recording; run a trial or pilot; modify the process as appropriate; conduct the interview; and analyze the data. The researcher prepares three kinds of documents in order to conduct the interview effectively.

1. Information sheet

This is a invitation to potential participants to participate in the research study. Researcher sends a information sheet to potential participants in order to obtain

permission for the interview. The main content of the letter is to explain the purpose of the research study and for confidential treatment.

2. Consent form

Consent form was created to acquire permission from the participants.

3. Interview note

The researcher uses this document to write down an introduction of this study in order to explain to participants and to list questions with spaces for answering and extra probing questions.

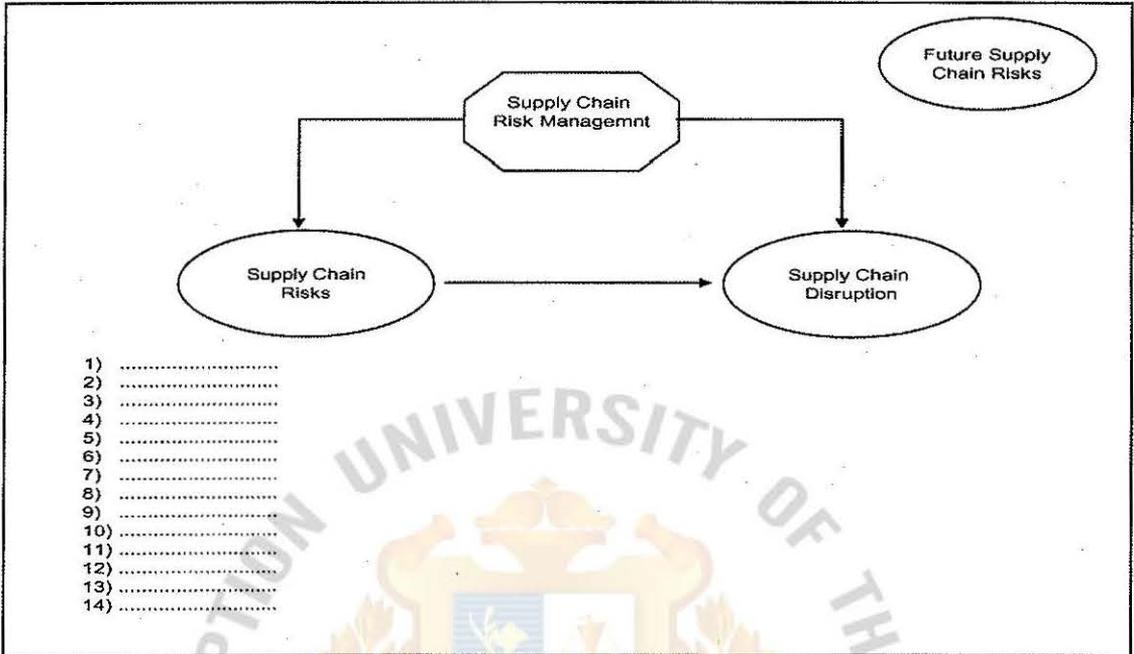
To prepare for an interview, the researcher conducted a pilot interview with colleagues in order to practice interview's skills and review the questions into an order that is logical and will ease participants. During the interview, data will be recorded by note-taking or perhaps by audio-recording after obtaining permission from participants.

3.6 Data Analysis

In the qualitative analysis, understandings are created by a process of uncovering and discovering themes that run through the raw data. Interpreting the implication of those themes for the research questions is necessary (Leary, 2004). According to Weber (1990), the content analysis is one of the data analysis methods for qualitative analysis that aims to interpret meaning in speech and text. NVIVO, one of the software programs using content analysis strategy base has become the most popular one to use qualitative data. This program can operate coding, search text and construct graphic structure. (MacMillan and McLachlan, 1999)

In this study, NVIVO is selected to aid in data analysis. The researcher had a chance to study how to use this software in practice for 2 days. NVIVO can help the researcher in data analysis and discover links between elements of data with graphic facilities. The draft result of linking of data is shown in Figure 3.1.

Figure 3.1 : Supply Chain Risks Model



In addition, summary of the descriptive table will be shown as an example in Figure 3.2 below.

Figure 3.2 : Summary of Supply Chain Risk

| No | supply chain risk | Supplier A | Supplier B | Supplier C | Supplier D | Supplier E |
|----|-------------------|--|---|--------------------------------|--------------------------------|--|
| 1 | Disaster | Company had to stop production for 3 days because of | No disaster risk because..... | No disaster risk because..... | No disaster risk because..... | No disaster risk because..... |
| 2 | Logistics | No logistics risk because..... | There was an accident of transportation from port to factory. It caused damage material | No logistics risk because..... | No logistics risk because..... | There was a port congestion at departure port. |
| 3 | Supply dependence | | | | | |
| 4 | Quality | | | | | |

Figure 3.3 : Descriptive Summary of Supply Chain Risk Management

| No | supply chain risk | Risk management | Supplier A | Supplier B | Supplier C | Supplier D | Supplier E |
|----|-------------------|-----------------|---|---|------------|------------|---|
| 1 | Disaster | Prevention | Constructed factory in the higher level of surrounding. | - | - | - | - |
| | | Correction | Used drain water machine to reduce flood. | - | - | - | - |
| 2 | Logistics | Prevention | - | Used reliability transport provider with monthly performance evaluation | - | - | Studied possibility of other ports to depart. |
| | | Correction | - | Arranged new shipment by airfreight | - | - | Arranged new shipment by airfreight |
| 3 | Supply dependence | Prevention | | | | | |
| | | Correction | | | | | |
| 4 | Quality | Prevention | | | | | |
| | | Correction | | | | | |

3.7 Quality of Research

3.7.1 Reliability

According to Yin (2003), the goal of reliability is to minimize the errors and biases in a study. Overcoming interviewer and interviewee biases is related to the way in which the qualitative research interview is conducted. Healey and Rawlinson (1994) said that a well informed interviewer has a basis for assessing the accuracy of some information offered.

To ensure the reliability, the researcher studies the supplier's company profile before conducting a interview. The ability to understand this type of information can create credibility and encourage interviewee to offer more detailed account of the topic

under discussion. Moreover, a list of interview themes was given to the interviewee before the interview. This allowed the interviewee to prepare himself/herself for the discussion in which he/she is to participate. The researcher chooses qualified persons to conduct the face-to-face interviews based on their responsibility and knowledge in the related theme.

3.7.2 Validity

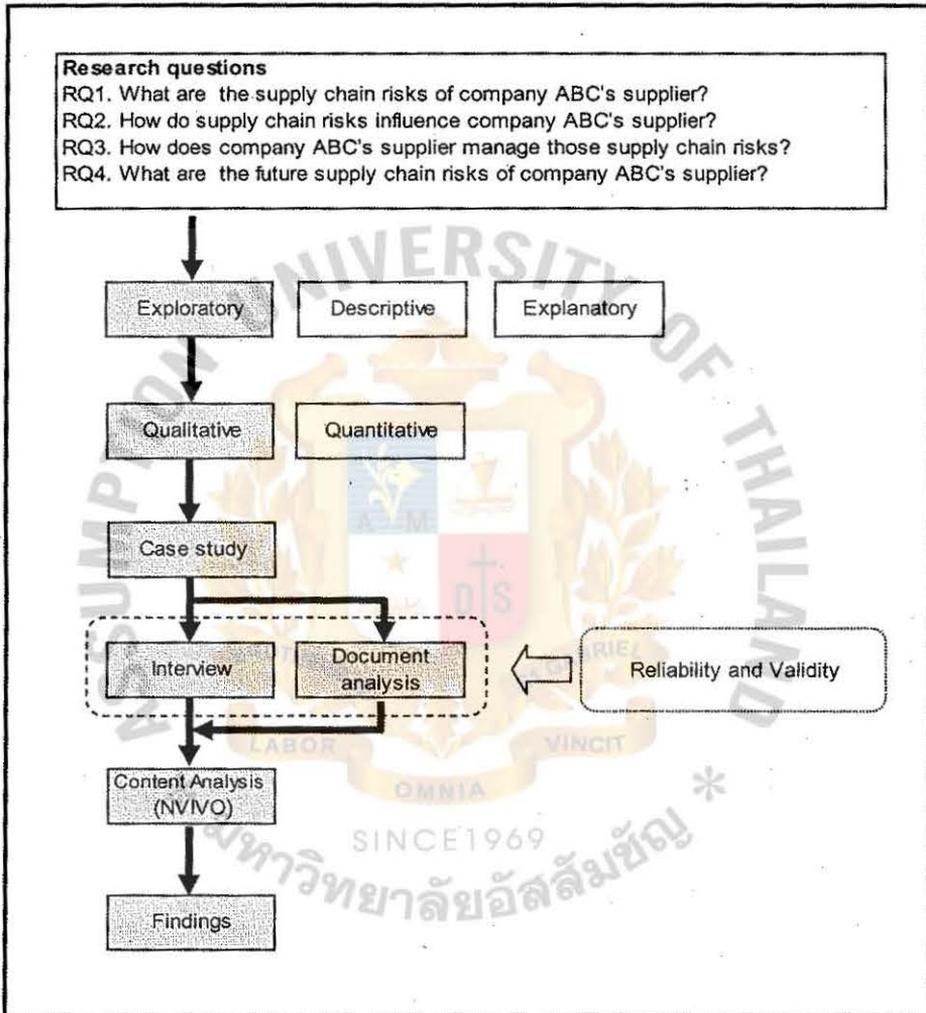
Yin (2003) shows that there are three tactics to increase construct validity: using multiple source of evidence, establish chain of evidence and have a draft case study report reviewed by key informants.

In the data collection of this study, the researcher selected document analysis and interviews as a multiple source of evidence and created a chain of information between these two evidences. In addition, the draft case study report is also reviewed by the interviewee.

3.8 Summary of Research Methodology

The research methodology is compiled in this study as shown in Figure 3.4 below.

Figure 3.4 : Summary of Research Methodology



Source : Compiled for this study

Exploratory research is selected to respond to research questions which need to explore what are supply chain risks of the supplier and how the supplier manages those risks. The research considers using the qualitative method in order to gain more understanding. Furthermore, the case study as a research strategy is used. The researcher uses the document analysis and interview methods to collect data. At this stage, reliability and validity are carefully taking care of. Finally, NVIVO software program is selected to aid in data analysis.

CHAPTER IV

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

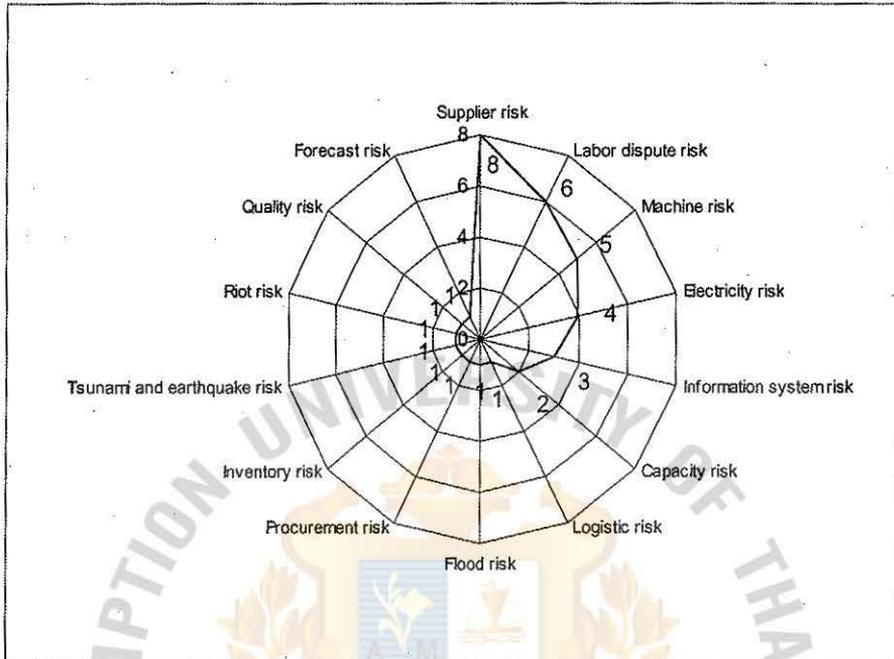
This study proposes to explore supply chain risks and how to manage those supply chain risks of ABC company' suppliers. In this chapter, the findings of five interview questions with 8 suppliers are presented. The content of this chapter consists of six sessions. First of all, supply chain risks will be explained. Then, supply chain disruption which is caused by supply chain risks will be described. Thirdly, interceptive approaches to solve problem are presented. Fourthly, preventive approaches are also explored and explained. Next, the researcher will describe the future supply chain risks. In the last session, an integrated framework of supply chain risk is shown. The presentation of this chapter is in accordance with five interview questions:

- 1) In past 5 years, what were the supply chain risks which your company confronted?
- 2) According to your mentioned supply chain risks, how did those supply chain risks affect your company?
- 3) When the problems occurred, how did your company resolve those problems?
- 4) How does your company manage the prevention of supply chain risks?
- 5) In the future, what are other supply chain risks that could probably occur besides the existing supply chain risks?

4.1 Supply Chain Risks

According to the findings, the researcher found total of 14 supply chain risks. Supplier risk from tier 2 supplier is the most mentioned supply chain risks. All suppliers faced this risk in the past. The second most mentioned risk is labor dispute risk. The third one is machine risk. The result of the interviews of supply chain risks are shown in Figure 4.1. Each supply chain risk will be explained one by one in this session.

Figure 4.1 : Supply Chain Risks



4.1.1 Supplier risk

According to interview, the researcher found that supplier risk is the most mentioned risk. All eight suppliers faced problems about their tier 2 supplier who could not deliver component parts or materials on time. The tier 2 supplier was not able to deliver on time because he was confronted with the floods, labor disputes, machine breakdowns, Tsunami and earthquakes, and logistics problems. As mentioned below:

Flood caused the supplier risks. Tier 2 supplier faced the big flood problem in year 2010 in North-eastern of Thailand. As two suppliers mentioned:

‘There was no flood in past 10 years. But in the last year, one of suppliers in Korat faced the flood problem.’ (Supplier A)

‘Last year, there was flood in Korat. It affected to our supplier’ (Supplier G)

Labor dispute at tier 2 supplier resulted in supplier risks. Operators of tier 2 supplier denied operating overtime production because they tried to put pressure for requesting higher salary and bonus. As suppliers stated:

‘There were labor disputes with the supplier. The labor union proposed high bonus and an increasing salary to company but there was no agreement between the labor union and the supplier. So, some employees denied working overtime.’ (Supplier A)

‘The supplier problem was one of the main risks in the past because of the labor dispute between the company and the labor union’ (Supplier D)

Tier 2 supplier caused a supplier risk to tier 1 supplier because the machines were out of order. Tier 2 supplier could not produce and deliver parts to the tier 1 supplier.

‘Our supplier could not deliver semi-products to our company because of the painting machine breakdown.’ (Supplier E)

According to the interview, tier 2 supplier’s plant in Japan was damaged from the Tsunami and earthquakes. Therefore, they could not deliver component parts to tier 1 supplier on time. As one stated:

‘Big impact is Tsunami and earthquakes in Japan. Our company faced the severe problem from the Tsunami and earthquakes. Electronic part supplier’s plant and machines in Japan were destroyed. The suppliers needed time to recover their production. It caused the scarcity of electronic component parts.’ (Supplier A)

Risk relating to packing and transportation failure of tier 2 supplier is one of the supplier risks which the researcher found from the interview. As suppliers explained:

'One more thing is transportation risk, employees of another company in the Industrial estate strike and disturb transportation route in Industrial estate.' (Supplier A)

'The supplier delays delivering forging part to our company because the container boxes for delivery were not enough.' (Supplier H)

4.1.2 Labor dispute risk

According to interview, six of eight suppliers mentioned labor dispute risk. Labor dispute has possibility to occur every year because labor union in company will request for increase in salary and bonus every year. In case that conclusion cannot be reached, the labor dispute problem will occur. As one of the supplier mentioned:

'Every year, the labor union in the company requests for increase in salary and high bonus. The labor union and company had a discussion to reach the agreement. So, there was labor dispute issue.'
(Supplier E)

Moreover, labor disputes tend to be high in the first period of establishment in company. As one mentioned:

'During the first establishment of labor unions in our company, there were labor disputes many times.' (Supplier H)

4.1.3 Machine risk

Machine breakdown is one of the common problems which the researcher found from interviews with suppliers. Five of eight suppliers mentioned about this risk. The main reasons are from new localization of machines in Thailand, old machines and poor maintenance. Examples of explanation are described below:

'There was machine breakdown in the past. Originally, we bought all of machines from Japan but the cost is very high. So we try to change from Japanese machines to local machines in Thailand. But at that time, there was a problem of local machine because of technical issues.' (Supplier E)

'There was machine breakdown because of old machines.'
(Supplier C)

4.1.4 Electricity risk

Four of eight suppliers mentioned about electricity risk. Electricity is the basic infrastructure to operate production. The researcher found that electricity is one of the supply chain risks. According to interview, electricity was down because of accidents. As the suppliers stated:

'Electricity was shutdown because a big truck hit the electricity power in the Industrial estate.' (Supplier A)

'There have been accidents in the past in which a big truck hit the power electricity generator in industrial estate. It caused electricity to shut down.' (Supplier H)

4.1.5 Information system risk

Three of eight suppliers mentioned about information system risk. ABC Company links the information system with suppliers in order to place an order and share important information. Information system was shut down at the supplier. As one stated

‘Our company and customer links information together by the information system. E-kanban will be ordered by the system. But sometimes, there was system shutdown.’ (Supplier H)

4.1.6 Capacity risk

Available capacity is one of the supply chain risks. Two of eight suppliers mentioned about this risk. The research found that supplier’s available capacity may not respond with customer’s orders. As one mentioned:

‘Our operators were working for 5 days for some production lines but some production line operators, were working 7 days per week. That means no holiday at all. Our production capacity of this line could not match with the customer’s demand.’ (Supplier D)

4.1.7 Logistics risk

According to interview, one of eight suppliers stated about logistics risk. Non-delivery related to transportation is one of the supply chain risks because of loss during transportation to the customer. One supplier mentioned that:

‘In the past, our parts were stolen during transportation on the way from the company to the customer.’ (Supplier H)

4.1.8 Flood risk

Flood is one of the disasters that suppliers faced. One of eight suppliers mentioned this risk. Actually, supplier’s plant was not flooded but employees could not commute from their house to the company. One supplier explained that:

‘We also faced the flood problem. Employees could not come to the company.’ (Supplier C)

4.1.9 Procurement risk

Purchasing matter was also found that it is one of supply chain risks. One of eight suppliers stated this risk. According to interview, in the seller market situation, the seller could raise the selling price. If company did not agree with this price level, the seller would deny selling materials or component parts.

‘Most of our materials are resin and the price is based on oil prices. In the last 4 year, the resin price fluctuated a lot. The supplier strongly requested us to adjust price. If there was no adjustment, the supplier would stop supplying material.’ (Supplier E)

4.1.10 Inventory risk

One of eight suppliers mentioned about inventory risk. Keeping inventory is one of the supply chain risks. The researcher found from the interview that keeping inventory can cause defective parts. As one stated:

‘Last 3 years ago, we kept safety stock of chromium parts for 3 days. These parts were packed with bubble sheets and kept in our warehouses. There was quality problem from keeping inventory.’ (Supplier E)

4.1.11 Tsunami and earthquake risk

According to interview, one of eight suppliers mentioned Tsunami and earthquake risk. Tsunami and earthquakes in Japan resulted in scarcity for importers in each country. As one mentioned:

‘The effect of the Tsunami in Mar 2011 made our company in Thailand face the difficulties to import compound materials from Japan. There was scarcity of materials.’ (Supplier E)

4.1.12 Riot risk

The researcher found that riots also affect the supply chain. From the interview, one of eight suppliers stated this risk. Supplier explained that it was difficult during a riot situation because it has an impact on their production because of curfew.

‘In the year 2009, there was a curfew because of riots of red shirts in Bangkok.’ (Supplier G)

4.1.13 Quality risk

The researcher found that quality control is one of the supply chain risks. One of eight suppliers stated this risk. Normally, there is a quality problem in production. Zero defective parts are impossible. The important thing is controlling and preventing it.

‘There were defects in production. It’s not much of a problem because it’s impossible for zero defects but we can control this by using KPI and quality control procedure.’ (Supplier H)

4.1.14 Forecast risk

According to interview, one of eight suppliers mentioned about forecast risk. Accurate production forecast from customers is important for supplier to prepare and plan a production schedule. In case the actual production fluctuates and is higher than normal forecast, there is possibility that the supplier cannot deliver required quantities as customer’s order.

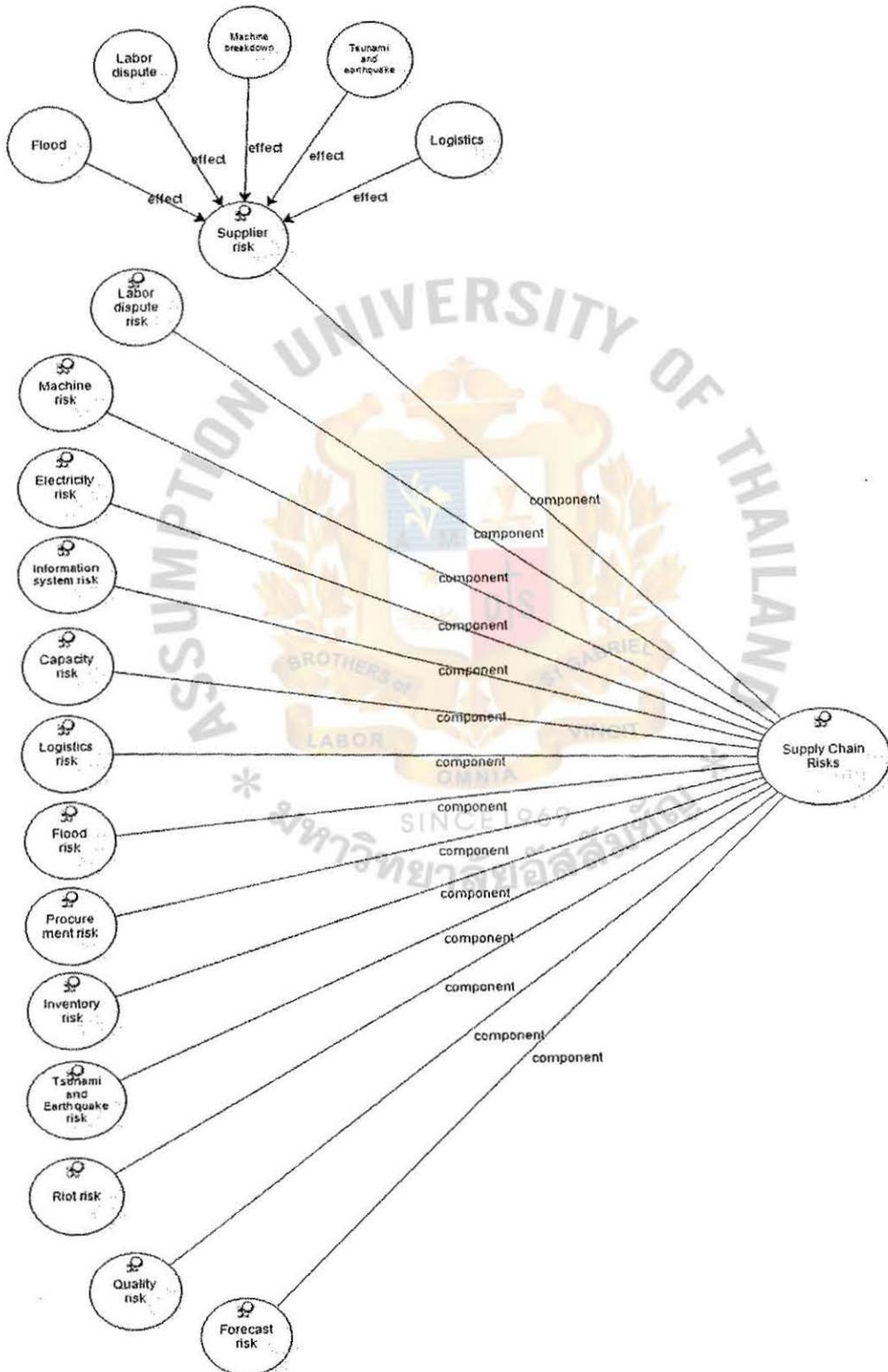
‘Actual production volume of customer was higher than production forecast. We need lead time for importing and installation of CNC machines for around 8-10 months and assembly machine for around 6-8 months.’ (Supplier H)

Figure 4.2 : Summary of Supply Chain Risk

| No | Supply chain risks | Supplier A | Supplier B | Supplier C | Supplier D | Supplier E | Supplier F | Supplier G | Supplier H | |
|----|-------------------------|-----------------------------|---|---|--|--|---|---|---|--|
| 1 | Supplier risk | Flood | One of suppliers in Korat faced the flood problem. | | Supplier in Korat confronted flood. | | | Supplier faced the flood problem. | Supplier in Korat faced the flood problem. | |
| | | Machine | | | | | Supplier's painting machine breakdown. | | | |
| | | Labor dispute | No overtime production of supplier's operators because of labor dispute. | Employees denied working overtime production. | | Operators of supplier refused to operate over time production. | | | | |
| | | Tsunami and earthquake | There was scarcity of electronic component parts from Japan. | | | | | | Tier 2 supplier in Japan could not export component parts and material to Thailand. | |
| | | Logistics | There was strike in industrial estate. It disturbed transportation route. | | | | | | | Container box for delivery was not enough. |
| 2 | Labor dispute risk | | There was labor dispute for salary and bonus. | | There was the conflict between company and labor union. | Labor union requested for increasing salary and high bonus. There was labor dispute issue. | For labor dispute, operators denied working over time production. | There was conflict between union and company about salary | There was labor dispute many times. | |
| 3 | Machine risk | | EDP painting machine was out of order | Machine breakdown because of old machine. | Production line stop because of machine breakdown | There was a problem of local machine because of technical issue. | | | Machine breakdown was almost 12 days. | |
| 4 | Electricity risk | There was electricity down. | There was electricity down. | | There was electricity down many times in industrial estate. | | | | There was electricity down. | |
| 5 | Information system risk | | System could not operate for ordering production and ordering part from supplier. | | Sometime we could not print out order sheet from system. | | | | There was system down. | |
| 6 | Capacity risk | | | | Production capacity of could not match with customer demand. | | Production capacity of could not match with customer order. | | | |
| 7 | Logistic risk | | | | | | | | Parts were stolen during transportation from our company to customer. | |

| No | Supply chain risks | Supplier A | Supplier B | Supplier C | Supplier D | Supplier E | Supplier F | Supplier G | Supplier H |
|----|-----------------------------|------------|------------|---|------------|---|------------|--|---|
| 8 | Flood risk | | | Employees could not commute to work and operated production due to flood. | | | | | |
| 9 | Procurement risk | | | | | If there was no price adjustment with supplier, supplier would stop supplying material. | | | |
| 10 | Inventory risk | | | | | There was quality problem from keeping inventory. | | | |
| 11 | Tsunami and earthquake risk | | | | | The effect of tsunami in Mar 2011, there was difficulty to import compound material from Japan. | | | |
| 12 | Riot risk | | | | | | | In year 2009, there was a curfew because of riot in Bangkok. | |
| 13 | Quality risk | | | | | | | | There was defect in production. |
| 14 | Forecast risk | | | | | | | | Actual production volume of customer was higher than production forecast. |

Figure 4.3 : Model of Supply Chain Risk



4.2 Supply Chain Disruptions

Once supply chain risks were explored, the researcher would like to know the effect of those risks to the supplier. According to the findings, the researcher found that supply chain risks resulted in supply chain disruptions. The supplier confronted with delays and shortages of input, inability of facilities, damage of facilities, inability to coordinate and execute transactions, unavailability of manpower, unavailability of outbound services, availability of faults, and unavailability of production capacity. Details of each supply chain disruption are explained below.

4.2.1 Delay and shortage of input

According to the interview, the researcher found that supplier risks, procurement risk, and Tsunami and earthquake risks caused delay and shortage of input to tier 1 suppliers. Regarding supplier risks, once the flood occurred, tier 2 suppliers faced decreasing capacity or production stop. This also affected delay of delivery and short supply to tier 1 suppliers. Tier 1 suppliers could not obtain material or component parts for production. As the suppliers explained:

‘Because of the floods problem, the supplier could not produce parts and deliver parts to our company because water ran into supplier’s plant. The machines could not operate.’ (Supplier C)

‘About delay delivery from suppliers, the suppliers delayed delivery of materials to our company because they faced the flood problem in their production plant.’ (Supplier F)

‘The machines at the supplier plant were flooded. The suppliers could not produce parts and deliver them to our company.’
(Supplier G)

In addition, labor dispute at tier 2 suppliers also caused delay delivery of parts to tier 1 suppliers. As one explained:

‘For labor dispute problems of suppliers, the conflict between the company and labor unions affected our company. Operators of the supplier refused to operate over time production in order to put pressure on the company. It caused a delay of delivery for our company.’ (Supplier D)

Machine breakdowns at tier 2 supplier also caused production stop. Tier 2 suppliers could not deliver parts to tier 1 suppliers. Therefore, tier 1 suppliers could not produce the part. As one stated:

‘For supplier failure, the supplier could not deliver an order to our company. We could not produce parts and had to use our safety stock to deliver to customer.’ (Supplier E)

There was a scarcity of raw materials and component parts because of the Tsunami and earthquakes in Japan. Tier 1 suppliers received materials and component parts delay from tier 2 supplier. As one stated:

‘The effect of the Tsunami and earthquake was terrible. There were some safety stocks at supplier’s plant in Japan but the supplier faced difficulty to manage and arrange export shipment at that time. This caused delay of delivery to us. In addition, the suppliers also could not deliver component part as per our requested order quantities because they had to allocate the remaining safety stocks to all customers over the world.’ (Supplier A)

Tier 2 supplier’s failure of transportation caused tier 1 suppliers to have no component parts or raw materials to produce parts. As one explained:

‘Because of supplier failure, the suppliers could not deliver parts to our company.’ (Supplier H)

Regarding procurement risks, material price fluctuation resulted in price increase of materials. Tier 2 suppliers would not supply material to tier 1 suppliers in case tier 1 supplier didn’t accept the price increase. As a supplier stated:

‘In case of material price fluctuation, supplier of resin price wanted to adjust price of material. If we didn’t agree, the supplier would stop supplying material to us.’ (Supplier E)

One supplier mentioned about Tsunami and earthquake risk. Tsunami and earthquakes in Japan caused the scarcity of material because supply production bases were destroyed. The mother company in Japan could not deliver materials to the suppliers.

‘The effect of Tsunami and earthquakes caused the mother company in Japan to stop deliver of compound materials to our company because the supplier’s plant in Japan was damaged from Tsunami and earthquakes. At that time, our safety stock of materials in Thailand gradually reduced but we could not receive new materials from Japan.’ (Supplier E)

In summary, supplier risks (from floods, labor disputes, machine breakdowns, Tsunami and earthquakes, and logistics problems at tier 2 supplier), procurement risk and Tsunami and earthquake risks caused delay and shortage of materials or component parts to tier 1 suppliers.

4.2.2 Inability of facilities

According to interview, the researcher found that machine risks and electricity risks caused inability of facility. The supplier could not operate production. Once machines breakdown, the machine could not operate. Suppliers could not produce parts for delivery to the customer. As some companies stated:

‘Our EDP painting machine was out of order. We stopped production for around 1 hour.’ (Supplier B)

‘For machine breakdown, local machines could not operate so we could not produce parts as our production plans for a day. But it did not affect to customer because our safety stock was available for 3 days.’ (Supplier E)

Regarding electricity risk, machines could not operate. Therefore, suppliers had to stop production because of electricity shutdown. One supplier had to stop production around an hour but another supplier had to stop for 2 hours. As some supplies explained:

‘For electricity shutdown, our machines could not be operated. We had to stop production line for 2 hours.’ (Supplier B)

‘For electricity shutdown, our company could not operate production anymore. The highest down time was around half day. At that time, we delivered safety stock to customer instead.’

(Supplier D)

In brief, machines and electricity risk resulted in inability of facilities. The suppliers could not operate production because of machine breakdown and electricity shutdown.

4.2.3 Damage of facilities

According to the interview, the researcher found that electricity risk not only caused inability of facilities but also caused damage of facilities. Electricity shut down during operation production would cause damage of machines, such as drilling machine. As one mentioned:

‘The electricity was shut down around an hour in this area. We could not produce parts and it caused the damage of drilling tools.’

(Supplier H)

4.2.4 Inability of coordinated operations and executed transactions

This study found that information risk resulted in inability of coordinated operations and executed transactions of the suppliers. According to interview, once the information system was down, the suppliers could not order parts from production and order components from tier 2 supplier. Moreover, suppliers also could not print out order sheets from customers to attach with parts for delivery. As suppliers mentioned:

‘Information system shutdown seldom occurred. Our system could not operate for ordering production and ordering parts from supplier.’ (Supplier B)

‘Information system shut down also affect the company. Our company and customers linked information systems in order to place a required order. But some times we could not print out order sheet from system. This caused delay delivery to customers because we need to attach order sheets with parts. A customer needs to scan a barcode for receiving part.’ (Supplier D)

4.2.5 Unavailability of manpower

According to the findings, the suppliers faced the unavailability of manpower because of effect from labor dispute risk, flood risk, and riot risk. Regarding labor dispute risks, employees of the supplier denied operating overtime production in order to put pressure to supplier during negotiations. There was lack of manpower to operate production. As many suppliers explained:

‘Labor dispute issues are quite difficult to manage. At that time, labor unions requested increase in salary and high bonus. During negotiation period, employees denied working overtime. It caused low production capacity which could not meet our production plans.’ (Supplier B)

‘Labor dispute problem of our company also resulted in no overtime production because operators refused to operate. It caused low capacity which could not meet production plans and customer’s demand.’ (Supplier D)

‘While the company and unions were discussing plans, some employees denied working overtime in order to put pressure on the company. As a result, production capacity dropped. We could not reach the production plans.’ (Supplier E)

From the findings, one supplier explained that flood risk was related to difficulty to commute among employees. Some employees could not come to work because transportation route was flooded. Therefore, the supplier lacked manpower to operate production. As one explained:

‘We also faced the flood problem. Employees could not come to company It resulted in lack of manpower to produce parts so production capacity decreased.’ (Supplier C)

This study found that curfews resulting from riot risk caused the difficulty of working overtime in the night. Operators had to commute to home before the curfew period. It effected to manpower to operate production during the night shift. As one mentioned:

‘For the curfew case, it affected night shift manufacturing because we already planed overtime production. Employees finished work at 5:00 PM. and then operated overtime until 8:00 PM. Curfew was from 10:00 PM. so our company was much concerned about the safety of employees. We decided that there should not be overtime production because of no manpower.’ (Supplier G)

In sum, labor disputes, floods, and riot risk could cause unavailability of manpower. Supplier faced the lack of manpower problem.

4.2.6 Unavailability of outbound services

Research found that logistic risk cause the unavailability of outbound services for customer. The supplier could not deliver parts to customer in full. According to interview, there were lost parts during transportation because 3PL stole them.

‘For transportation problem, customer did receive parts completely in accordance with customer’s orders because of loss from transportation.’ (Supplier H)

4.2.7 Availability of fault

One supplier explained that inventory risk could result in defective parts because of keeping inventory under inappropriate conditions. The suppliers could not deliver parts to customer. The defective parts needed to be repaired and corrected. As one stated:

‘In case of keeping inventory, we found that bubble sheet packing on part caused the appearance defects to the chromium part. Defected parts could not be delivered to the customer. We needed to repair defective parts.’ (Supplier E)

Furthermore, quality risks also caused defective parts. Once there was a defective part, it would be investigated for destroy or repair. If this part had a minor defect, it could be repaired but the supplier had to take time and resources to repair the part.

‘For quality problem, our inspector rejected defected parts because it could not pass quality standards and had to rework.’ (Supplier H)

In summary, inventory and quality risk could result in availability of fault which caused defective parts.

4.2.8 Unavailability of production capacity

From the findings, the capacity of the company was not enough to response with the customer’s demand. This caused unavailability of production capacity to produce parts for the customer. As one explained,

‘In case of capacity issue, our operators were working with 5 days for some production lines but some production lines operators were working 7 days per week. That means no holiday at all. Our production capacity of this line could not match with the customer demand.’ (Supplier D)

In addition, forecast risk also resulted in unavailability of production capacity. In case that actual production volume of the customer was higher than forecast production volume, the supplier could not produce parts and deliver in accordance with the customer’s order. As companies explained:

‘Actually we received forecast from the customer and then we planned for production. But actual production volume was greater than forecast. So, we could not produce and deliver products to the customer.’ (Supplier F)

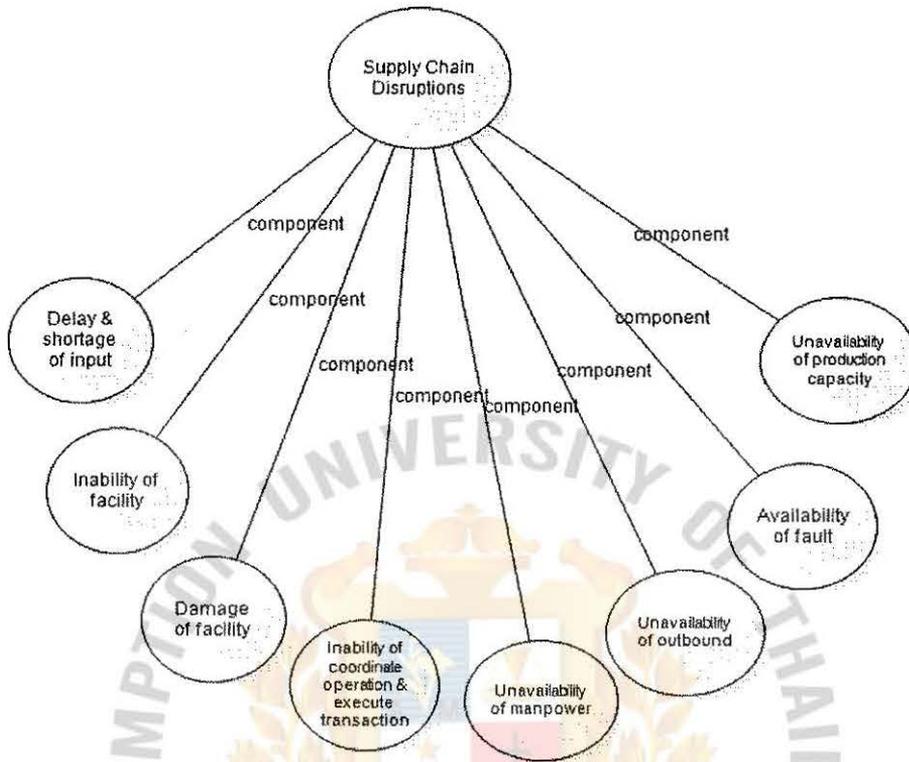
‘For fluctuating forecast, our production capacity was not enough to serve the customer’s order.’ (Supplier H)

In brief, capacity and forecast risk could cause the unavailability of production capacity to operate production according to the customer’s demand.

Figure 4.4 : Summary of Supply Chain Disruptions

| No | Supply Chain Disruptions | Supply Chain Risks | | | | | | | |
|----|---|--------------------|--|---------------|--|--|--------------------|---------------------------------------|--|
| | | Supplier A | Supplier B | Supplier C | Supplier D | Supplier E | Supplier F | Supplier G | Supplier H |
| 1 | Delay and shortage of input | Supplier risk | Supplier risk | Supplier risk | Supplier risk | 1) Supplier risk 2) Procurement risk 3) Tsunami and earthquake | Supplier risk | Supplier risk | Supplier risk |
| 2 | Inability of facility | Electricity risk | 1) Machine risk 2) Electricity risk | Machine risk | 1) Machine risk 2) Electricity risk | Machine risk | | | 1) Machine risk 2) Electricity risk |
| 3 | Damage of facility | | | | | | | | Electricity risk |
| 4 | Inability of coordinated operation and executed transaction | | Information system risk | | Information system risk | | | | Information system risk |
| 5 | Unavailability of manpower | | Labor dispute risk | Flood risk | Labor dispute risk | Labor dispute risk | Labor dispute risk | 1) Labor dispute risk 2) Riot risk | Labor dispute risk |
| 6 | Unavailability of outbound | | | | | | | | Logistics risk |
| 7 | Availability of fault | | | | | Inventory risk | | | Quality risk |
| 8 | Unavailability of production capacity | | | | Capacity risk | | Capacity risk | | Forecast risk |

Figure 4.5 : Model of Supply Chain Disruption



4.3 Corrective Approaches

According to the findings, supply chain risks resulted in supply chain disruptions. The supplier confronted delay and shortage of input, inability of facilities, and damage of facilities, inability to coordinate and execute transactions, unavailability of manpower, unavailability of outbound services, availability of fault, and unavailability of production capacity. Once the supply chain disruptions occurred, corrective actions were conducted to solve the problem. Supplier explained how to solve problem of each supply chain disruption as follows:

4.3.1 Delay and shortage of input

According to the interview, the researcher found that supplier risks, procurement risk, and Tsunami and earthquake risk caused delay and shortage of input for tier 1 suppliers. In case of flood problems, the tier 2 supplier's machines were flooded. The

tier 1 supplier tried to find new tier 2 supplier both in Thailand and other countries. Then source changes were conducted for new tier 2 supplier. As one mentioned:

‘During the flood problems, we tried very hard to find new suppliers who could produce resin parts. Fortunately, there were new suppliers who just passed our supplier evaluation criteria. So we switched from current supplier to new suppliers for producing this part immediately.’ (Supplier A)

Suppliers also cooperated with customers and requested for adjusting delivery plans. The supplier moved mold from tier 2 suppliers to new suppliers to start production. As one explained:

‘We cooperated with the customers to solve the problem together and adjusted plans for export parts. We tried to find new sources in Thailand, Japan and USA. Finally, we found new supplier and then we moved mold from current suppliers to new supplier for producing parts.’ (Supplier C)

Tier 1 suppliers cooperated with tier 2 supplier to solve the problems together. Machines were needed to be fixed and some spare parts needed change. Tier 1 suppliers contacted their alliance company and requested for spare parts. Then tier 1 suppliers cooperated with tier 2 suppliers and sent their technicians to tier 2 suppliers for fixing machines. As one explained:

‘The suppliers drained water from their plants but the machines were damaged. The suppliers needed to fix and change spare parts. We tried to find the spare parts. Finally, we found them from our alliance company and three technicians were sent from the company to the supplier for fixing the machines.’ (Supplier G)

Labor problems of tier 2 suppliers caused supplier risk. Once labor disputes occurred at tier 2 supplier, tier 1 supplier kept monitoring the stock information of the tier 2 suppliers closely. As one stated:

‘For labor disputes, we closely monitored stocks and situation with the supplier. The supplier needed to send stock amount information and updated situation to us continuously. Basically, we keep safety stock of finished goods for around 3-7 days. Finally, the suppliers could finish negotiations with their labor union within 2 days.’
(Supplier A)

There is lack of manpower to operate production at tier 2 suppliers due to labor disputes so tier 1 supplier cooperated with tier 2 suppliers and sent their manpower to tier 2 suppliers to operate production. As two suppliers mentioned:

‘For delay of delivery from suppliers, there were two main problems. The first one was that suppliers could not produce parts as planned because their operator resigned or were on strike. There was no manpower to operate production. So, our company sent our operators to the supplier and helped them with the production. Moreover we also contacted customer to report the situation and rearrange production plans to set priorities for production. For example, if components of A parts is not enough, we will switch to produce B parts instead.’ (Company B)

‘For labor dispute problem of suppliers, we brought our operators to the supplier and then operated production instead of the supplier’s operators. Our operators were quite skillful so they could operate production under the supervision of supplier’s production manager.’
(Supplier D)

Once tier 2 supplier's machines were out of order, tier 1 and tier 2 suppliers cooperated with each other to solve the problem. Tier 1 suppliers considered operating some processes in their plants. As one stated:

'About solving supplier failures, our company and supplier discussed and studied how to solve this problem together. Finally, we brought semi-product parts from supplies to our plant and proceeded the painting by ourselves.' (Supplier E)

Supplier risk from the Tsunami and earthquakes caused difficulty of importing component parts from Japan. Tier 2 suppliers in Japan could not arrange shipments to meet requirement date. Therefore, shipments were arranged by airfreights to shorten lead time of delivery. In parallel, new sources were studied to make changes. As one described:

'In case of the Tsunami and earthquakes, we conducted special activity to control and monitor stock and shipment of suppliers in order to match with our production and we requested suppliers to arrange shipments by airfreight. Meanwhile, we also studied how to change source of component parts to new sources by cooperating with the mother company in Japan and with the customer.'

(Supplier A)

In addition, sharing information and cooperating with customers was conducted. The supplier discussed with the customer and requested to switch order. As one stated:

'Once we faced the effect of Tsunami, we reported the severity of the situation to customers immediately and cooperated with customers to switch orders. At that time we delayed delivery of export parts and service parts.' (Supplier G)

Regarding supplier risk from logistics, tier 2 suppliers could not deliver parts to tier 1 suppliers because of road disruptions from the striking mob. To solve this problem, tier 1 suppliers contacted with the industrial estate to solve this problem and waited until negotiations were completed between the striking mob and police. As one explained:

‘Transportation problem occurred because the suppliers could not pass through the striking mob. Industrial estate officers and police came to negotiate with the striking mob. It took time for negotiations but finally, the striking mob allowed trucks and car to pass.’
(Supplier A)

Container boxes for delivery were not enough at tier 2 suppliers to send to tier 1 suppliers. Therefore, tier 1 suppliers had to conduct special approval of temporary container box’s specification for delivery. Finally, tier 2 supplier could use temporary container boxes for delivery. As one explained:

‘For supplier failure of delivery, we discussed with the supplier and conducted approval for special container specification.’
(Company H)

Regarding procurement risk, tier 2 suppliers would not supply material to tier 1 supplier if there was no price adjustment. Therefore, tier 1 supplier negotiated with tier 2 supplier in order to compromise. Finally, the suppliers and tier 2 suppliers could reach a conclusion. As one stated:

‘For material price fluctuation problem, we negotiated with suppliers and requested them for data of resin price fluctuation. Finally, we allowed suppliers to increase the price. So, the supplier still kept the supply resin material for us.’ (Supplier E)

Regarding Tsunami and earthquake risk, there was scarcity of material in Japan. To solve this problem, the suppliers contacted the mother company in Japan in order to seek new sources of materials and requested the customers to accept this change. As one explained:

'For Tsunami and earthquake problem, we cooperated with the mother company in Japan and all affiliate companies all over the world to find the new source. Finally, we found our affiliate company in Vietnam who currently uses this material. Therefore, we urgently contacted the affiliate company and requested for support of compound materials. In addition, we also reported and requested customer for approving material source change.' (Supplier E)

In summary, the supplier risk, procurement risk, and Tsunami and earthquake risk caused delay and shortage of input. To solve the problem, the suppliers changed the source to new supplier. According to the findings, researcher found that there was cooperation and collaboration of tier 1 and tier 2 suppliers to solve problem for example, tier 1 sent their operators to operate production at tier 2 supplier, tier 1 supplier cooperated production with tier 2 supplier in case of machine breakdown at tier 2 supplier and tier 1 supplier changed process from tier 2 supplier to tier 1 in-house production. In addition, suppliers also contacted customers to inform them about the situation and requested the customer for support in order to solve the problem.

4.3.2 Inability of facilities

According to the interview, the researcher found that machine risks and electricity risk caused inability of facility. The suppliers could not operate production. Regarding machine risks, once the machine was breakdown, most of the suppliers could not repair the machine by themselves. They needed to contact with the machine's seller for the repairs. If spare parts were not available in Thailand, their imports from other countries were needed. As two examples mentioned:

'At that time, we contacted the suppliers of machine and requested them to fix it. Our maintenance department also cooperated the supplier to repair EDP painting machine. Color in EDP pool had to be drained first and then electrical circuit inside of EDP pool was fixed. It took totally around 4 hours because of the big pool and only one drainage machine.' (Supplier B)

'Fortunately, at that time we kept safety stock of finished goods for around 20 days. Thus, there was no effect on the customers. We urgently contacted the supplier in Japan to import spare parts by air freight and fix the machines.' (Supplier H)

One supplier of plastic part production could use tier 2 suppliers to produce parts instead because machine and processes of tier 2 suppliers are compatible. As one stated:

'When the machine was out of order, we could not repair it by ourselves because of no technicians and machine specialists. We tried to find suppliers who could produce this part and then we moved our injection mold to this supplier. We and the suppliers proceeded to do trial parts and evaluation. Finally, the supplier could produce this part for us.' (Supplier E)

In brief, to solve problem of machine risk, the supplier contacted machine's seller for repairing machines. In case spare parts were not available in stock. The order o be given to the spare part's supplier. In addition, tier 1 suppliers cooperates with tier 2 suppliers to utilized tier 2 suppliers for producing parts instead of them.

Regarding electricity risk, once electricity was shut down, the supplier had to wait until electricity resumed. They could not do anything much. But suppliers would contact and informed the situation to the customer in order to arrange priority of

customer's order. Safety stock would be delivered to the customer instead. As example of two suppliers explained:

'For electricity shutdown, we informed the situation to the customer and requested for delay delivery of after-sales service parts and export parts in order to have enough parts for domestic production.'

(Supplier A)

'Because of electricity shutdown problems, we could not operate production. We contacted the Electricity generator office to request for the fixing. We had to wait around 2 hours. Our safety stock was delivered to customers instead.'

(Supplier B)

In sum, to solve electricity problems, the suppliers could not solve problem by themselves. They had to contact for assistance from the Electricity generator office or concerned parties to solve this problem. In the meantime, the suppliers also cooperated with the customers and requested the customers to set priority for orders. Safety stocks in inventory were delivered to customers instead.

4.3.3 Damage of facilities

Electricity risk not only caused inability of facilities but also caused damaged facilities. Electricity shutdown during operation of production would cause damage to the drilling machines. To solve this problem, the suppliers contacted the industrial estate to fix and solve this electricity shutdown. As one explained:

'For electricity shutdown, we contacted the industrial estate to solve this electricity problem.'

4.3.4 Inability to coordinate operation and execute transactions

According to the interview, once information system was shut down, it affected the linkage of information between customers and suppliers. Operation transaction could not be conducted. To solve this problem, the supplier would proceed with activities by manual operations. As one reflected:

‘In case of system error, we could not order production and order parts from supplier via the electronic system. So, we printed out production information from the system and then sent it manually to production. To order parts, we printed out order sheets and sent it to the suppliers via fax and e-mail.’ (Supplier B)

In case that the suppliers could not print out order sheets from the information system link between suppliers and customers, the suppliers would request other companies in the same area to print it instead.

‘If the information system shut down, we went to another company in this area to print out order sheet. This company also used the same information system for the same customer.’ (Supplier D)

‘For information system shutdown, in this industrial estate, there are many companies which use the same system and deliver parts to the same customer. So, we went to another company and printed out E-kanban.’ (Supplier H)

In summary, in case of information system shutdown, the supplier proceeded operation manually. Some suppliers who could not print out order sheets went to the alliance company and printed out documents because their alliance company used the same information system.

4.3.5 Unavailability of manpower

According to interview, once labor dispute occurred, there was lack of manpower to operate production because employees denied operating overtime production. Therefore, the supplier tried to reach an agreement with the labor union as soon as possible. The negotiation in order to compromise was conducted. As suppliers mentioned:

‘Human issues are very complicated and difficult to control. Our top management tried to negotiate with the labor union. Finally, in a compromise between the company and labor unions, an agreement was reached for increasing salary and bonus.’ (Supplier B)

‘For the labor problem, the company negotiated with the unions and explained the reason why the company could not provide benefits as per the unions request. It took around one day for negotiation. Fortunately, the company had safety stock of finished goods for around 2-3 days. So there was no effect on the customer.’

(Supplier G)

Labor disputes affected lack of manpower to operate production. Therefore, some suppliers requested more manpower from foremen, supervisors and other support departments in their company to operate production instead of operators. As two suppliers stated:

‘In case of labor dispute problem, at that time, our operators were not enough so we requested foremen and supervisors to operate the production instead.’ (Supplier E)

‘Support functions including engineering, maintenance, quality assurance, quality control departments came to operate overtime production instead. Finally, we could negotiate with the labor union

about their request for salary and bonus and reach an agreement.’

(Supplier H)

In summary, there are two main corrective measures for labor disputes. Supplier tried to negotiation with the labor unions in order to compromise and solve problem as soon as possible. Supplier would also request other supporting departments to operate production instead of operators.

Regarding flood risk, some employees could not commute to work and operate production due to flooded road. To solve this problem, the suppliers arranged accommodation for employees in the company’s premises. As one mentioned:

‘For flood problem in our company, we provided accommodation in the company area to all employees.’ (Supplier C)

Riot risk resulted in curfew. There was restriction of time to stay in the residence. So, it caused lack of manpower during night shift production. The suppliers tried to increase production efficiency and request customers to set priority of orders. As one stated:

‘During the curfew period, we contacted the customers and requested for cooperation to clarify priority of order and balance stock In addition, we also increased production efficiency in order to gain more output.’ (Supplier G)

4.3.6 Unavailability of outbound services

The researcher found that logistic risk caused the unavailability of outbound services to customers. The suppliers could not deliver parts to customer in full. There was loss of parts during transportation because the 3PL stole them. To solve this issue, the suppliers delivered parts from safety stocks to customer again and requested 3PL to take responsibility for this loss.

'For transportation problem, there was safety stock in our warehouse. So we delivered parts to customer again and requested 3PL to pay money for this loss.' (Supplier H)

4.3.7 Availability of fault

Inventory risk could result in defective parts in case of keeping inventory in an inappropriate condition. The suppliers could not deliver parts to the customer. Once defective part were found, the supplier inspected all parts and repaired it. In addition, the company also changed packing material specification.

'In case of defects from keeping inventory, we urgently took action to solve this problem. All safety stocks for 3 days in the warehouse were inspected again. Moreover, we changed the packing material.'
(Supplier E)

Furthermore, quality risks also caused defective parts. Once defective parts were found, the concerned quality departments would come to inspect and made judgments for destroying or repairing. If this part had a minor defect, it could be repaired. Nevertheless, suppliers had to take a time and resources to repair the parts. As one explained:

'In case of quality problems, our quality assurance and quality control department came to inspect the parts. They found that defective parts could be repaired so these parts were sent for repair again.'

(Supplier H)

In sum, to solve the problem of fault, the suppliers had to inspect all defective parts and repair them.

4.3.8 Unavailability of production capacity

In case that capacity of company was not enough to respond with customer's demand, it caused unavailability of production capacity to produce parts for customers. From the interview, the suppliers conducted improvement (kaizen) in order to increase efficiency and increase production time by adding 2 shift operations and overtime production in order to solve this problem. As one mentioned:

'To increase production capacity, we conducted kaizen activity to improve production efficiency. The main point is to reduce takt time. In addition, we also operate production with 2 shifts and overtime production.' (Supplier D)

In case of fluctuating forecast, capacity of company was not enough to response with the customer's demand. This caused unavailability of production capacity to produce parts for the customers. Therefore, the suppliers added more resources in production processes and reduced cycle time. In addition, the supplier planed to reduce lead time of the new machine installation in order to response with high production volume. As one mentioned:

'For fluctuating forecast problem, production volume of the customer increased over than the forecast. We increased production shifts from 1 to 2 shifts per day and added more operators in order to reduce production cycle time. In addition, we conducted localization of machine in Thailand in order to reduce import lead time. The mother company in Japan issued the drawing and then we utilized local suppliers in Thailand to produce machines.' (Supplier H)

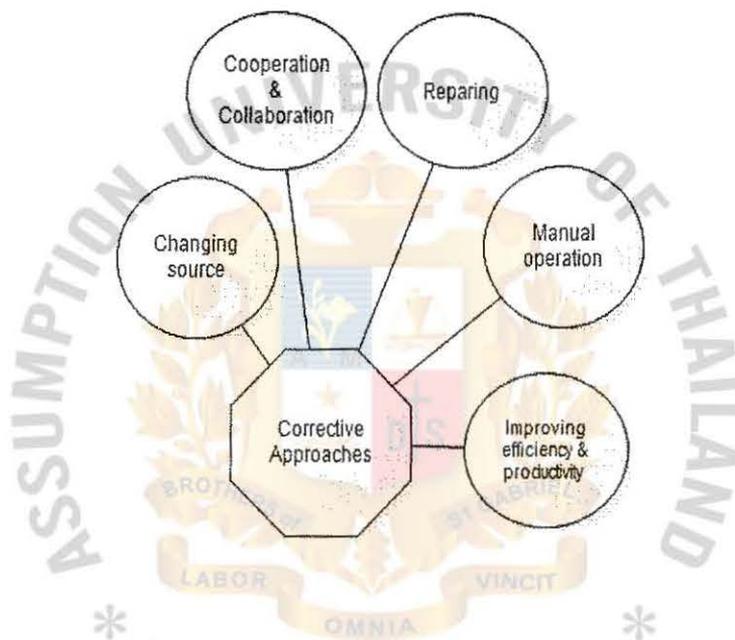
In sum, in case of unavailability of production capacity, the suppliers tried to improve efficiency and increase production time by adding 2 shift operations and overtime production. In addition, the suppliers tried to reduce installation lead time of new machines in order to obtain more capacity at an earlier time.

Figure 4.6 : Descriptive Summary of Corrective Approaches

| No | Supply chain risks | Supplier A | Supplier B | Supplier C | Supplier D | Supplier E | Supplier F | Supplier G | Supplier H |
|----|---|---|---|--|---|---|--|---|---|
| 1 | Delay and shortage of input | 1) Changed new supplier 2) Monitored stocks. 3) Arranged airfreight | 1) Sent operators to tier 2 supplier and help them for production. | 1) Cooperated with customer adjusted plan 2) Moved mold to new tier 2 supplier. | 1) Sent operators to tier 2 supplier and help them for production | 1) Proceeded the painting at inhouse. 2) Negotiated price with tier 2 supplier. 3) Find new source. | Changed new supplier | 1) Sent spare part and technician to tier 2 supplier for fixing machine. 2) Cooperated with customer for priority of order | 1) Approved special container specification. |
| 2 | Inability of facility | Informed customer and requested for delay delivery. | 1) Contacted supplier of machine and request them for fixing 2) Contacted to Electricity generator office. | Contacted supplier of machine and request them for fixing | 1) Contacted supplier of machine and request them for fixing 2) Contacted Industrial estate to fix this problem. | Moved injection mold to tier 2 supplier for production. | | | 1) Contacted supplier of machine for fixing and imported spare parts 2) Contacted Industrial estate to fix this problem. |
| 3 | Damage of facility | | | | | | | | Requested industrial estate to solve this problem. |
| 4 | Inability of coordinated operation and executed transaction | | Operated transaction manually. | | Print out order sheet at alliance company. | | | | Print out E-kanban at alliance company. |
| 5 | Unavailability of manpower | | Negotiated with labor union. | Provided accommodation in company area. | Negotiate with labor union. | Used manpower from other functions to operate production. | Negotiated with labor union. | 1) Negotiated with labor union. 2) Contacted with customer to clarify priority 3) increased production efficiency. | Used manpower from other functions to operate production. |
| 6 | Unavailability of outbound | | | | | | | | Delivered parts again and requested 3PL to pay money for this lost. |
| 7 | Availability of fault | | | | | 1) Inspected and repair. 2) Changed packing material. | | | Innspected parts and repaired |
| 8 | Unavailability of production capacity | | | | Reduced takt time increase working time. | | Contacted with customer to change order to another supplier. | | Increased production shift and added more operators. |

In conclusion, according to finding, this study the researcher found that there were many different actions to solve each supply chain disruption. The main five crucial methods are changing sources, cooperation and collaboration with the tier 2 suppliers and customers, repairing, manual operations, and improving efficiency and productivity.

Figure 4.7 : Model of Corrective Approaches



4.4 Preventive and Mitigating Approaches

According to the interview, once supply chain disruption occurred, the supplier conducted corrective action to solve problem. To manage supply chain risks in the future, the suppliers explained how they prevent and mitigate effect from supply chain risks. Finding of preventive and mitigating actions of each supply chain risk are described below.

4.4.1 Supplier risk

According to findings, the researcher found that tier 2 supplier cause delay delivery and short supply to tier 1 supplier because of five problems. There were floods, labor disputes, machine breakdown, Tsunami and earthquake, and logistics. To prevent

supplier risks, the preventive and mitigating approaches of each problem are explained below.

4.4.1A Supplier risk from flood

According to the interview, to prevent and mitigate effect from flood at tier 2 suppliers, tier 1 suppliers evaluated and monitored risk of tier 2 suppliers and then requested tier 2 suppliers to keep more safety stock of finished good in the rainy season. As one explained:

‘To prevent risk of flood problems at the supplier, we evaluate risks of suppliers and then we request the supplier to keep more safety stock of finished goods. In case that supplier has no storage, our company will consider ordering and keeping component parts by ourselves. Moreover, we will build up more safety stock of finished goods in the raining season but we cannot specific about the amount because it also related to production capacity of ourselves and the supplier.’ (Supplier A)

In addition, tier 1 suppliers also conducted multiple source strategies to prevent the effect from delay delivery and short supply from tier 2 suppliers. As one stated:

‘About the flood problem at the supplier, we implemented multiple source strategies to prevent risk from single source supplier.’ (Supplier C)

Actually, tier 2 supplier had to keep not only safety stock of finished goods, but also safety stock of spare parts. Flood can cause machine breakdown. Therefore, spare parts are necessary to store as well. As one explained:

‘Similarly, It’s quite difficult to prevent heavy floods. The point is how to solve problem quickly. As a result, the supplier created risk

management of spare parts by categorizing which spare parts needed to be kept and how much quantity has to be kept. In addition, suppliers also increased safety stocks in the raining season.’
(Supplier G)

In summary, to prevent and mitigate supplier risk caused from flooding, the supplier evaluated and monitored the situation closely. In rainy season, tier 1 supplier will request tier 2 supplier to keep more safety stocks. Actually, floods can cause machine breakdown. Therefore, spare parts are considered to be stored as safety stock. The suppliers also explained about multiple source strategy. In case tier 2 suppliers were flooded, tier 1 suppliers can change to another supplier.

4.4.1B Supplier risk from machine

Compatibility of process and machine of tier 2 and tier 1 suppliers were investigated and prepared. In case that tier 2 supplier’s machine broke down, Tier 2 and tier 1 supplier can switch processes with each other. As one mentioned:

‘For supplier failure, purchasing had conducted risk management with supplier. We checked all processes and machines of suppliers. We created process maps and machine list of suppliers to check compatible processes and machines with our company. Moreover, purchasing also surveyed suppliers capacity every month in order to know maximum capacity and remaining capacity. Once the problem occurs, we can switch process between supplier and our company in a short time.’ (Supplier E)

4.4.1C Supplier risk from labor dispute

According to the findings, to prevent supplier risk resulting from labor dispute, tier 1 suppliers consider to keep safety stock of components in their inventory. The amount of safety stock depends on history of delivery performance, availability of labor union, capacity, impact of problem, availability of back up parts and lead time to solve the

problem. As one supplier explained:

‘For labor dispute problem at suppliers, we created criteria for considering amount of safety stock part by part such as history of delivery performance, availability of labor union, capacity, impact of the problem, availability of back up parts and lead time to solve the problem. Nevertheless, we cannot keep high amount of safety stock if parts are high value or bulky.’ (Supplier A)

One supplier explained that critical supplier will be listed up and closely monitored. Moreover, tier 2 supplier is requested to reserve more manpower. In case that operators deny operating overtime, there is available manpower to operate production.

‘About delay delivery from supplier, purchasing will monitor and control supplier closely. Most frequency problem with suppliers will be listed up and closely monitored. Moreover, we also requested suppliers to reserve manpower by 5% more. In case of emergency, there is the manpower to operate production.’ (Supplier B)

Tier 1 suppliers would like to obtain information earlier in case of any labor dispute at the tier 2 suppliers. Therefore, they create a good relationship with the Human Resource Department of tier 2 suppliers. As one mentioned:

‘Moreover, we try to create good relationship and cooperate with the Human Resource Department of suppliers in order to get information of labor dispute earlier because some supplier didn’t inform the problem to us. They will inform when they cannot control the situation and cannot deliver parts.’ (Supplier A)

In brief, to prevent and mitigate supplier risk from labor dispute, tier 1 supplier closely monitors critical tier 2 supplier and tries to obtain information of labor issue earlier from internal source of tier 2 supplier. Safety stock of components will be kept more at

tier 1 suppliers. In addition, tier 2 suppliers are requested to reserve more manpower to operate in a critical situation.

4.4.1D Supplier risk from Tsunami and earthquakes

To prevent supplier risk from Tsunami and earthquakes in Japan that caused scarcity of spare part and components, the supplier has not created a concrete plan yet. The suppliers found that it is quite risky to import parts from other countries. Therefore, localization in Thailand of component parts is considered. As one explained:

‘The Tsunami and earthquake problem, there is no concrete plan to respond with Tsunami and earthquake problem. But we realize that it is so risky to import component parts or material from other countries. Therefore, we try very much to conduct localization. The main objective is to localize component parts in Thailand as much as possible.’ (Supplier A)

One supplier mentioned that they are trying to find alliance companies because alliance companies can share information and support for spare parts and machines which are commonly use. The company in alliance can assist each other in case of scarcity of spare parts and components.

‘So far, we haven’t had a concrete plan to prevent risk from the Tsunami and earthquakes but we are trying to find an alliance in Thailand and other countries. The alliance can share information of production, technology and cooperate for spare parts and components which are commonly used’ (Supplier G)

In sum, the supplier pursues for localization of components in Thailand and tries to find an alliance company for sharing information and support the storage of spare part and components in case a critical situation occurs so prevention and mitigation of supplier risk from Tsunami and earthquake in Japan is avoided.

4.4.1E Supplier risk from logistics

Tier 2 suppliers could not deliver parts to tier 1 suppliers because of disruption from the striking mob. To prevent and mitigate effect of this risk, tier 2 and tier 1 supplier cooperated to find new transportation routes. As one mentioned:

‘For transportation problem, we cooperated with suppliers to study and create multiple transportation routes between suppliers and our company.’ (Supplier A)

According to the findings, tier 2 suppliers didn’t have enough returnable container boxes for delivery to tier 1 supplier. To prevent this risk, tier 2 supplier is requested to control and monitor stock of container boxes, in case the quantity of container boxes are not enough. Tier 2 suppliers will arrange trucks to pick up returnable container boxes from tier 1 immediately. In parallel, tier 1 supplier also controls these container boxes for returning them to tier 2 supplier faster. As one mentioned:

‘For supplier failure, suppliers need to control and monitor stock quantity of container boxes closely and suppliers will arrange for trucks to pick up container boxes from our company immediately once the supplier found that stock of container boxes is not enough. Furthermore, our company will return empty container boxes to suppliers faster.’ (Supplier H)

4.4.2 Labor dispute risk

Regarding labor dispute risks, employees of the supplier denied operating overtime production in order to put pressure on the suppliers during negotiations. There was lack of manpower to operate production. According to the interview, the researcher found that the relationship between the company and labor unions is important. To prevent effect of this risk, the company tries to create good relationships with labor

unions and understand truly what employees' requirements are. As some suppliers explained:

'We try to create the good relationship between the company, employees and labor unions. Close communication between the company and unions is very important. During the negotiation period, we will discuss with the labor unions in advance to understand their requirements.' (Supplier E)

'To prevent labor dispute problem, our company created a new function under Human Resource Department to take care of labor unions and labor disputes. The main responsibility is to create good relationship and closely communicate with unions and employees. We arrange a meeting every 3 month with the labor unions.' (Supplier H)

'We have to make our employees happy to work in our company. If we could do this one, the proposal and requirement from the labor unions will be lower because the company already provides the good things for them.' (Supplier B)

During negotiation period for salary and bonus, the company increased more safety stocks to reduce the impact of labor disputes. The suppliers have to prepare good explanation to labor union about the reason of increasing safety stock. Labor unions may lose trustworthiness with the company. As companies explained:

'We try to minimize the impact of labor dispute problems in our company. We will increase more safety stocks of finished goods during the salary and bonus negotiation period.' (Supplier D)

'Basically, the union will propose requirements to company around September every year. So, we increase safety stocks of finished

goods from 2 to 4 days during the period of negotiation. Nevertheless, we have to carefully take care how to explain to the labor unions why we increase the safety stocks. Labor union may lose trustworthiness and this causes a severe impact.’ (Supplier H)

One supplier reserves manpower to operate production if operators deny operating overtime production or normal production. As one stated:

‘Furthermore, the company also reserves more 5% of operators in order to have manpower to operate production during critical situation.’ (Supplier D)

In brief, the researcher found that the suppliers try to create good relationship and close communication with labor unions and employees, reserves more safety stock during negotiation period, and reserves more manpower in order to prevent effects and mitigate from labor dispute risks.

4.4.3 Machine risk

To prevent machine breakdown, daily and monthly and yearly preventive maintenance is necessary especially for old machine. Moreover, all critical spare parts are listed up and kept as safety stock. In addition, back up machines have to be investigated and prepared. As companies mentioned:

‘Preventive maintenance is conducted weekly and old machine will be taken care of maintenance closely.’(Supplier B)

‘To prevent machine breakdown problems, we conducted preventive maintenance daily, monthly and yearly especially for old machines. Moreover, we also listed up of spare parts which have high possibility of damage and kept safety stock of spare part. The most important thing, we found suppliers who are able to produce the

same product of our company in Thailand. In case of machine breakdown, we can switch to this supplier. Nevertheless, we have to test and evaluate this supplier for quality and capability prior to this.’ (Supplier C)

‘To prevent machine breakdown, purchasing surveyed all machines of current suppliers in order to check compatibility of supplier’s machines and our machines. We considered the similarity of machine type, machine brand and tonnage of machine. In case of machine breakdown, we can move molds to supplier for production. Every month, purchasing will survey the capacity of all suppliers to check current capacity and remaining capacity.’ (Supplier E)

Compatibility of machines in the production line is investigated and prepared. In case of a machine breakdown, the company can use another machine instead. As one stated:

‘Our company also has back up machines in our plant. When one machine breaks down, we can use another machine to produce the part.’ (Supplier D)

According to the interview, the researcher found that cooperation for spare parts is very interesting. The supplier pooled spare parts with their alliance company in order to reduce stock of spare parts and lead time of ordering. As one mentioned:

‘Our company and the other Japanese companies in this industrial estate cooperated together to pool spare parts system. We have a meeting every month to share production information and problems. Spare parts could be borrowed among members. This activity contributed the benefit for reducing spare part inventory.’

(Supplier D)

One supplier also did a contract with machine's suppliers for keeping safety stock of spare parts because they don't want to keep more spare parts in their inventory and reduce lead time to find spare parts.

'We did the contract with machine's supplier to keep safety stock of spare parts for us.' (Supplier H)

In summary, to prevent and mitigate effects from machine risk, the supplier conducts preventive maintenance, keeps critical spare parts, prepares back up compatible machine, keeps spare parts in safety stock and cooperates with the alliance company to pool spare parts. In addition, one supplier conducts contracts with other machine's sellers for keeping spare part for them.

4.4.4 Electricity risk

According to the interview, the suppliers could not prevent this risk. The company tries to minimize the impact by keeping safety stocks. Quantity of safety stock is considered in accordance with the historical record of electricity shutdown time. As companies stated:

It's difficult to prevent electricity shutdown because of uncontrollable factors. But we consider keeping more safety stocks by considering the down time of electricity.' (Supplier A)

'We could not prevent this risk. We tried to minimize the impact for the customers. We considered quantity of safety stocks from historical data. In the past, the company faced the electrical down time around 2 hours. So, we decided to keep stocks at least for 2 hours.' (Supplier B)

The suppliers needed to prepare a plan to respond to electricity shutdown. Procedures for action step by step in case of electricity shutdown were described. As one

mentioned:

‘For electricity shutdown, we could not prevent this risk but we created a plan to respond to it. We established a procedure to explain what has to be done step by step when electricity shut down.’
(Supplier H)

In brief, the suppliers cannot prevent the effect from this risk. They keep safety stock of finished goods to mitigate effect of risk. The safety stock quantity is assumed from historical electricity downtime. The suppliers also prepare a procedure to describe what has to be done step by step when electricity shut down.

4.4.5 Information system risk

According to the interview, to prevent the effect of information system risk, Information Technology Department had been established to take care of information system. Furthermore, the suppliers also separated computer servers between normal operation computer and computer which is linked to the information system of customer.

‘In case of the information system shutdown, we established the Information Technology Department to take care of the information system in our company.’ (Company H)

‘We found that the main reason for problems occurred because of the computer servers. There are many computers connected to only one computer server. So, we separated the computer servers.’
(Supplier D)

A plan has to be conducted in order to instruct procedure how to manage step by step and this has to be tested every year. In addition one supplier also stated that information is needed to be backed up to prevent loss.

'For system error, we made a plan in case of information system shutdown. When information system was down, we described step by step how to do in procedure manual. Furthermore, testing was conducted every year to ensure that it's applicable.' (Supplier B)

'Moreover, information will be backed up in the computer server to prevent information loss' (Supplier H)

In sum, one supplier established new Information Technology Departments to take care of the information systems. To prevent the effect of risk, the suppliers also separated computer servers which link information with customer.

4.4.6 Capacity risk

To prevent the effect from capacity risk, the supplier plans to invest new machines in order to increase capacity but it may not be enough to serve with the customer's demand. Therefore, global capacity allocation from the mother company should be considered also. As one stated:

'To prevent capacity problem, our company plans to invest new machine in this production line. Furthermore, now we are discussing about allocation of global production volume with the mother company in Japan. Now, our production capacity in Thailand is almost full. The production base in another country should be carefully considered for production volume allocation.' (Supplier D)

4.4.7 Logistics risk

According to interview, there was loss of parts during transportation. To prevent the effect of logistics risk, monitoring by GPS of transportation route and driver's behavior is needed to control 3PL. As one explained:

'In case of transportation problems, we strongly requested 3PL to install GPS in a truck in order to monitor driving behavior and transportation routes of the truck driver.' (Supplier H)

4.4.8 Flood risk

Flood problems resulted in inability of employees to commute to work. It affected lack of manpower to operate production. To prevent this effect, the suppliers prepared accommodation in the company's premises. In addition, the suppliers also increased safety stocks in the raining season as well.

'We built up more safety stock in the raining season. Moreover, we also prepared accommodation for employees in case of any emergency cases.' (Supplier C)

4.4.9 Procurement risk

There was argument of selling price with tier 2 suppliers. Tier 2 suppliers would not deliver materials if there was any price adjustment. To prevent the purchasing problem, tier 1 suppliers have set some regulation of price adjustment with tier 2 suppliers. In case the price of material price went up, the suppliers can follow this price adjustment regulation. As supplier noted:

'For material price fluctuation, we set up material price adjustment rules with suppliers. Price adjustment will be done 2 times per year. Average price of the last 6 months will be calculated and implemented to the next period. For example, average price of resin from Jan – June 2010 is 350 baht/kg. This price will be the buying price for period July – Dec 2010.' (Supplier E)

4.4.10 Inventory risk

One supplier explained that inventory risk could result in defective parts in case of keeping inventory in an inappropriate condition. The suppliers could not deliver parts to the customer. The defective parts were needed to be repaired. To prevent effect from this risk, the supplier ensured a good condition for keeping stocks. As one explained:

‘About problem of keeping inventory, the main reasons of this problem resulted from inappropriate packing material. If there are any defects, we have to check many parts in warehouse. Therefore, we reduced the quantity of safety stocks in our inventory first and then changed packing materials and set procedures to ensure the quality of the packing material.’ (Supplier E)

4.4.11 Tsunami and earthquake risk

Tsunami and earthquake in Japan caused scarcity of materials. The researcher found that so far, concrete plans to response with this risk were not settled. To prevent effect of this risk, the supply chain of all component parts and materials had to be investigated and dual source strategy has to be conducted. As one mentioned:

‘For Tsunami and earthquakes, frankly speaking, currently we have no concrete plans yet. Nevertheless, the purchasing department is proceeding with activities to investigate the supply chain of all purchased parts and materials. Moreover, the purchasing department tries its best to conduct dual source strategy.’ (Supplier E)

4.4.12 Riot risk

This study found that curfew resulting from riot risk caused the difficulty of working overtime in the night. Operators had to commute to home before the curfew period. It

effected to lack of manpower to operate production during the night shift. Actually, suppliers could not prevent riots but it is necessary to minimize the impact. Increasing efficiency and operator's skills are important to respond to critical situations. Furthermore, the suppliers also conducted kaizen in production processes continuously in order to improve efficiency and productivity. As one stated:

'Surely we could not prevent riots but how to reduce its effect had to be considered. Our company highly concentrated on improving efficiency and reducing cycle time. The most important thing, we have to improve potential and skill of employees continuously. Moreover, kaizen is the most important thing to improve production efficiency and productivity as well.' (Supplier G)

4.4.13 Quality risk

Quality risks caused defective parts. Once there was defective part, the part would be investigated for destroy or repair. If this part had a minor defect, it could be repaired. But suppliers had to take a time and resources to repair. According to the interview with the supplier, to prevent effect from this risk, quality-built-in process is important to ensure quality of each production process. It can prevent defective part flow for the next production process. Furthermore, the suppliers also installed pokayoke in each production process in order to detect errors. As one explained:

To prevent quality problems, we realized that quality control at the end of the process was not appropriate. We established a quality-built-in process to ensure the quality at each production process. Operators at each production process had to check the quality by themselves before delivering parts to next process. Moreover, we created Pokayoke to check errors at each production process.'

(Supplier H)

4.4.14 Forecast risk

Forecast risk resulted in unavailability of production capacity. In case that actual production volume of the customer was higher than forecast production volume, the suppliers could not produce parts and deliver in accordance with the customer's order. To prevent effects from this forecast risk, the suppliers didn't rely on forecast from customers but supplier considered takt time of customer's production to plan their production as well. Furthermore, closely monitoring of the production volume by working group and top management was done.

'For fluctuating forecast, our company established project groups to monitor and followed up capacity and demand of customer every month. Top management was also involved in this project group to check and closely monitor it. To speculate and plan for production, our company also considers takt time of customer's production as well. We can understand the maximum production volume of the customer. This data is very important information which can be used to plan production. We also checked and monitored daily orders of the customer in order to know the actual demand and fluctuation. This data will be used to adjust production plans and capacity.'(Supplier H)

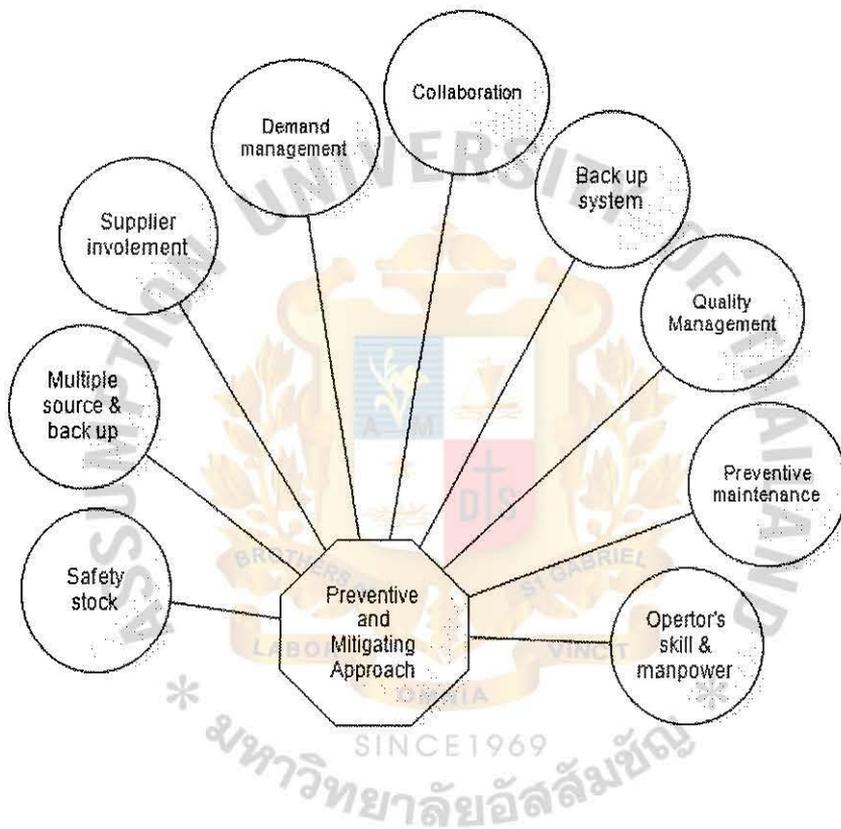
Figure 4.8 : Descriptive Summary of Preventive and Mitigating Approaches

| No | Supply chain risks | | Preventive strategies | | | | | | | | |
|----|-------------------------|---|---|--|--|--|---|--|---|--|---|
| | | | Supplier A | Supplier B | Supplier C | Supplier D | Supplier E | Supplier F | Supplier G | Supplier H | |
| 1 | Supplier risk | Flood | -Keeping more safety stock in rainy season both tier 2 and tier 1 supplier. | | -Conducting multiple source strategy to prevent risk from single source supplier. | | | -Conducting dual source strategy to prevent failure of supply from tier 2 supplier. | -Keeping safety stock of critical spare part -Increasing safety stock in raining season. | | |
| | | Machine | | | | | -Back up compatible process and machine between tier 2 supplier and tier 1 supplier. | | | | |
| | | Labor dispute | -Creating criteria for considering amount of safety stock part. -Cooperating with Human Resource department of tier 2 supplier in order to get information of labor dispute earlier. | -Most frequency problem supplier will be listed up and closely monitored. -Requesting tier 2 supplier reserve manpower 5% more. | | -List up critical supplier Then, tier 1 supplier consider to keep more safety stock of component parts in warehouse. | | | | | |
| | | Tsunami and earthquake | -So far, no concrete plan but there is risky to import from other countries. Therefore, supplier try very much to conduct localization. | | | | | | | -Cooperation with alliance company for spare parts and machine which are common use. | |
| | | Logistics | -Cooperation with tier 2 supplier to study and create multiple transportation routes between tier 2 supplier and tier 1 supplier. | | | | | | | | -Requesting tier 2 supplier to control stock quantity of container box closely. -Arrangement of additional truck to pick up container boxes. |
| 2 | Labor dispute risk | | -Making our employees happy to work. | | | -Increasing more safety stock in negotiation period. -Reserving more manpower 5% of operators. | -Create the good relationship with employees and labor union. -Close communication | -Create good relationship with labor union. -Arranging meeting every 3 months with labor union -Increasing safety stock in negotiation | -Close two way communicate -Increasing safety stock during negotiation period. | Furthermore, our company will return empty container box to supplier faster. | |
| 3 | Machine risk | | -Reducing repairing time. -Preventive maintenance | -Preventive maintenance - Keeping safety stock of critical spare parts. - Finding back up from tier 2 supplier. | -Preventive maintenance. -Preparing back up of finished parts. - Keeping safety stock. -Pool spare parts system. -Back up machine. | -Finding back up from tier 2 supplier in case of machine breakdown, we can move mold to supplier for producing. | | | | -Back up of spare parts and machines in Japan. - Making contract with machine's supplier to keep safety stock of spare parts. | |
| 4 | Electricity risk | -Keeping more safety stock by considering the down time of electricity. | -Keeping safety stock from historical data of down time | | -Request industrial estate to change electricity system and provide electricity back up. | | | | | -Creating contingency plan explaining what have to do step by step when electricity down. | |
| 5 | Information system risk | | -Creating contingency plan described step by step how to do in procedure manual. | | -Separating computer server linked with customer from other computers. | | | | | -Establishment of IT function to take care of system. -Back up information in computer server. | |
| 6 | Capacity risk | | | | -New machine investment. -Allocation of global production volume. | | | -Plus capacity 20% more. -Check and monitor daily order of customer. | | | |

| No | Supply chain risks | Preventive strategies | | | | | | | |
|----|------------------------|-----------------------|------------|---|------------|---|------------|---|---|
| | | Supplier A | Supplier B | Supplier C | Supplier D | Supplier E | Supplier F | Supplier G | Supplier H |
| 7 | Logistic risk | | | | | | | | -Requesting 3PL to install GPS in a truck in order to monitor driving behavior and transportation route of truck driver. |
| 8 | Flood risk | | | -Seek new transportation route to company. -Keep more safety stock in the raining season. -Preparing accommodation for employees. | | | | | |
| 9 | Procurement risk | | | | | -Setting material price adjustment rule with supplier. Price adjustment will be done 2 time per year. | | | |
| 10 | Inventory risk | | | | | -Reducing quantity of safety stock -Changing packing material | | | |
| 11 | Tsunami and earthquake | | | | | Actually, there is no concrete plan but supplier try to conduct dual sources strategy. | | | |
| 12 | Riot risk | | | | | | | -Improving efficiency, reducing cycle time. -Improving potential and skill of employee continuously. -Kaizen to improve production efficiency and productivity. | |
| 13 | Quality risk | | | | | | | | -Establishment quality-built-in process -Creating Pokayoke to check error. |
| 14 | Forecast risk | | | | | | | | -Monitor capacity and demand of customer every month. - Considers takt time of customer's production. -Checking daily order of customer. |

In summary, according to the findings, there are nine main principles to prevent and mitigating adverse affect from supply chain risks; safety stock, multiple source strategy, supplier involvement, demand management, collaboration, back up system, quality management, preventive maintenance, and operator’s skill & manpower.

Figure 4.9 : Model of Preventive and Mitigating Approaches



4.5 Future Supply Chain Risks

Regarding the research question, the researcher would like to explore supply chain risks in the future. According to the interview, the researcher found that there are 2 categories of future supply chain risks. The first one is same as the current supply chain risks but the impact will be higher. These are disasters, labor disputes, and capacity. The second one is a new supply chain risk which has never occurred before. It is management risk.

4.5.1 Disasters

Disaster risk is the most mentioned future risk. Four of eight suppliers explained about this risk. According to the findings, it's very difficult to predict when and how it will occur. In addition, it is also difficult to prevent because of uncontrollable risk. It is noticed that the strange weather in the world and recent impact of Tsunami and earthquakes in Japan caused a severe impact to suppliers at present and in the future. As example of suppliers stated below

'In the future, we think risk from disasters will be more and more critical because of the strange weather in the world especially, the Tsunami and earthquakes in Japan which we have never faced this disaster before.' (Supplier A)

'In the future, we think that there may be no other risks which will affect company except the uncontrollable risks like, electricity shutdown and disasters. We cannot expect and prevent those risks. The only one thing that we can do is to reduce the effect of those risks.' (Supplier E)

'Nobody knows exactly what and when a disaster occurs it will happen and it is very difficult to prevent it. In the future, we think disasters will cause a severe impact to the company.' (Supplier G)

4.5.2 Labor disputes

According to the interview, two of eight suppliers mentioned about this risk. One supplier explained that Rayong province is the critical area for labor dispute risks because labor unions in this area cooperate together. They will pursue requirements by following each other. For example, if labor union in company AAA could acquire salary and bonus in accordance with their request, labor unions in other companies will strongly request the same benefits.

'We think that labor disputes are a critical issue. Especially, in this Rayong area, labor unions cooperate and coordinate with each other. Requesting benefits of labor union with the company will be higher and higher every year. If the company does not provide benefits in accordance with their request, there is high possibility for strikes. Many companies in this area had strikes by labor union every year.'

(Supplier D)

From historical records, the labor dispute risk occurs every year and its impact is greater because of economic growth in Thailand. Moreover, it's not clear for new government's policy in this year. As one explained:

'In the future, we think that risk from labor disputes will be higher because the effect from government's policy and minimum wage is not clear. Labor unions in Thailand may request more benefits due to high growth rate of economy. The one reason we think this risk will be more and more severe is because of historical records. The numbers of these problems increased every year in Thailand.'

(Supplier H)

4.5.3 Management

Management failure is a new expected future risk. Two of eight suppliers mentioned about this risk. The main reasons are from organization change, management change and no concrete plan to response with the change. It may result in delay delivery and quality problem for the customers. As two suppliers noted:

'In the mid-term period, I think management is one of the risks. Management from the mother company in Japan may change because there is new management team and a new organization. We

are afraid that the above mentioned matter will affect the company. It may cause management failure.’ (Supplier B)

‘So far, there are many new products because of high growth rate in the automotive industry and localization policy. Many imported parts will be changed to local parts. Nevertheless, we don’t have concrete plan and master schedules to respond with this rapid change. We afraid that it will affect the delay of production preparation which will cause delay delivery and quality problem to for customer.’ (Supplier C)

4.5.4 Capacity

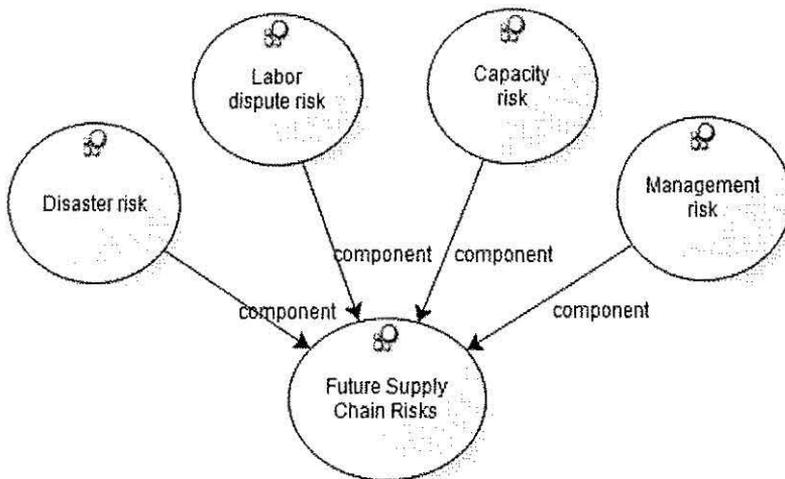
From the findings, one of eight suppliers stated about capacity risk. The supplier explained that after recovering production from disaster of the Tsunami and earthquake in Japan, customers increased production volume very much because of back orders. The capacity to respond with this high increase was very important. Rapidly increasing production volume may cause the capacity risk.

‘Regarding effect from the Tsunami and earthquake in Japan, production volume of each car assemble company was dropped for around one month and a haft. But now, the situation in Japan is getting better so most of car assemble companies in Thailand increased production volume very much around end of this year to recover the production volume plan. We are afraid that high increase in production volume will cause the capacity and quality problem. The suppliers may not have much capacity to respond with high production volumes. Moreover, high production volume may results in poor quality.’ (Supplier G)

Figure 4.10 : Descriptive Summary of Future Supply Chain Risks

| No | supply chain risk | Supplier A | Supplier B | Supplier C | Supplier D | Supplier E | Supplier F | Supplier G | Supplier H |
|----|--------------------|--|--|--|--|--|--|---|--|
| 1 | Disaster risk | Disaster will be more and more critical because of strange weather in the world. | | | | Disaster is uncontrollable risks. We cannot expect and prevent it. | Disaster will be the future supply chain risk which its impact and effect will be greater such as flood and storm. | In the future, disaster will cause the severe impact to company. | |
| 2 | Labor dispute risk | | | | In Rayong area, many companies in this area were strike by labor union every year. | | | | Labor dispute risk will be more and more severe because of historical record. The number of this problem increased every year in Thailand. |
| 3 | Management risk | | Management from mother company in Japan maybe changed because of new management team and organization. | Many imported parts will be changed to local parts. Nevertheless, we don't have concrete plan and master schedule. | | | | | |
| 4 | Capacity risk | | | | | | | Supplier may not has much capacity to response with high production volume. | |

Figure 4.11 : Model of Future Supply Chain Risks



The above integrated framework is the combination of findings about supply chain risks, supply chain disruptions, corrective approaches, preventive and mitigating approaches, and future supply chain risks. Firstly, the researcher found that there are a total of fourteen supply chain risks; supplier, labor dispute, machine, electricity, information system, logistics, flood, capacity, procurement, inventory, tsunami and earthquake, riot, quality, and forecast risk.

The mentioned supply chain risks result in supply chain disruptions. According to the findings, supply chain disruptions include delay and shortage of input, inability of facilities, damage of facilities, inability to coordinate and execute transactions, unavailability of manpower, unavailability of outbound services, availability of fault, and unavailability of production capacity. Totally, there are eight supply chain disruptions.

Supply chain risk management plays an important role to manage those supply chain risks. Once the supply chain disruption occurs, a corrective approach was conducted to solve the problem. This study found that there are five main principles that supplier used. These are changing source, cooperation and collaboration with tier 2 supplier and customer, repairing, manual operation, improving efficiency and productivity. In addition, to prevent and mitigate effect from those supply chain risks, there are nine main principles to prevent adverse affect from supply chain risks ; safety stock, multiple source strategy, supplier involvement, demand management, collaboration, back up system, quality management, preventive maintenance, and operator's skill and manpower.

Furthermore, this study also explored future supply chain risks which may occur in the future. There are four future supply chain risk; disasters, labor disputes, capacity and management.

CHAPTER V

SUMMARY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter proposes to identify how the findings of this study relate and differ from previous research and fulfill research questions. Then, the conclusion of this study will be reflected. In the final part of this chapter, some recommendations are provided as well.

5.1 Summary of the Findings

In accordance to four research questions mentioned in chapter I, some explanation of the summary of the findings are provided.

5.1.1 Supply Chain Risks

Details of this topic propose to answer a research question number 1 (RQ1) that is “What are the supply chain risks of ABC company’s supplier?”

Actually, there is plenty of literature identifying supply chain risks but only Blackhurst et al. (2008) explained about supply chain risks in the automotive industry. The supply chain risks in the automotive industry consist of fourteen supply chain risks. These are disruption/disasters, logistics, supplier dependence, quality, information system, forecast, legal, intellectual property, procurement, receivables (accounting), inventory, capacity, management and security.

According to findings, supply chain risks of ABC company’s supplier in Thailand automotive industry are supplier, labor disputes, machines, electricity, information system, logistics, floods, capacity, procurement, inventory, Tsunami and earthquakes, riots, quality, and forecast risk. Blackhurst et al. (2008) explained about labor disputes, riots, Tsunami and earthquakes, and flood risks in terms of

“disruption/disaster risk”. Twelve of fourteen of the supply chain risks from the findings support the information explored by Blackhurst et al. (2008). These are supplier, labor disputes, floods, Tsunami and earthquakes, riots, information system, capacity, logistics, procurement, inventory, quality and forecast risk. Two of fourteen supply chain risks from the findings were not mentioned in Blackhurst et al. (2008) and were rarely explained by others. These are machine and electricity. In addition, the research found that legal, intellectual property, receivables (accounting), management and security stated by Blackhurst were not mentioned from the interviews with the ABC company’s supplier.

Figure 5.1 : Comparing of Findings and Literature

| Literature | Findings |
|--------------------------|------------------------|
| supplier | supplier |
| disruption/disaster | labor dispute |
| | flood, |
| | tsunami and earthquake |
| | riot |
| information system | information system |
| capacity | capacity |
| logistics | logistics |
| procurement | procurement |
| inventory | inventory |
| quality | quality |
| forecast | forecast |
| legal | - |
| intellectual property | - |
| receivables (accounting) | - |
| management | - |
| security | - |
| - | machine |
| - | electricity, |

5.1.2 Supply Chain Disruptions

This topic proposes to answer the research question number 2 (RQ2) of this study that is “How do supply chain risks influence ABC company’s supplier?”

In agreement with others (Blackhurst, et al., 2005; Blackhurst, et al., 2008), research found that supply chain risks result in supply chain disruptions. Along with the findings from Gaonkar and Viswanadhum (2004), this study found that supply chain disruption can occur at various nodes on the supply side, demand side, during transport or storage. According to the findings, there are eight supply chain disruptions. The supplier was influenced with delay and shortage of input, inability of facility, damage of facility, inability to coordinate and execute transactions, unavailability of manpower, unavailability of outbound services, availability of fault, and unavailability of production capacity.

5.1.3 Supply chain risk management

Once supply disruption occurs, corrective approaches were conducted to solve the problems. In the future, to prevent and mitigate effect from the supply chain risks, preventive and mitigating approaches were also conducted. The purpose of topic is to fulfill research question number 3 (RQ3) that is “How does the ABC company’s supplier manage those supply chain risks?”

Corrective approaches

According to findings, research found that there were many different actions to solve each supply chain disruption as explained in chapter IV. For example, in the case of delay and shortage supply of input, the supplier seeks new tier 2 suppliers and changes source. Once there were labor disputes at tier 2 supplier, tier 1 and tier 2 supplier cooperated together. Tier 1 suppliers brought their manpower to operate production at tier 2 supplier. In case that the information system was down, the suppliers coordinated operations and executed transactions manually. In conclusion, crucial approaches which the researcher found are changing source, cooperation and collaboration with tier 2 suppliers and customers, repairing, manual operation, improving efficiency and productivity.

The above mentioned actions for solving supply chain disruptions also supports the opinions from others (Juttner et al., 2003; Kleindorfer and Saad, 2005). Once there are supply chain disruptions, the supplier finds alternative plans to solve the problems. The key point is to continue the business.

Preventive and mitigating approaches

According to findings from the interview with suppliers, there are the nine main principles to prevent and mitigate adverse effects of supply chain risks.

1. In support with Khan and Burnes (2007), study found that safety stock is one of the methods to protect against risks. The supplier keeps an safety stock to secure their business continuity. Actually, it is not only safety stock of raw materials, component parts, and finished good but also spare parts. The amount of safety stock depends on historical record of risk, history of delivery performance, availability of labor unions, capacity, impact of problem, availability of back up part and lead time to solve the problem.
2. In agreement with others (Kleindorfer and Saad, 2005; Khan and Burnes, 2007), this research found that the supplier utilizes multiple source strategies and finds back up parts in Thailand and other countries. In case that their tier 2 supplier cannot deliver, the supplier can switch to another supplier.
3. This also supports the opinions from others (Tang, 2006; and Khan and Bunes, 2007), that early supplier involvement and collaboration with upstream partners can ensure efficient and effective supply of material. The suppliers conducted supplier evaluation criteria to evaluate and monitor their tier 2 supplier. Critical tier 2 suppliers are listed up and carefully taken care of.
4. This research also found that demand management is one of approaches to mitigate impact of supply chain risks according to Tang (2006) mentioned. The supplier

closely monitors the customer demand and takes action urgently to respond to the increasing demand.

5. Along with the finding of others (Jutther, Peck and Christopher, 2003; Kleindorfer and Saad, 2005; Tang, 2006), this study found that collaborative information sharing with supply chain partners is one of the mitigation strategies. Alliance atmosphere is created. The supplier cooperates with the alliance company to share information and assist each other to operate business. The alliance company can be company in the same group or different group of companies. For example, the supplier can conduct pool of spare parts among alliance company.

6. In agreement with others (Tang, 2006; Kleindorfer and Saad, 2005), this research found that back up system can provide ability to reduce risks. In the production process, the supplier lays out many similar production processes in their plant. In addition, facilities especially for machines are arranged to be compatible in the plant to response with risks. In case that one production process cannot produce, the suppliers can move to another production process. In case that one machine breaks down, the supplier can move to another machine for production.

7. In support with Kleindorfer and Saad (2005), this research found that quality management principle is one of the risk management strategies to reduce risks as well as operating cost. The supplier establishes quality built-in process to ensure quality of parts in each production process before conveying parts to next process. Moreover, pokayoke is also installed to check errors.

8. This study found that prevention is better than correction as Kleindorfer and Saad (2005) explained in previous research. Daily, monthly, yearly preventive maintenance of machines should be conducted especially for old machine.

9. Previous research rarely explained about human resource for risk management. According to the findings, the researcher found that operator's skill and manpower can mitigate the supply chain risks. To response with the change and uncertainty, the

operator's skill is one of the important factors. It can improve efficiency and reduce cycle time. In case of critical situation, supplier can use less manpower to produce parts. Furthermore, manpower is one of the risk management strategies. The supplier reserves more manpower over than actual requirement to use in a crisis. In case the employee cannot come to operate production, the supplier still has additional manpower to operate.

5.1.4 Future supply chain risks

According to findings, details of this topic can fulfill the research question number four (RQ4) that is "What are the future supply chain risks of ABC company's supplier?"

The researcher found that there are four future supply chain risks; disasters, labor disputes, capacity and management. The most mentioned supply chain risk is disaster. Four of eight companies stated about this risk because it is unpredictable and uncontrollable. Labor disputes and management are the second mentioned risk. The last one is capacity because most of car assembled companies in Thailand are increasing production volume due to economic growth and back orders from the Tsunami effect in Japan.

Finding of management risk supports explanation of Blackhurst et al. (2008) that management risk is one of the supply chain risks. But for ABC company's supplier, this risk has not occurred yet. It is expected to be the future risk.

5.2 Conclusions

Supply chain in the automotive industry is complex. There are a large number of suppliers and huge number of components. In addition, each supplier may have multiple components or members. This also makes a mesh network within the supply chain. In the practical world, there are uncertainties and risks that can cause supply

chain disruption. Companies need to conduct risk management to prevent or mitigate those supply chain risks.

This study explored supply chain risks and how to manage those supply chain risks of car assembled company's suppliers in Thailand. This research focuses on a single case study of ABC company and uses the qualitative approach with the interview method from the sample of top 8 high purchasing suppliers of the ABC company.

According to findings, there are a total fourteen supply chain risks; supplier, labor dispute, machine, electricity, information system, logistics, flood, capacity, procurement, inventory, tsunami and earthquake, riot, quality, and forecast risk. Supply chain risks cause supply chain disruptions. Supply chain disruptions cause delay and shortage of input, inability of facilities, damage of facilities, inability to coordinate and execute transactions, unavailability of manpower, unavailability of outbound, availability of fault, and unavailability of production capacity. Once supply chain disruption occurs, corrective approach was conducted to solve the problem. This study found that there are five main principles that the supplier used. These are changing source, cooperation and collaboration with tier 2 supplier and customer, repairing, manual operation, improving efficiency and productivity. In addition, to prevent and mitigate effects from those supply chain risks, there are nine main principles to prevent adverse affect from supply chain risks ; safety stock, multiple source strategy, supplier involvement, demand management, collaboration, back up system, quality management, preventive maintenance, and operator's skill and manpower. Lastly, this study found that there are four future supply chain risks which may occur in the future; disasters, labor disputes, capacity and management.

5.3 Theoretical Implications

In terms of theory, this research develops an integrated framework which is a combination of findings about supply chain risks, supply chain disruptions, interceptive approach, preventive approach, and future supply chain risks of ABC company's suppliers in the automotive industry. This model explained the

relationship in the supply chain context. Supply chain risks result in supply chain disruptions. Once supply chain disruption occurs, the corrective approach is utilized to solve the problems. In addition, the preventive and mitigating approach is also utilized to protect and mitigate adverse effect from supply chain risks. Furthermore, future supply chain risks are explored.

5.4 Managerial Implications

In terms of practice, this study identifies the supply chain risks and how to manage those supply chain risks of ABC company's suppliers. The managers of ABC company can understand insight thoroughly about supply chain risks and supply chain risk management of suppliers. The ABC company can cooperate with suppliers to conduct supplier development program to improve their supply chain risk management to prevent and mitigate those supply chain risks and mitigate effect of those risks. Moreover, the other companies in the automotive industry can understand and utilize these findings to improve their supply chain risk management as well.

5.5 Limitations and Recommendations for Future Research

There are some limitations which reduce the way the findings can be generalized. Limitations include study of one company only as a case study, the small size of the study, and undisclosed information which may discredit the company. However the study also has significant strengths, such as the distinctive inclusion of researcher's position as a purchasing assistant manager of ABC's company which increased the willingness of the participants to engage openly. Moreover, the researcher was able to understand well about the automotive industry context, characteristic, and historical records of each supplier. The study involved a small number of participants (8 suppliers). An obvious strength is that it was possible to explore their narratives and gain more understanding.

Regarding to the recommendations for future research, the researcher found that disasters is the most mentioned in future supply chain risks. Most of companies stated

that disasters can cause the high impact for the company. Future research should focus on the risk management of disaster. Four main components of risk management should be concentrated upon; risk identification to identify what kind of disasters, risk assessment which risk weights need to be evaluated and examined, risk mitigation strategies to reduce its impact, and risk monitoring to secure business continuously.

Moreover, according to the findings, this research would like to propose additional recommendations which are as follows:

1. According to interview, the researcher found that a few suppliers conducted risk management following the four components as Hallikas et al. (2004) explained. Most of suppliers do not proceed with risk management identification and risk assessment. The suppliers proceed with risk management based on historical records of risks that used to occur long time ago. Without risk identification and risk assessment, the supplier may face unexpected new risks. The suppliers should realize the importance of risk identification and risk assessment and then proceed to deal with them. Once the risks are indentified and assessed, the number of strategies can be created to manage those risks. In another way, suppliers should conduct business continuity plan (BCP) to handle with risk and secure business.

2. Due to an increased focus on supply chain agility and responsiveness, safety stock is less attractive to protect against risk (Zsidisin, Melnyk, & Ragatz, 2005). Nevertheless, the researcher found that most suppliers of ABC company still use this measure to protect against risk and uncertainty in the supply chain. For examples, they concentrate on raw materials, finished goods and spare parts safety stocks. The supplier should minimize safety stock as much as possible to minimize inventory cost and still can secure business. In addition, suppliers should take care of safety stock carefully because keeping stock may cause quality problem and obsolete problem.

3. According to findings, all suppliers of ABC company explained that they also faced the problem from their suppliers. Therefore, supplier risk is the most mentioned risks of the ABC company's suppliers. To prevent supplier risk of ABC company's

supplier, ABC company should cooperate with suppliers to conduct supplier development programs to improve tier 2 suppliers. This development program will secure the business continuity of tier 2 supplier, tier 1 suppliers of the ABC company.



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APPENDIX A

INTERVIEW NOTE (ENGLISH)

Date

Interviewee

Title

Good morning/afternoon, first of all, I would like to thank you for your time . Let me introduce myself and the objective of the research one more time. My name is Mr. Nitinon Dejsakulkrai, a master of science in supply chain management candidate, Assumption University of Thailand. I am conducting a research titled “Managing supply chain risks : A case study of car assembled company.

The objective of this research is aim to define supply chain risks of car assembled company's supplier and how to manage those supply risks.

Regarding your work experience, how long have you been working incompany ? and how long have you been in plant manager position ?

There are total 5 questions. May I start the first question.

- 1) In past 5 years, what were the supply chain risks which your company confronted?
- 2) According to your mentioned supply chain risks, how did those supply chain risks affect your company?
- 3) When the problems occurred, how did your company resolve those problems?
- 4) How does your company manage the prevention of supply chain risks?
- 5) In the future, what are other supply chain risks that could probably occur besides the existing supply chain risks?

Today information from interview is very useful and informative for the research. It provides the good knowledge and more understanding for supply chain risks and how to manage those risks.

APPENDIX B

RESEARCH QUESTION MAP

| Research Questions | Interview Questions | Reference |
|--|--|--|
| 1. What are the supply chain risks of ABC company's supplier? | 1. In past 5 years, what were the supply chain risks which your company confronted? | Sheffi (2001), Martha and Subbakrishna (2002), Cucchiella and Gastaldi (2006), Wu et al. (2006), Matook, et al. (2008), Chopra and Sodhi's (2004), Blackhurst, et al. (2008) |
| 2. How do supply chain risks influence ABC company's supplier? | 2. According to your mentioned supply chain risks, how did those supply chain risks affect your company? | Svensson (2000), Blackhurst (2005), Blackhurst, et al. (2008) |
| 3. How does ABC company's supplier manage those supply chain risks? | 3.1 When the problems occurred, how did your company resolve those problems? | Hallikas et al. (2004), Juttner et al (2003), Kleindorfer and Saad (2005), Tang (2006), Khan and Burnes (2007) |
| | 3.2 How does your company manage the prevention of supply chain risks? | |
| 4. What are the future supply chain risks of ABC company's supplier? | 4. In the future, what are other supply chain risks that could probably occur besides the existing supply chain risks? | Blackhurst, et al. (2008) |

APPENDIX C

SUMMARY OF RESEARCH

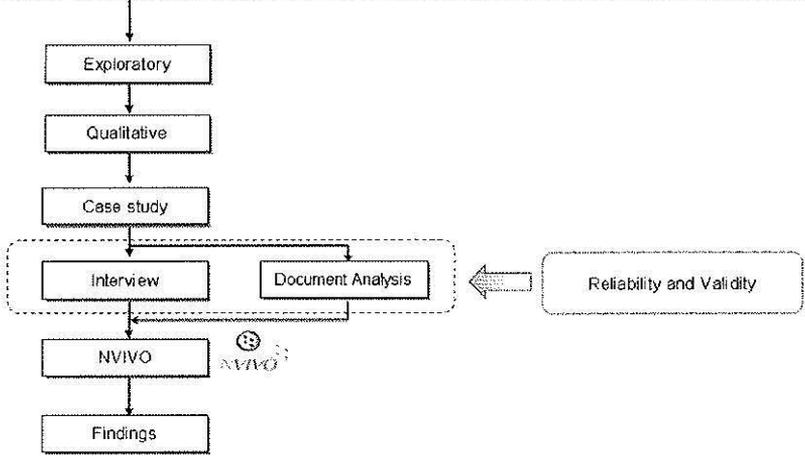
Study Overview

| | |
|-------------------------------|--|
| Statement of Problem | <p>ABC company has proceeded supply chain risk management to prevent an adverse effect to production. But there are production line stops because of delay delivery and shortage supply from suppliers.</p> <p>From 2008 to 2010, there are production line stops around 7,200 minutes. The estimated impact 5,760 million baht.</p> |
| Main Research Question | What are supply chain risks and how to manage those supply chain risks of ABC company's supplier? |
| Research Questions | <p>RQ1. What are the supply chain risks of ABC company's supplier ?</p> <p>RQ2. How does each supply chain risk influence to ABC company's supplier?</p> <p>RQ3. How does ABC company's supplier manage those supply chain risks ?</p> <p>RQ4. What are the future supply chain risks of ABC company's supplier ?</p> |
| Research Objectives | <ol style="list-style-type: none"> 1. To determine the supply chain risks of ABC company's supplier. 2. To examine each supply risk influencing to ABC company's supplier . 3. To examine ABC company's supplier manage those supply chain risks. 4. To explore future supply chain risks of ABC company's supplier. |

Research Methodology

Research Questions

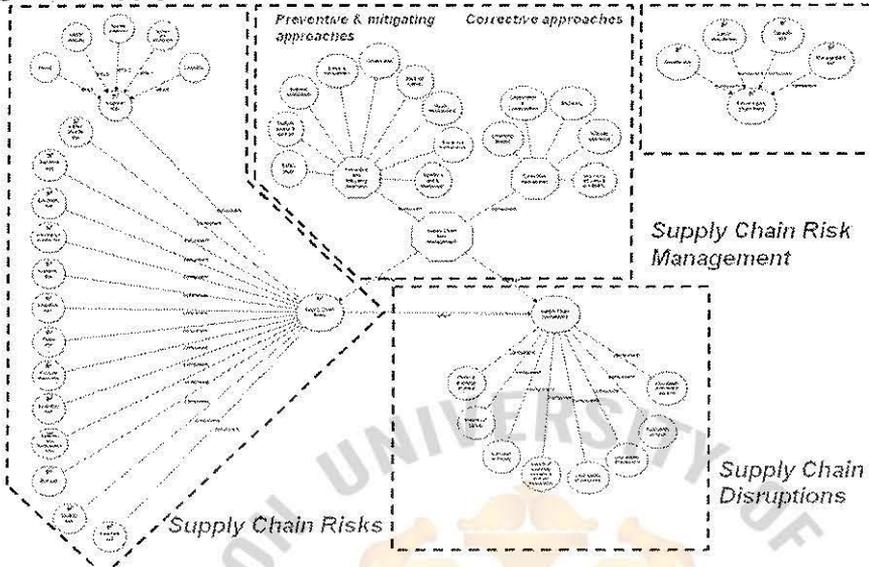
RQ1 What are the supply chain risks of company ABC's supplier ? RQ3 How does company ABC's supplier manage those supply chain risks ?
 RQ2 How does each supply chain risk influence to company ABC's supplier ? RQ4 What are the future supply chain risks of company ABC's supplier ?





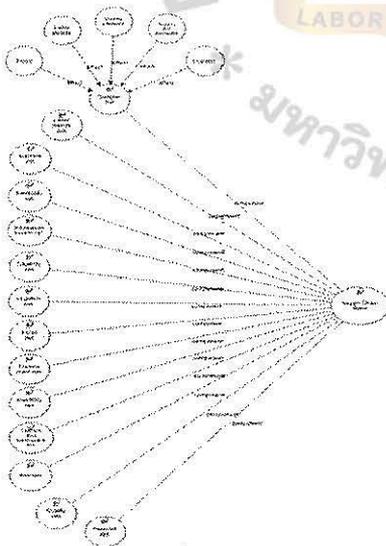
Presentation and Critical Discussion of the Results

Integrated supply chain risks framework



Presentation and Critical Discussion of the Results

Supply Chain Risks



There are 14 supply chain risks as follows.

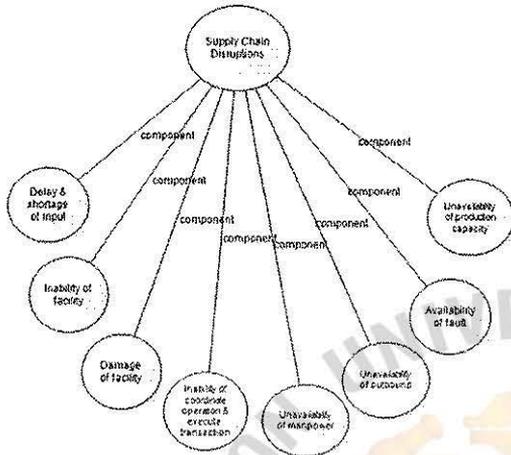
| No. | Supply Chain Risk | Frequency |
|-----|-----------------------------|-----------|
| 1 | Supplier risk | 8 of 8 |
| 2 | Labor dispute risk | 6 of 8 |
| 3 | Machine risk | 5 of 8 |
| 4 | Electricity risk | 4 of 8 |
| 5 | Information system risk | 3 of 8 |
| 6 | Capacity risk | 2 of 8 |
| 7 | Logistic risk | 1 of 8 |
| 8 | Flood risk | 1 of 8 |
| 9 | Procurement risk | 1 of 8 |
| 10 | Inventory risk | 1 of 8 |
| 11 | Tsunami and earthquake risk | 1 of 8 |
| 12 | Riot risk | 1 of 8 |
| 13 | Quality risk | 1 of 8 |
| 14 | Forecast risk | 1 of 8 |

Supplier risk is the most mentioned risk. It results from flood, machine, labor dispute, tsunami and earthquake, and logistics problem at tier 2 supplier.



Presentation and Critical Discussion of the Results

Supply Chain Disruptions



There are 8 supply chain disruptions as follows.

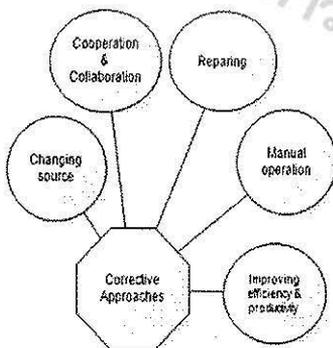
| No | Supply Chain Disruptions | Frequency |
|----|---|-----------|
| 1 | Delay and shortage of input | 8 of 8 |
| 2 | Unavailability of manpower | 7 of 8 |
| 3 | Inability of facility | 6 of 8 |
| 4 | Inability of coordinated operation and executed transaction | 3 of 8 |
| 5 | Unavailability of production capacity | 3 of 8 |
| 6 | Availability of fault | 2 of 8 |
| 7 | Damage of facility | 1 of 8 |
| 8 | Unavailability of outbound | 1 of 8 |

Delay and shortage of input is the most mentioned disruption. Tier 2 supplier delays delivering and cannot supply to tier 1 supplier.



Presentation and Critical Discussion of the Results

Supply Chain Risk Management: Corrective Approaches



There are 5 corrective approaches.

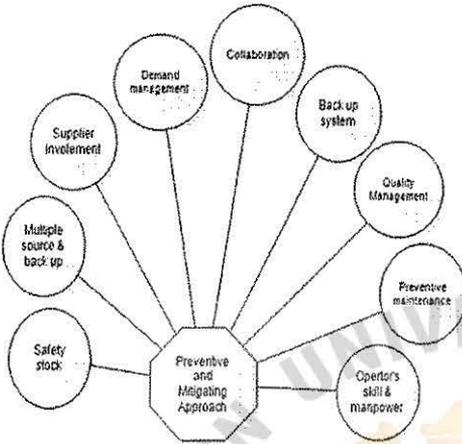
| No | Supply Chain Disruptions | Frequency |
|----|---------------------------------------|-----------|
| 1 | Cooperation & Collaboration | 7 of 8 |
| 2 | Repairing | 4 of 8 |
| 3 | Changing source | 3 of 8 |
| 4 | Manual operation | 3 of 8 |
| 5 | Improving efficiency and productivity | 2 of 8 |

Cooperation & collaboration with tier 2 supplier and customer is the most mentioned corrective approach.



Presentation and Critical Discussion of the Results

Supply Chain Risk Management: Preventive and Mitigating Approaches



There are 9 preventive and mitigating approaches.

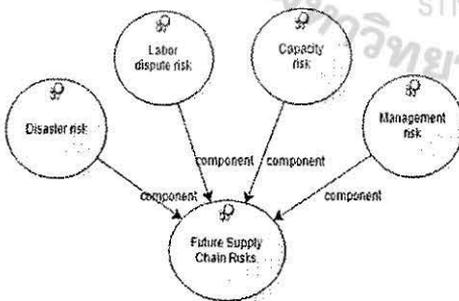
| No. | Preventive and Mitigating Approach | Weighted |
|-----|------------------------------------|----------|
| 1 | Safety stock | 6 of 8 |
| 2 | Multiple source & back up part | 4 of 8 |
| 3 | Preventive maintenance | 3 of 8 |
| 4 | Operator's skill and man power | 3 of 8 |
| 5 | Supplier involvement | 2 of 8 |
| 6 | Demand management | 1 of 8 |
| 7 | Collaboration | 1 of 8 |
| 8 | Back up system | 1 of 8 |
| 9 | Quality Management | 1 of 8 |

Safety stock is the most mentioned approach to mitigate adverse effect from supply chain risk.



Presentation and Critical Discussion of the Results

Future Supply Chain Risks



There are 4 future supply chain risks as follows

| No. | Future supply chain risks | Weighted |
|-----|---------------------------|----------|
| 1 | Disaster risk | 4 of 8 |
| 2 | Labor dispute risk | 2 of 8 |
| 3 | Management risk | 2 of 8 |
| 4 | Capacity risk | 1 of 8 |

Disaster is the most mentioned future supply chain risk.

In the future, the adverse effect of this risk will be more severe.



Conclusions

According to findings, *supply chain risks* result in *supply chain disruptions*. Once supply chain disruption occurs, supply chain risk management with *corrective approaches* are conducted to solve the problem. To prevent and mitigate effect from those supply chain risks, supply chain risk management with *preventive and mitigating approaches* are also conducted. In the future, there are *future supply chain risks* which may cause adverse effect.

Research Questions

RQ1. What are the supply chain risks of company ABC's supplier ?

Findings

There are 14 supply chain risks; supplier, labor dispute, machine, electricity, information system, logistics, flood, capacity, procurement, inventory, tsunami and earthquake, riot, quality, and forecast risk.



Conclusions

Research Questions

RQ2. How does each supply chain risk influence to company ABC's supplier?

RQ3. How does company ABC's supplier manage those supply chain risks ?

RQ4. What are the future supply chain risks of company ABC's supplier ?

Findings

Along with findings from *Gaonkar & Viswanadhum (2004)*, research found 8 supply chain disruptions; delay & shortage of input, inability of facility, damage of facility, inability to coordinate & execute transaction, unavailability of manpower, unavailability of outbound, availability of fault, and unavailability of production capacity.

• Corrective approaches :

In support with others (*Juttner et al., 2003; Kleindorfer and Saad, 2005*), supplier find alternative plan to solve the problem from supply chain disruptions; changing source, cooperation and collaboration with tier 2 supplier and customer, repairing, manual operation, improving efficiency and productivity.

- Preventive and mitigating approaches :

In agreement with others (*Juttner, Peck and Christopher, 2003; Kleindorfer and Saad, 2005; Tang, 2006; and Khan and Bunes, 2007*), there are nine main principles to prevent and mitigate adverse affect from supply chain risks ; safety stock, multiple source strategy, supplier involvement, demand management, collaboration, back up system, quality management, preventive maintenance, and operator's skill.

There are 4 future supply chain risks; disaster, labor dispute, capacity and management.



Theoretical and Managerial Implication

• Theoretical Implication

Research develops integrated framework which is a combination of findings about supply chain risks, supply chain disruptions, supply chain risk management, and future supply chain risks of ABC company's supplier in automotive industry.

• Managerial Implication

1. Manager of ABC company can understand thoroughly insight about supply chain risks and supply chain risk management of suppliers.
2. ABC company can cooperate with supplier to conduct supplier development program to improve their supply chain risk management to prevent and mitigate those supply chain risks.
3. Moreover, the other companies in automotive industry can understand and utilize these findings to improve their supply chain risk management.



Limitations and Recommendation for future research

Limitations

- Study one company as a case study.
- Small size of the study.
- Undisclosed information which may discredit their company.

Recommendation for future research

According to findings from future supply chain risks, future research should focus on **risk management of disaster**. Four main components of risk management should be concentrated; risk identification to identify what kind of disaster, risk assessment which risk weights need to be evaluated and examined, risk mitigation strategy to reduce its impact, and risk monitoring to secure business continuity.

