Supply chain risk management on natural disaster

A study of global supply chain influence by 2011 Tohoku earthquake

Zi Ye

September 2011

Bachelor’s Thesis in Industrial management and Logistics

Supervisor: Claes Åkerman
Examiner: Roland Hellberg
Abstract

Supply chain management as an important strategy in industries has been extensively used in global environment. Comparing to that, supply chain risk management is a relatively new concept which addresses more attention of researchers and industries in recent years. The reason could be that more and more risks emerge in supply networks due to increased activity and complexity of environment. Natural disasters as a most powerful and unpredictable risk causes badly affections on supply chain globally every year.

The purpose behind this work is to investigate how supply chain globally affected by Tohoku earthquake in Japan and how they responded to the disaster, thus bring up to how supply chain globally should do to face natural disasters. For this I developed a theoretical framework and defined key definitions related to supply chain risks and management. It provided the perspective of both proactive supply chain risk management and reactive supply chain risk management, thus concluded with a model of resilient supply chain.

The research approach I adopted is case study by quantitative research with collecting secondary data through books, journal articles, online data sources such as websites of various organizations and catalogues. The collected data about Tohoku earthquake presented in findings and the collected data of supply chain related theories presented in theoretical framework.

In the empirical findings, I presented four industries comprises import and export, printer equipment industry, auto industry and electronics industry who badly affected in Tohoku disaster. Most of Japan located companies are affected by damaged facilities and plants which caused production suspension. Compare to Japan located companies, those from America, Canada and European countries affected indirectly by supply chain disruption from Japan. Although, several months has passed since earthquake, function of some supply chains are still not return to normal level. It is analyst that global industry will lead a trend of reallocation in next three years.

In conclusion part, both loss and measures of four badly affected industries has been summarized. Companies in Japan try to rebuild their damaged pants and facilities and allocate employees to work in southern Japan in the mean while. Plants out of Japan either lay off
people of suspend temporarily to face the loss of supply chain disruption. To confront natural risks, establish a resilient supply chain which can touch the goal of flexible, agile and able to recover after risks is a bright way.
Table of Contents

1 Introduction..............................................................................................................1
  1.1 Background.........................................................................................................1
  1.2 Purpose...............................................................................................................4
  1.3 Research Questions............................................................................................4
  1.4 Delimitation.........................................................................................................5

2 Methodology............................................................................................................6
  2.1 Research Philosophy.........................................................................................6
  2.2 Research Approach............................................................................................7
  2.3 Paradigm of Study...............................................................................................8
    2.3.1 Qualitative Research....................................................................................8
    2.3.2 Quantitative Research.................................................................................9
  2.4 Research Strategy..............................................................................................9
    2.4.1 Data Collection............................................................................................9
      2.4.1.1 Primary Data........................................................................................9
      2.4.1.2 Secondary Data....................................................................................10
      2.4.1.3 Validity and Reliability........................................................................10

3 Theoretical Framework..........................................................................................10
  3.1 Supply Chain Risks..........................................................................................11
  3.2 Supply Chain Risk Management (SCRM).......................................................12
  3.3 Proactive Supply Chain Risk Management......................................................13
    3.3.1 Supply Chain Risk Identification...............................................................14
    3.3.2 Supply Chain Risk Assessment.................................................................16
    3.3.3 Supply Chain Risk Mitigation..................................................................18
  3.4 Reactive Supply Chain Risk Management......................................................20
  3.5 A Resilient Supply Chain..................................................................................21
  3.6 Summarizing.....................................................................................................23

4 Findings..................................................................................................................24
  4.1 Impacts from Tohoku.......................................................................................25
4.1.1 Import and Export ................................................................. 25
4.1.2 Printer Equipment Industry .................................................. 26
4.1.3 Automobile Industry .......................................................... 27
4.1.4 Electronics Industry ........................................................... 29
4.2 Mitigation Strategies of Industries ............................................. 31

5 Analysis .................................................................................. 32

5.1 Proactive SCRM in Tohoku Earthquake ................................... 32
  5.1.1 Geographical Risks ............................................................. 33
  5.1.2 Key Techniques and Products Risks ..................................... 34
  5.1.3 Just-In-Time (JIT) Approach ................................................. 35
  5.1.4 Strategy of Supplier Relationship .......................................... 36

5.2 Reactive SCRM in Tohoku Earthquake ................................... 37

5.3 Global SCRM face the test of nature disasters .......................... 38

6 Conclusion ............................................................................ 38

6.1 Discussion & Future Suggestions ............................................ 41

7 List of References .................................................................... 41
1 Introduction

This part comprises the background, research problem, purpose and delimitations. The purpose of this part is to give a clear introduction of the topic and let reader have an overall view of the problem.

1.1 Background

The industrial world today has become a business confederation more than individual organizations. Supply chain management (SCM) as a decisive strategy in industries has been extensively used in global environment. Companies work hard on it to improve the effectiveness and efficiency of a portion or the whole supply chain. More and more organizations try to break down the fall walls and bridge organizational boundaries to achieve the goal of supply chain collaboration or supply networks facing complex and changeable business environment at present Fawcett et al (2001). However, there exists a big contradiction. When a supply chain become more integrated, effective and high efficient, the more likely of uncertainties, and accidents in one part will affect other links in the whole chain. The risk is increasing quietly while organizations are working hard on taking actions to achieve supply chain integration. The reasons of why supply chain risk management (SCRM) is important will be state in Chapter 3. The main stream of current actions has been summarized into 9 points according to Norman and Jansson (2004). These 9 points can be classified into 3 main aspects: relationship strategy, production strategy, and marketing strategy.

Relationship strategy comprises 4 points:

- Increased outsourcing
- Globalization of supply chains
- Reduction of supplier base
- More intertwined and integrated processes between companies

More and more companies focus on their core products or services and outsource their non-core business to other companies who has more strength on it. And most of the time,
those competitive suppliers and customers who can provide big value locate in global market instead of regional area. Therefore, globalization of supply chains became an important strategy for companies establishing relationship with each other to get what they want under good conditions. Carlsson (2007) did an exploratory survey to identify differences in demands from system suppliers to component suppliers from 7 different aspects. It showed higher demands to system supplies are very clear. It reflected the intention of companies that prefer establish relationship with one or two suppliers who rely on broad competences and wide net to contact which guarantee larger and more complex order. In order to forming a synchronous supply chain where information shared faster, easily and at relatively low cost, organizations cooperate and collaborate in short distances to achieve win-win situation. Freytag and Mikkelsen (2007).

Production strategy includes two points

- Reduced buffers, e.g. inventory and lead time
- Increased demand for on-time deliveries in shorter time windows, and shorter lead times

Since Toyota production system developed by Toyota comprises its management philosophy and practices which introduced to the world. Logistics module over the world has been affected by it. Companies adopt Lean, JIT, and TQM, etc. one after another to create value with lower waste and higher efficiency. They reduce buffers, inventories and lead time aiming at reducing associated carrying costs.

Market strategy includes three points

- Shorter product life cycles and compressed time-to-market
- Fast and heavy ramp-up of demand early in product life cycles
- Capacity limitation of key components

The product life cycles (PLC) concept is applied by companies as a useful framework for describe how products and markets work. Kotler et al (2005). As market prosperity and product variety rises, companies shorter product life cycles to shorter the time of capital recovery. Compressed time-to-market helps race against time to hold the market against competitors and uncertainties of the market. Striking a deal with a distributor, retailer or producer will substantially increase product demand to reach fast and heavy ramp up. To limit capacity of key components will help company hold the core competencies and continuously
being active in product market.

On the one hand, companies are competing and growing in global environment of economic prosperity, on the other hand, they are also struggling in deterioration of global natural environment. Since 2007, natural disaster category has been classified into five sub-groups and 12 types by CRED (Centre for Research on the Epidemiology of Disasters)

- **Biological disasters**: Insect infestations, epidemics and animal attacks (the last two categories are not included in the World Disasters Report)
- **Geophysical disasters**: Earthquakes and tsunamis, volcanic eruptions, dry mass movements (avalanches, landslides, rock falls and subsidence of geophysical origin)
- **Climatologically disasters**: Droughts (with associated food insecurities), extreme temperatures and wild fires
- **Hydrological disasters**: Floods (including waves and surges), wet mass movements (avalanches, landslides, rock falls and subsidence of hydrological origin)
- **Meteorological disasters**: Storms (divided into nine sub-categories).

In recent years, natural disasters are collectively increasing in frequency over the world. According to the International Federation of Red Cross and Red Crescent Societies, in the years between 1999 and 2009, 4,301 natural disasters, 1.16 million casualties and 1.1 trillion costs (US$) were reported worldwide. To global supply chains, disasters not only influenced but even caused “supply chain rippling effects”. More companies face devastating disruptions of operations due to natural disasters.

- European Heat Wave (2003) raised summer temperatures 20 to 30% higher than the seasonal average in Celsius degrees over a large portion of European continent. The impacts of this extreme climate event included short of water supplying, electricity shortage by slower cooling down of nuclear reactors and food storage, drought on vegetation and forestry production, for instance: 75% of Ukraine’s wheat crops were parched to death. (United Nations Environment Programme)
- Hurricane Katrina (2005) which passed New Orleans, USA caused damages amounting to almost US$ 137 billion. The initial impact is near-total evacuation of the city which caused shortage of labor force afterwards, thus the sectors most affected were service-related industries. The Mississippi delta provides the Unite States with one of the
largest fisheries and the most important flyway terminus. The damage on the facilities in and around New Orleans city which included two ports, several oil refineries and chemical companies brought overall impact on supply chain of the whole America.

- Iceland volcanic eruption at Eyjafjallajökull (2010) caused effect of shutdown of most air traffic in European countries for days. Flights both to and from European countries are banned which directly influenced air transportation over the world. Although air is only one of the four modes of transportation for supply chain, it is probably the mode that has the most expensive implications because the use of high-value, perishable, or urgent goods. The affected industries comprised airline industry, tourism industry, air freight based international trade and courier industries (ex, FedEx, DHL and TNT)

The latest natural disaster which shocked global supply chain occurred Friday, 11th March 2011, the most powerful known earthquake of the Japanese history: Tohoku earthquake. It is as well as one of the five most powerful earthquakes in the modern history of the world. The 9.0 magnitude tremor triggered extremely destructive tsunami waves of up to 38.9 meters that struck the north-east coast, in some cases traveling up to 10 km inland of Japan. Besides loss of life and destruction of infrastructure, the tsunami caused a number of nuclear accidents which cause a serious situation of ongoing level-7 event and 20 km evacuation zone around the Fukushima I Nuclear power plant. According to EM-DAT, disasters can be classified into two generic categories which refer to natural and technological. Although the disaster in Japan contained both of them which initially caused by natural disaster but affected worst by technological disaster, it classified as natural disaster in this paper.

1.2 Purpose

The purpose of this thesis is to investigate the Implication of global supply chain in the latest natural disaster 2011 Tohoku earthquake and what should be done to fight against future natural disasters. The research focused on the impacts on supply chain globally of the disaster and response activity targeting the badly affected industries.

1.3 Research Question

Before decide the research problem, one should have enough understanding of the idea and background of it. The situation occurs quite often which researchers change their research problem due to various reasons in course of study. In view of that the disaster occurred
recently, only short-term impact can be seen. Far-reaching impact could appear in months or several years, therefore, these portions of impacts are analyzed according to similar disasters in previous years and experts expect. Due to the same reason, most of the companies are still working on it to get through this hard period, thus, empirical data is little. Most information can be found as document in Chinese due to geographical and informational convenience. However, this is an interesting area which attracts me to study in. Shortage of articles in the area of risk management in natural disasters also provides a broad space for me to stretch my opinion.

The thesis will focus on three research questions which related to the risk management of nature disaster:

1. How did supply chain globally affected by Tohoku earthquake?
2. How did industries response to the earthquake?
3. Identify improvements of the supply chain management system against natural disasters.

1.4 Delimitation

I emphasize that my study on supply chain risk management according to Tohoku disaster only focus on industrial area, not touch the humanitarian area. When disasters occurred, people would think more on giving relief in humanitarian perspective. Aid transporting and some other humanitarian activities are also included in risk management and use knowledge of supply chain management. For this reason, the author draws a scope of this study to avoid confusion.

In findings part, I only chose four industries which refer to import & export, printer equipment industry, automobile industries and electronics industries to investigate. There are several reasons to support my chose. The reason for import & export is that destructive tsunami wave caused by earthquake struck the north–east coast where is full of ports. The reason for electronic industries is that Japan accounts for 40 percent of global electronic components and 12 percent of global technology goods and services demand. Therefore, earthquake would hit the electronic industry without doubt. The reason for automobile industry is that Japan owns the biggest automobile company- Toyota in the world, while has two more automobile companies which refer to Honda and Nissan sitting in the top ten sales brand over the world. Due to destroyed ports, core product and technology of automobile
which holding in Japan located plants would not available for both Japan and global market. The reason for printer equipment industry is that northeast coast is the base for plants of Japanese several large printer companies. For the reasons above I will only give detail summarize and analysis on these four industries.

2 Methodology

Research methodology is a process that guiding researchers conduct research process in a proper way. Properly structured reports can be more convincing and reliable than those based on a random approach or on common science (Ghauri & Gronhaug, 2010). Good research is replicable; therefore, many researchers summarized and developed their way of research which created conception of scientific research methodology today. It can gain a systematic way for new researchers to follow the footprint of successful pioneers and hit the goal easily.

2.1 Research Philosophy

The actual suitability of research method is derived from the nature of social phenomena to be explored (Morgan & Smircich, 1980). The definition of science is considered as a truth-seeking function, thus, business research can be seen as truth-seeking about business phenomena. This thesis will follow the methodology of business research which defined by Hair et al (2007) as seeking to predict and explain phenomena that taken together comprise the ever-changing business environment. There are two basic research philosophies of establishing a research process and draw conclusions which refer to positivism and hermeneutics (Andersson, 1979). The table gave a clear comparison between the positivistic paradigms and hermeneutic paradigms.
Table 2.1: Comparison between the Positivistic Paradigm and Hermeneutic Paradigm adapted from Evert Gummesson (2000)

<table>
<thead>
<tr>
<th>Positivistic Paradigm</th>
<th>Hermeneutic Paradigm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description and explanation study</td>
<td>Understanding and interpretation study</td>
</tr>
<tr>
<td>Well define, narrow study</td>
<td>Narrow as well as total studies (holistic view)</td>
</tr>
<tr>
<td>Deductive</td>
<td>Inductive</td>
</tr>
<tr>
<td>Generalization and abstraction</td>
<td>Specific and concrete (local theory) but also attempts generalization</td>
</tr>
<tr>
<td>Clear distinction between facts and value judgments; search for objectivity</td>
<td>Distinction between facts and value judgments is less clear; recognition of subjectivity</td>
</tr>
<tr>
<td>Rational, verbal, and logical approach to the subject of research</td>
<td>Pre understanding that often cannot be articulated in words; tacit knowledge</td>
</tr>
<tr>
<td>Statistical and mathematical techniques for quantitative processing of data are central</td>
<td>Data are primarily non-quantitative</td>
</tr>
<tr>
<td>Researcher is observer</td>
<td>Researcher is actor</td>
</tr>
<tr>
<td>Distinction between science and personal experience</td>
<td>Both science and personal experience; researcher use personality as an instrument</td>
</tr>
<tr>
<td>Clear distinction between reason and feeling</td>
<td>Both feeling and reason govern the action</td>
</tr>
<tr>
<td>Researcher discovers an object of research external to himself rather than “creating” than actual object of study.</td>
<td>Researcher partially creates what he studies.</td>
</tr>
</tbody>
</table>

The research philosophy for this thesis will adapt positivistic paradigm although the statistical and mathematical technique for quantitative processing of data may not seen as central part owning to limited quantity of relative data.

2.2 Research Approach

There are two types of research approach which refer to deductive and inductive. According to Ghauri & Gronhaug (2010), “deductive reasoning is the logical process of deriving a conclusion from a known premise or something known as true” while “inductive reasoning is the systematic process of establishing a general proposition on the basis of observation or particular facts”. Being terse, induction is based on empirical evidence while deduction is based on logic. Induction approach is often associated with the qualitative type of research while deduction support by quantitative type of research.

This paper will view supply chain risk management in two perspectives: the proactive risk
management and the reactive risk management. The research approach chosen to conduct this study is induction because the research goes from observations-findings-theory building and drawn conclusions through observations. Amount of data from different companies which affected by Tohoku earthquake provide opportunity to assess the performance of supply chain risk management in different level. The author does not focus on single company as it hard to reflect the situation or performance of supply chain risk management level in a big environment. Induction approach will help to gain deeper understanding of the subject in order to generate answers to research questions and fulfil research objective.

2.3 Paradigm of Study

The selections of topic and paradigm would help researchers understand the phenomena (Creswell, 1994). Two method in this part are widely discussed which is quantitative method and qualitative method. They function and accounts for different proportion with consideration of discipline fields, research philosophy and research approach.

<table>
<thead>
<tr>
<th>Quantitative</th>
<th>Qualitative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers</td>
<td>Words</td>
</tr>
<tr>
<td>Point of view of researcher</td>
<td>Points of view of participants</td>
</tr>
<tr>
<td>Researcher distant</td>
<td>Researcher close</td>
</tr>
<tr>
<td>Theory testing</td>
<td>Theory emergent</td>
</tr>
<tr>
<td>Static</td>
<td>Process</td>
</tr>
<tr>
<td>Structured</td>
<td>Unstructured</td>
</tr>
<tr>
<td>Generalization</td>
<td>Contextual understanding</td>
</tr>
<tr>
<td>Hard, reliable data</td>
<td>Rich, deep data</td>
</tr>
<tr>
<td>Macro</td>
<td>Micro</td>
</tr>
<tr>
<td>Behaviour</td>
<td>Meaning</td>
</tr>
<tr>
<td>Artificial settings</td>
<td>Natural settings</td>
</tr>
</tbody>
</table>

Table 2.2: Common contrasts between quantitative and qualitative adapted from Bryman and Bell (2003, p.203)

2.3.1 Qualitative Research

According to Miles and Huberman (1984), qualitative research is an investigation process where researchers gradually make sense of phenomenon by contrasting, comparing, replicating, cataloguing and classifying the object of study. It represents description without assigning numbers directly (Hair et al 2007). The key purpose of this kind of research is to understand and gain insights with exploratory and flexible approach (Ghauri & Gronhaug 2010). This thesis follows the process of qualitative research mainly due to the reason that the study takes method of observation and using non-figure data. In qualitative research, the
author conducts data collection and analysis simultaneously in an interactive way as: doing analysis with collected data, new questions are raised, and doing further data collection.

2.3.2 Quantitative Research

Quantitative data is defined by Hair et al (2007) as “measurements in which numbers are used directly to represent characteristics of something”. According to Uwe Flick (1998), the process of a quantitative research is neatly arranged in a linear sequence of conceptual, methodological, and empirical steps. The techniques which often used in quantitative research comprise observations, experimentations and surveys. Since majority data applied in this thesis are secondary and the accident is latest, accurate figures and statistics are hard to find in short time. The thesis does not use much quantitative research method.

2.4 Research Strategy

There are five research strategies has been considered as primary category which refer to case study, survey, experiments, histories and archival analysis. According to Yin (1994), when boundaries between phenomenon and context are not evident clearly, one use case study as empirical enquiry which investigate contemporary phenomenon within real life context. In view of this, the thesis will focus on strategy of case study which choose Tohoku earthquake as background and try to do investigation on multiple cases based on it. It can provide an overall view of supply chain risk management situation, thus raising application of risk management framework.

2.4.1 Data collection

There are two types of data: primary and secondary. Data can be seen as cells which revolve heart of purpose forming the body of a paper. Data collection considered as the most important and time-consuming work which need to deal with from start to the end of the study. A good planning in data gathering will lead a good result to research work.

2.4.1.1 Primary data

Primary data are usually collected by researchers directly for the purpose of research. Normally, observations, experiments, surveys (questionnaires) and interviews are used as tools to collect primary data. Although it would provide more accurate and reliable information, the author will do the study without primary data due to the reason that the case are latest and it is still the sensitive period for most of the companies. Therefore, to get
primary data seems an impossible mission.

2.4.1.2 Secondary data

Secondary data are those data which not gathered directly and purposefully for specific research. They include books, journal articles, online data sources such as websites of various organizations and catalogues. Secondary data facilitate international research in both time-saving and fast way. Since more and more secondary data are collected by experts from international organizations and governments, the quality and reliability are high and trustworthy. The thesis mainly based on secondary data collection which includes: books, journal articles and online data sources. The author believe the secondary data which used to support study are reliable and enough for the research purpose.

2.4.1.3 Validity and Reliability

Before using any data to support studies, researchers have to ensure the accuracy of data which are collected. Accuracy is associated with both of the term validity and the term reliability. Merriam, S. B. (1988) defined validity as measuring how the research findings converge with reality and Hair et al (2007) divided it into three approaches as content validity, construct validity and criterion validity. Reliability refers to the stability of the measure and also comprises three aspects: test-retest reliability, alternative-forms reliability and internal consistency reliability. Although the data sources used in the study are not primary, most of them are based on reliable sources. The theoretical framework mainly based on scientific literatures including books and journal articles which should be validity since the models and frameworks has been used and proved by previous researchers for different arguments. The data sources of findings and background are from official websites and news channels as radio, TV and webs. This part of information has been checked and compared cautiously before using in order to make them reach the conception of validity and reliability. Therefore, the data sources used in this thesis are confirmed to be validity and reliable.

3 Theoretical framework

This chapter will focus on background and framework of supply chain risk management. The
chapter goes through literature conceptual development of Supply chain risk management (SCRM). The author did research about SCRM in proactive stage and SCRM in reactive stage respectively. Amount of related literatures will be reviewed to help in-depth study of supply chain risk management according to impact of Tohoku Earthquake.

3.1 Supply chain risks

For the reason of rapid development world economy and business globalization, market turbulence and uncertainty has increased much in recent years. As the result of improved efficiency and saved cost of supply chain, vulnerabilities of supply chains which bring risks like disturbance and disruption are increasing at the same time. Vulnerability is the word often used to describe lack of robustness or resilience of a supply chain against internal and external threats. Although vulnerability does not equal or inevitably lead to risk, it is still a dangerous factor that would affect performance of supply network. Risk can be numerically defined as the probability of a hazardous event multiplied by the cost of damage that would result should the event happen. (Noson et al, 1988). Zsidisin (2005) defined supply chain risk as “the potential occurrence of an incident or failure to seize opportunities with inbound supply in which its outcomes result in a financial loss for the firm.” In recent years, with more empirical data which is collected from a big amount of industries, risk types has been expanded and classified into more detail and comprehensive level. In this view, industries in different areas could identify possible risks that self related and manage them in proper way. As figure 3.1 shows, three supply chain risk perspectives need to be understood. There are three main actors in supply networks which refer to suppliers, the target company and customers. The risk list under each actor is the risk types that would exist or latent in them. The overlapping regions between three groups are the chains which connect both sides of supplier (upstream) and customer (downstream). As the growing complexity and breadth of world trade, followed by a variety of risks. The risks which related to these three groups are listed respectively. Since Supply chain is a network of upstream (suppliers) and downstream (customers) members, performance would be influenced by any simple risks from a single group, for instance, the supply chain disruption risk from suppliers group will lead to stock or manufacturing risks of middle manufacturer, thus let customers face shortage risk or financial
risk. For a small or local company, the figure 3.1 may enough for them to consider if any of those risks latent in their chain. For an international company with branches over the world, there are more complex and unpredictable factors that would bring risks. Each branch in the world map has different suppliers and customers. Due to branches in different country will influence by different geographical or political factors, the risk type for the whole supply chain would be more.

Figure 3.1: Supply chain risk type adapted from Supply-Chain Council (SCC) Risk Management Team & Douglas Kent December 6, 2007

3.2 Supply chain risk management

Supply chain risk management attempts to reduce supply chain vulnerability via a coordinated holistic approach, involving all supply chain stakeholders, which identifies and analyses the risk of failure points within the supply chain. The latest definition of SCRM was given by supply chain council risk research team (SCC) (2008). According to plenty of research, they describe SCRM as:

“Supply chain risk management is the systematic identification, assessment, and quantification of potential supply chain disruptions with the objective to control exposure to risk or reduce its negative impact on supply chain performance. Potential
disruptions can either occur within the supply chain (e.g. insufficient quality, unreliable suppliers, machine break-down, uncertain demand, etc.) or outside the supply chain (e.g. flooding, terrorism, labor strikes, natural disasters, large variability in demand, etc.). Management of risk includes the development of continuous strategies designed to control, mitigate, reduce, or eliminate risk.”

On October 2001, at the Manchester Metropolitan University in Crewe, UK, International Supply Chain Risk Management (ISCRiM) network formed. Supply chain risk management (SCRM) has became a forefront field attracts scholars as well as boards of companies to study about it. Since then body of literatures that related SCRM field have increased rapidly. A part of literatures discussed categorization of risks and provided general framework of SCRM, for instance: Nishat Faisal et al. (2007) who provided a framework of risk management to small and medium-sized companies, Tang and Tomlin (2008) who provided a unified framework to achieve supply chain flexibility against risk, Olson and Wu (2010) made a general review of enterprise risk management in supply chain. Other literatures discussed contingency plans and mitigation strategies according to specific risk which include Craighead et al. (2006) discussed poor communication, part shortages and quality issues and Williams et al. (2008) focus on supply chain security against terrorist acts.

This paper will view supply chain risk management in two perspectives: the proactive risk management and the reactive risk management. The goal of adopting proactive method is to deal with vulnerabilities prior to the occurrence of critical events and accidents in order to make supply chain more robust or resilient to secure the mission of supply chain system under the environment of new and changing risks and emerging vulnerabilities. (Asbjornslett, 2009) The goal of reactive approaches is to deal with the consequence of the occurrence of an event or accidents in order to reduce the resulting (negative) outcomes and impacts (SCC 2008). The most research is focused on Supply chain disruption management.

### 3.3 Proactive supply chain risk management

Norrman and Jansson (2004) described Ericsson’s implementation process of new organization and “Ericsson risk management evaluation tool (ERMET)” for SCRM by developing a proactive risk management strategy after a fire at a sun-supplier. Trevor and Christopher (2005) proposed secure site location decision process to locate emergency
resources in a manner as to not be vulnerable to attack. Dani (2009) did a discussion regarding SCR and SCRM leads on to the issues of proactive risk management and presented a framework of it. Besides these researches that focused on proactive approach, some others that focused on general framework of SCRM can also regarded as proactive process since majority are handling risks before events or accidents occurrence. SCC (2008) summarized a framework of supply chain risk management comprises an integral three-phase approach: risk identification, risk assessment (risk analysis) and risk mitigation. To find answer to a question of each phrase is the way to achieve the proactive risk management.

Phase 1 – Risk Identification: What can go wrong? Find them!
Phase 2 – Risk Assessment: How likely is it to happen? Assess it!
Phase 3 – Risk mitigation: What are the consequences? Avoid or mitigate them!

According to Mullai 2009, risk communication and re-assessment of supply chain may need after phase 3 to bring it up to a continuous cyclic process. Different methods and tools can be used to support work of different phases.

3.3.1 Supply Chain Risk Identification

To give rise to more concern on supply chain vulnerability, Christopher and Peck (2003), taking inspiration from Mason-Jones and Towill (1998) established supply chain risk profile for business.

![Risk Profile Diagram](image)

Figure 3.2: risk profile


It would show the link where greatest vulnerabilities lying and the disruption probability. The potential risks which cause supply chain disruptions mainly come from five sources:

1. Supply risk: How vulnerable is it if the chain of supplier disrupted? In the background of economic globalization, offshore sourcing and reliance on key suppliers, the risk is much
higher nowadays.

2. Demand risk: How volatile is demand? How do other products’ demands affect demand of our products?

3. Process risk: How resilient are our processes? Do we know the bottlenecks, additional capacities and sources of variability in the whole process?

4. Control risk: How likely do our own internal control systems cause ‘chaos’ effects?

5. Environmental risk: where is the weak point across the whole supply chain that could bring risk under external forces?

It is a good way to take an audit of main sources of risks across the supply network. Christopher (1992) suggests that for multi-product, multi-market business, to identify the major profit streams and to focus on create deep insights into the how supply chain risk could affect those profit streams should be done priority. Mapping risk profile became the first step to find out the companies’ internal vulnerabilities. In this way, to reduce the impact as well as develop contingency strategies timely against internal and external risks. According to Kearney (2003) mapping risk profile comprises 6 steps:

1. Prioritize earnings drivers: Identify and map the earning drivers which support overall business of the company. Any disruption or risk on these parts would cause big problem on finance which directly bring dangerous to business.

2. Identify critical infrastructure: Identify essential components like equipments, people, plans, and relationships etc. which support companies’ earning generation.

3. Locate vulnerabilities: Find vulnerabilities in the weakest links, a bottle neck, limited alternatives, a high degree of concentration, high-risk areas, industries and products and insecure access points to important infrastructure.

4. Model scenarios: Using modeling tools and techniques to create scenarios of crises’ impacts and assess strengths and weaknesses of a company.

5. Develop responses: After having understanding of internal vulnerabilities, companies came to the stage of practical stage of risk mitigation. Redundant solutions are often seen as traditional risk management method. Scholars indicate that flexible responses could help a company manage risk against various situations and keep sustainable competitiveness.
6. Monitor the risk environment: to redraw the company’s risk map constantly since everything, for instance: environment, consumer tastes, products and processes are changing all the time.

Tools that can be used to identify risks in this phase are Risk checklists, Ishikawa diagrams and Gantt charts.

3.3.2 Supply Chain Risk Assessment

When risk is defined, the next step is to assess it. Supply chain risk assessment help organizations recognize risk level and impact in order to prioritize resources for risk management. To achieve the performance of assessment, one should take assess procedure with consideration of several questions: what is the nature of the risk? What conditions may lead to the event? How frequently did it happened or expected to happen? And what are the potential impacts of the event?

Two measures are typically used to form the assess process which refer to Likelihood and Impact. Likelihood is to assess the probability that if the event will occur through analysis of historical data. Impact means to predict and measure consequences of possible affection of event. The impact can be translated into terms of dollars, scale which presents by numbers and other forms. A risk matrix can be used to assess the level of risks. (As figure shows) As illustrated, the lighter color cells indicate less impact and lower likelihood. Both method of using subjective likelihood and experts’ opinions can be used to define the possibilities. To give a defined time horizon is necessary for the reason of focusing on clear time period. The method of “what-if” simulations, financial models, and experts’ opinions can be used to measure impacts. The tools can be used in this assessment phrase are failure mode effects analysis (FMEA), fault tree analysis (FTA) and event tree analysis (ETA).
Some more sophisticated method which used to assess risks is supply chain simulation. With high development of computer technology, various different simulation software are available to use according to different situation. In order to see the impacts and interaction of one or combination of several risks together, a computer simulation model is useful to assess supply chain risks. According to analysis of Melnyk (2008), to select specific type of simulation approach which fit supply chain is a critical decision facing the researchers. The types of simulation approach include: static vs. dynamic, deterministic vs. stochastic, continuous vs. discrete, systems dynamic vs discrete, event vs complex systems. Melnyk (2008) also emphasize that two considerations must be noted when building a simulation model of a supply chain. The one is that both multiple tiers of suppliers and customer should be brought together in a dynamic, multi-echelon system as figure shows. The other one is to focus on interest which is the performance of only one node or entity in the model through any analysis of data while the overall simulation model deals with the entire supply chain. (As shown in Fig 3.4) Regardless of use simulation approach in assessment phase, it would also play a vital role in mitigation stage to assess the performance of alternative plans and actions and see how it will affect the chain.
3.3.3 Supply chain risk mitigation

After identification of risk and assessment of impact and likelihood, the last and most important step is to take actions to mitigate risks. Two options are given by Dani (2009) in proactive mode:

(i) Designing a new supply chain

(ii) Updating an existing supply chain

According to Juttner and Ziegenbein (2009), three steps should be taken in this phase:

- Identification of mitigation actions: with understand of supply chain risk profile, the method of brainstorm can be used in this step to bring up as many risk mitigation measures as one can. The decision making team need to think about as many cause-oriented and impact-oriented measures as possible. Mitigation measures can be implemented at the strategic level, the tactical level and the operational level.

- Assessment of mitigation actions: After alternative mitigation measures have been identified, one should take an assessment to see if risks and impact can be reduced. A comparison should be done to view risk profiles of before and after implementation of
measures. At the same time, costs during the process need to be considered. Simulation approach can be used to assess the proposed measures and costs in a holistic view.

- Decision of mitigation actions and action plans: It is a central element of risk mitigation stage as well as risk management process. Final decisions should be made in this step based on previous analysis. The commitment from upper stream and downstream in supply chain might be needed since an interorganizational process would cause effect to other companies in the same supply network. The final mitigation actions should follow a fixed schedule and meet the deadline.

Based on these three steps, a detailed list of risk management strategies and measures can be present. Although the options may be endless, they cannot jump out of taxonomy of risk management strategies and measures which called: avoidancereduction, transfer and acceptance (USCG 2001; Knight 1999)

<table>
<thead>
<tr>
<th></th>
<th>Risk management strategies</th>
<th>Categories of measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Avoid</td>
<td>- Eliminate</td>
</tr>
<tr>
<td>R</td>
<td>Reduce</td>
<td>- Reduce the frequency of causes (prevention)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Eliminate some causes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Reduce the frequency of consequences</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Reduce or mitigate consequences (mitigation)</td>
</tr>
<tr>
<td>T</td>
<td>Transfer</td>
<td>- Transfer by contract</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Transfer by insurance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Physical transfer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Risk sharing</td>
</tr>
<tr>
<td>A</td>
<td>Accept</td>
<td>- Retain</td>
</tr>
</tbody>
</table>

Table 3.1: Taxonomy of risk management strategies and measures adapted from USCG 2001; Knight 1999

A single measure can be used to affect one or several risks and multiple measures can be combined to a single or system elements (Mullai 2009). With the rising complication of supply chain system, single measure may not enough to handle the overall situation, where several measures has been used together to achieve goals of supply chain risk management.
Some practical strategies and measure are proposed by some previous scholars. Zsidisin et al. (2000) and Zsidisin (2003) provide 4 strategies to mitigate supply chain risk:

1. Carrying buffer stock and improving inventory management;
2. Using alternative sources of supply;
3. Use of contracts to manage price fluctuations; and
4. Quality initiatives.

For most manufacturing operations, over 70% of cost is associated with purchased goods and services. Therefore SCC (2008) identified some risk mitigation strategies which fits well with companies that have a few, significant suppliers or constrained, powerful suppliers. It also is useful of the supplier base or the raw materials purchased are inherently high risk. The source risk mitigation strategies include:

1. Multiple sources of supply
2. Strategic agreements or partnerships with suppliers
3. Collaborative Planning Forecasting and Replenishment CPFR
4. Joint product design and delivery

3.4 Reactive supply chain risk management

Originally, SCM was typically a reactive mode of management that developed to prevent costs of companies from disruption caused by business uncertainties and trade barriers. Although SCM and SCRM today demands a much more proactive, strategic and corporate approach which need companies throughout the supply chain cooperate together to obtain well performance of the whole chain, there are automatically rising risks need much developed reactive strategies and measures to deal with under this rapidly developing nature. Reactive supply chain risk management mainly focus on processes of coping with supply chain disruptions that caused by various incidents and accidents. With supply chain globalizing and integration, longer distance, shorter lead-time, smaller inventory, fewer significant supplier etc. provide more opportunities for supply chain disruptions (SCD). A SCD usually started with “triggering event” which can cause rippling effects to other sources, thus one or multiple sources adversely affect performance of one or more components located elsewhere in supply chain lead to final SCD (Melnyk et al 2009). SCD can be divided into supply side supply chain disruptions (SS-SCD) and customer side supply chain disruptions
Compared CS-SCD most disruptions happened on supply side since companies usually without clear sights on upper-streams. Companies can avoid or reduce or transfer supply chain disruption with investigation of customer response, however, upstream supply chain disruption usually hard to predict until it occurs. According to Kleindorfer and Saad (2005), a three-step framework which donates as SAM is considered as foundation of SCD management:

1. Specifying: the sources of risk and vulnerabilities has to be specified
2. Assessment: the risk has to be quantified through disciplined risk assessment process
3. Mitigation: Integrate appropriate measures and actions with on-going risk assessment with supply chain partners’ coordination.

In reactive SCRM, this three-step deal with the risks which already occurred and brought some impacts. Therefore, the core of the process is to mitigate risks and reduce impacts in shortest time and less economic losses. SCD may arise from many different sources owning to increased global outsourcing, high dependency of single source and complexity of supply chains. Only to specify sources of the risk and vulnerabilities can help a company remedy it with appropriate plans. Melnyk et al (2009) presented various sources that can cause SCD which include: Natural disasters, Demand Shifts, Human/Organizational Behavior, Information/Technology, Financial, Supplier Problems and Legal/Regulatory. He also reminded that these sources often do not occur independently of each other. When sources are specified, in assessment and mitigation step, similar measures with assessment and mitigation phase in proactive SCRM can be taken. Some predict processes are not needed in this part. Remedial measures which can mitigate risk currently should be taken first and foremost.

### 3.5 A resilient supply chain

Even the best managed supply chain cannot avoid unexpected risks and events that are impossible to predict. To combine proactive and reactive supply chain risk management methods in order to build a robust supply chain become an important topic. According to case studies of three different companies by Christopher Tang (2006), he found that an established robust supply chain strategy would enable a firm to deploy the associated contingency plans efficiently and effectively when facing a disruption which in another word could make a firm become more resilient. According to Christopher (2011), resilient implies the ability of a
system to return to its original or desired state after being disturbed. It means that a resilient supply chain can touch the goal of flexible, agile and able to recover after risks occur. A supply chain community with a great visibility of upstream and downstream risk profiles and shared commitment of risk mitigation and management is essential to achieve resilience. In order to create a resilient supply chain, information is seen as the glue to hold each single entity in the chain together.

Christopher referenced a report by A.T. Kearney which suggested four stages to supply chain risk management excellence (see Table 3.2). This stage of excellence in SCRM can be seen as a comparison list of companies in different level of SCRM. As table shows, Stage 1 companies have very limited definition of risk which only comprised aspects of financial, property and IT. In like manner, the limitation is shown in mitigation step, motivation and updates part. At the other extreme, stage 4 companies have wide perspective on supply chain which reflected on their risk definition, mitigation methods, actions, collaborations etc. Apparently, stage 4 companies are more close to the goal of creating a resilient supply chain. Companies can find their position according to the excellence stage and make up the shortfall of SCRM to reach higher stage.
### 3.6 Summarizing

In this chapter, I focused on background and framework of supply chain risk management. Much literature in the SCRM field has been reviewed. Supply chain risk and supply chain management are complex and interdependent. Understanding and managing these risks are crucial for maintaining the smooth operation of the supply chain.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
<th>Stage 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responsibility level</td>
<td>Functional or departmental skills</td>
<td>Business unit</td>
<td>Corporate (chief risk officer)</td>
<td>Extended enterprise (board level)</td>
</tr>
<tr>
<td>Scope of risk</td>
<td>Market risks (foreign exchange credit, commodity)</td>
<td>Market risk</td>
<td>All enterprise risks</td>
<td>Strategic risks</td>
</tr>
<tr>
<td></td>
<td>Property or safety risk</td>
<td>Property or safety risk</td>
<td>Business continuity</td>
<td>Operational resilience</td>
</tr>
<tr>
<td></td>
<td>IT disruption</td>
<td>IT disruption</td>
<td>Country risk</td>
<td>Global business environment</td>
</tr>
<tr>
<td></td>
<td>Easily quantified risks</td>
<td>Easily quantified risks</td>
<td>Key business processes</td>
<td>Organizational or cultural component of risk management</td>
</tr>
<tr>
<td>Risk-mitigation tools</td>
<td>Financial derivatives, property insurance</td>
<td>Incident data and trend analysis</td>
<td>Contingency planning</td>
<td>Advance warning systems</td>
</tr>
<tr>
<td></td>
<td>Supplier contract reviews</td>
<td>Supplier contract reviews</td>
<td>Scenario analysis</td>
<td>Back-up of processes as well as data</td>
</tr>
<tr>
<td></td>
<td>Self-assessment</td>
<td>Self-assessment</td>
<td>New business and new venture reviews</td>
<td>Quarterly drills that include key partners</td>
</tr>
<tr>
<td>Motivation</td>
<td>Follow regulations, reduce financial exposure</td>
<td>Avoid operational disruptions, avoid costs of accidents</td>
<td>Protect brand image, maintain earnings stability</td>
<td>Create competitive advantage, generate shareholder value</td>
</tr>
<tr>
<td>Updates to risk plan</td>
<td>Never</td>
<td>After major incidents</td>
<td>Annually</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Supply chain</td>
<td>Buffer inventories</td>
<td>Alternative suppliers</td>
<td>Co-ordinated forecasts throughout supply chain</td>
<td>Supply chain transparency</td>
</tr>
<tr>
<td></td>
<td>Excess capacity</td>
<td>Recovery plans - select scenarios</td>
<td>'What if' modelling</td>
<td>'War gaming'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Agility: products and processes</td>
<td>Dynamic reserves of critical components</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Focus internally</td>
<td>Communicate policies to suppliers</td>
<td>Collaborate with suppliers, industry associations</td>
<td>Lead industry initiatives, collaborate with government</td>
</tr>
</tbody>
</table>

Table 3.2: Stages of excellence in supply chain risk management adapted from A.T. Kearney, 2003.
risk management have been defined and explained. Mainly theoretical research has been
down with both proactive SCRM and reactive SCRM. In proactive SCRM, three steps
which refer to SCR Identification, SCR Assessment and SCR Mitigation are considered
as standard process to handle supply chain risks proactively. In reactive SCRM,
specifying, assessment and mitigation are three steps to handle risks afterwards. However,
the difference between CSR Identification in proactive SCRM and specifying step in
reactive SCRM is that the CSR identification try to find vulnerabilities before risks occur
and Specifying step find the sources of risks after is occurs. Even the best managed
supply chain cannot avoid unexpected risks and events that are impossible to predict.
Therefore, the thought of a resilient supply chain which combine proactive SCRM and
reactive SCRM has been proposed. A resilient supply chain can touch the goal of flexible,
agile and able to recover after risks occur.

4 Findings

Over the past few months, numerous questions have been raised about the impact on global
supply chain of the Tohoku earthquake and the devastating tsunami. In this chapter, the
author will try to find answer to the three research questions which rose in chapter 1 and
reach the purpose

Japan is the country that fully developed in most of the region, thus any small damage will
cause chain reaction on supply chain without mention such big disaster. Some facts can show
the importance of Japan in global supply chain: Firstly, Japan accounts for roughly 12 percent
of global technology goods and services demand. Second, Japan accounts for 40 percent of
global electronic components and advanced material supply. The conclusion can be drawn
that the most likelihood of widespread disruption is on global technology supply chain.
However, some inconspicuous factors could also affect supply chain of other industries. On
the other hand, Japan is the world’s third largest oil importer and its chemical industry ranked
second in the world after the USA. According to statistics of 2009, the average daily
consumption of crude oil is 440 million barrels. Earthquake caused damage to refining
facilities and chemical plants in the northeast which directly shutdown several oil and
chemical industries. A sharp decline of international oil price is caused by sudden drop of oil demand. In spite of that, Japan itself is a big consumer of the metal. It is the world’s second largest importer of copper as well as largest importer of aluminum in Asia. Due to the earthquake, at least five large steel mills and two copper smelters suffered structural damage and called for a moratorium on the production.

4.1 Impacts from Tohoku

While the Tohoku earthquake was one of the worst on record to strike a heavily populated area, the impact on the supply chain is due more to the aftermath tsunami and power outages resulting from the nuclear crisis. Japanese manufactures who make printers, copiers, and the consumables for these machines have struggled to keep factories running since March 11th disaster. Media describe that most facilities have reopened after heroic efforts of Japanese, however, damage done to the basic infrastructure as transportation networks and energy grid has limited production. The New York Times (NYT) reported that since the earthquake Japanese exports fell to ¥5.9 trillion, down 2.2 percent compared to the same period in 2010. Economists expect even sharper export declines for the next few months.

4.1.1 Import and Export

The earthquake along Japan’s northeastern coast brought big problem to supply chain of Industries due to the reason of most office equipment like printers and other supplies are mainly shipped by sea. Since the earthquake and tsunami have damaged many key ports along the coast north of Tokyo, some 129 berths have been affected. Japanese original equipment manufacturers (OEMs) faced a hard situation that to shift production to lines outside of Japan quickly. Some critical parts which manufactured domestically in Tohoku could not easily move to rest of the region in Japan and never mind move to other countries. The limitation of access into Japan’s damaged port immediately influenced China, which is Japan’s most important trade partner. Although there are some ports undamaged, the huge influx of goods diverted from the damaged ports to undamaged ports outside of the ruined region still caused supply chain disruption between Japan and global market. Japan is China’s largest source of imports and Japan is the number-two export destination for Chinese goods. The delayed imports of key components, especially for digital product possibly postpone
new product launches in China. The problem of shortage supplies from Japan did not clearly show in Europe and United states yet in late March and early April though because a certain amount of goods has been shipped from Japan before 11th of March and already en route to the world’s markets. However, an April 22nd’s article on the Voice of America website points out that Japan is the United States’ fourth-largest trading partner and the effects of the disaster has shown in two busiest container ports in USA.

4.1.2 Printer equipment industry

According to analysis of Actionable Intelligence, three companies which refer to Canon, Epson and Ricoh has been not only affected but even hit hard by earthquake. All three firms have built their substantial production units in the region that heavily attacked by earthquake. Because of damaged facilities and limited electricity, they can only gather sources and focus on bring back certain critical units online. Compare to them, other OEM’s have been less affected for the reason that their assets in the region are those sales offices or distribution centers.

**Canon**

After quake, eight canon factories in the Tohoku region shut down immediately which included Fukushima Canon, a manufacturing subsidiary that produces inkjet print heads, printers and ink tanks; Canon Chemicals, a mission-critical company makes toner cartridges and chemicals such as polymer components. Although most of Canon’s plants had reopened by early April, production was restricted owing to the limited power and other supplies.

**Epson**

Five Epson plants went offline in northeastern Japan by the force of earthquake. By the end of March, two plants reopened and two other facilities had partially resumed manufacturing. However, the firm warned that production may still affected by plenty of issues including power limitation and certain components procurement. Some of the plants have been closed indefinitely since quake such as Epson Toyoco’s Fukushima Plant which manufactures crystal devices and just located within the evacuation zone of damaged reactor. According to report on actionable intelligence on
July 29, Seiko Epson announced financial results for the first quarter, ended June 30, 2011. The printer OEM reported substantial year-over-year declines revenue and income in the first quarter. Compared with the first quarter of 2010, net sales declined 9.0 percent to ¥217.7 billion ($2.7 billion). Especially income of its printer business was down 29.1 percent to ¥13.3 billion ($164.9 million).

**Ricoh**

Five Ricoh subsidiaries were closed after quake and rolling blackouts limited production of other plants in the region. The firm said on April 7 that operations at most of the plants had been normalized, however, the shortage of certain sources were still a problem before production back into normalization.

According to the analysis of Actionable Intelligence, none of OEM’s escaped unscathed in this disaster. Besides the three OEM’s above that had been hard hit, many other companies got certain extent of damage as well. The plant of Oki Data in Fukushima which produces hardware and consumables for domestic market had been damaged. One of Konica Minolta’s sales branches in the region had suffered damage; however, other undamaged branches took over the service of it. For most of OEM’s, moving freight to ports and shipping products overseas also presented a problem. On April 27, Ricoh announced financial results for the fiscal year ended March 31, 2011. Ricoh’s net income of ¥19.6 billion ($240.2 million) marked a 29.5 percent decline from the previous fiscal year.

The companies who usually purchase printer, cartridge and related equipments and materials from these three companies would face supply shortage for a certain period.

4.1.3 **Automobile industry**

The automotive supply chain is the most complex kind in the whole industry world. There are approximately 20,000 parts in a car. No matter any of those parts is unavailable, there is no finished product. The supply chain started from raw material purchasing in different sub parts suppliers. They furnish the parts and supply them to down-stream members in supply chain. All of the suppliers that evolved into the manufacturing process of a car can reach 1000s. The worldwide automobile industry encountered shortages of critical components due to the disruption of so many electrical parts exported from northeastern Japan.
According to U.S research firm IHS25 released survey data, due to the sharp drop of production in Japan worldwide vehicle production cut to 600,000 by the end of March.

**Toyota**

The Toyota Motor Tohoku plant provides electronic brake and some other chassis-related components to Toyota vehicles. Two facilities were located close to the epicenter of the earthquake and tsunami. Toyota told the Canadian Broadcasting Corporation (CBC) that by mid-April, Toyota’s production was off by 260,000 cars owning to the earthquake. And it was expected that global car production will not resume to normal levels until November or December. Toyota factories in North America cut production by 75 percent between May and June to conserve parts which result to significantly fewer cars was available during the spring. Toyota Motors announced on 10th June that their net annual income is going to decrease by 31% this year when the financial year ends on 31st March 2012 from $5.1 billion to $3.5 billion. Toyota added that the main reason behind this huge decline is the Tohoku earthquake.

![Figure 4.1: A Toyota plant hit by tsunami of Tohoku earthquake from TundraHeadquarters.com Mar 14, 2011](image)

**Honda**
A number of operations of Honda which located in the Tochigi area (around 100km north of Tokyo) have been affected in disaster. During the late March, Honda Motor Company reports a massive shutdown of their plants. It directly influenced Japanese production of automobiles, outboard engines and motorcycles. Although domestic production of Honda was facing rapid reduction, the plant in other part of the world seems slightly affected according to media.

Since most vehicles sold by Honda in North America are produced either in the United States or in Canada, the supply of vehicles was predicted to remain steady on the east side of the Pacific Ocean for the short-term. Honda predicted a larger decline in profit than Toyota Motor Corp. In a statement of Tokyo-based company on 14th June, Honda forecast a bigger-than-estimated 63 percent decline in full-year profit which Net income may fall to 195 billion yen ($2.4 billion) in the 12 months ending March 31 from 534.1 billion yen a year earlier.

Compare to Japanese automakers, automakers in western world suffered less, however still bad blow. General Motors (GM) was forced to cut production at factories in the United States and Europe. Other auto manufacturers such as Nissan, Subaru, Mazda and Mitsubishi also reported their facility conditions and activities confront damages of earthquake and tsunami. In May, General Motors Corp.’s sales fell 1.2 percent, while Ford Mortor Co.’s sales fell 2.4 percent, compared with the same month in 2010. However, most of them only suspended manufacturing operations close to epicenter for short-term and got back to normalization in early April.

4.1.4 Electronics Industry

Japan is regarded as a critical part in the supply chain of global electronic industries. In this earthquake, electronic industry who manufactures panels, chips, LEDs and cameras etc also got different degrees of shock. However, due to different reasons, LED and panel industries didn’t get badly affect. The industries who had been badly hit are chip and camera industries.

Chip industries

Chip industries suffered a serious blow in the Tohoku earthquake. The most affected products are silicon wafer, DRAM memory and flash memory. It is reported that there are 18 chip factories located in the region where directly affected by quake. They are one 12in.factory, seven 8in. factories, seven 6in. factories and three 5in. and below
factories. The total production capacity of these plants accounts 20 percent of Japan’s semiconductor capacity and 4 percent of the world’s semiconductor capacity. Silicon is the most damaged industry in this earthquake. A market research company iSuppli reported that owning to earthquake, a quarter amount of the world silicon wafer which used for the production of semiconductor is suspended. The two biggest OEMs of silicon wafer which refer to Shin-Etsu Chemical Corporation and SUMCO Corporation have 62% market share in global market. Both of the company had factories in the earthquake affected region and shut down after disaster. The production capacity of suspended factories accounts for 25% of global silicon wafer supplying. NAND flash chip is considered as another badly hit product which manufactures by Toshiba. Second only to Samsung, Toshiba has 35% market share of NAND Flash in the global market. Due to the reasons of facility damage, short of material supplying and traffic congestion, although the main plant of Toshiba did not get badly hit, there was still problem to return to normal production. Since NAND flash is the key component of selling products like iPhone and iPad, market had serious concerned about shortage of supply.

Camera Industries
As the centre of the world’s camera industry, Japan filled the northeast region where earthquake struck with popular camera production plant as Canon, Nikon and Fuji. In all of those factories, the closest to the core of the earthquake was undoubtedly a large Nikon plant in Sendai who manufactures high-end SLR camera and flash components. It reported that the tsunami which brought by earthquake completely destroyed this plant. Both of Canon and Sony had several plants affected by earthquake and shut down for a period. Many companies who used to purchase high-end components from Sony acted as the cat on hot bricks by the reason of suspended supplying. The price of SLR camera and camera lens in China, however made by Nikon and Canon plants in Japan increased 5% to 10%.

Most companies expect that the earthquake will put a damper on growth in the year ahead; however, they believe that the influence will be minor at the second quarter of the year. It requires some time until supply chain system including procurement of raw materials and components will be normalized. Therefore, during this period, Japanese economy will
temporarily slow.

4.2 Mitigation strategies of industries

Japan’s earthquake disaster caused damage to a number of facilities and business equipment. Many companies who have plants in the affected region either be totally destroyed or partly damaged. The first thing they chose to do is to shut down the affected plants and allocate employees to work in southern part of Japan. 10 days after earthquake, many companies started to rebuild the damaged plants and facilities in order to return to production sooner since local and overseas companies got into supply disruption. Most of Canon factories had reopened by middle April, although production was restricted of limited availability of parts and power. Epson reported on April 12 that operation at the four plants had resumed. However, although many of the plants resumed operation, it did not mean the production returned or get back to normal level. Under this situation, foreign companies forced to made corresponding production adjustment. The truck plant 21 of General Motors which located in Louisiana stopped running and New York engine plant lay off 59 people. A part of GM plants in Spain and Germany also temporarily suspended. Ford Motor Company had a full cessation of 25 black and red passenger car orders because of difficulties in paint imported from Japan. The U.S. Apple company had delayed deliver time and cut certain amount of Apple Tablet PC iPad2.

All of actions above including shut down plants, cut production or lay off workers were only emergency measures to treat the temporary situation. It has been several month passed, many companies has been gradually resumed production and reduced influence from supply chain disruption from Japan. Since supply chain management is a very important strategy that significantly affects the company’s operations and profitability, there is no company would like to disclose information to the media about how they walked through the storm. The most companies just reported that they had solved the supply problem and return to production.

From a long-term perspective, analysts pointed out that in the next three years, there will be a wave of multinational companies’ factory relocation trend. The strong earthquake may facilitate Japanese companies to go on the road of overseas expansion and technology export. It may change the strategy of “technical non-proliferation” which widely implemented in Japanese industries.

- 31 -
Since strategy of supply chain management is regarded as trade secret in business world, author could not get detail information of what have companies exactly done to mitigate the badly supply disruption after earthquake. The most information is second hand from media and analysis of market research companies. To mitigate this influence of the big shock on global supply chain by Tohoku earthquake, there is still much more work for industry world to do. The mitigation actions of affected industries might continuers run in next one or two years.

5 Analysis

In this chapter, the author will analyze the data in findings part connected with theoretical framework which focus on supply chain risk management being applied in Tohoku disaster.

In the theoretical framework, we already divided the SCRM into proactive SCRM and reactive SCRM. The proactive SCRM is a systematic management process to find both emerging and latent vulnerabilities in a chain and use coordinated holistic approach to minimize risk. The reactive SCRM requires reactive strategies and reducing cost on dealing with risks which has occurred. Therefore, the author will still surround the two perspectives and do analysis with supply chain risks management in industries in Japan.

5.1 Proactive SCRM in Tohoku earthquake

According to theoretical framework, proactive SCRM will experience three phases which refer to risk identification, risk assessment and risk mitigation. Mason-Jones and Towill (1998) introduced supply chain risk profile for business. It classified five main sources that cause supply chain disruption which refer to supply risk, demand risk, process risk, control risk and environmental risk. According to situation of industries affected by Tohoku earthquake, there are four main risk sources which connect to the risk profile. They are geographical risk (environmental risk), key techniques and products risk (supply risk), Just-in-time approach (process risk) and strategy of supplier relationship (control risk). Author will analyze each source according to three phases and summarize the situation of proactive SCRM in supply chain globally that affected by earthquake.
5.1.1 Geographical Risk

Sitting on the edge of the Pacific Ring of Fire, tectonic activity is part of everyday life in Japan and with hundreds of earthquakes taking place every year. Only from geographic perspective, there has been already full of latent risks covered the whole area of Japan. Japanese industries has full aware of their environmental risk and did well assessment on their situation. Furthermore, Japanese industries didn't prohibit by the geographical constraints, On the contrary, grew up domestically in short time and quickly occupied the international market. In such a geographical troubled country, Japanese industries are developing in a strong sense of survival and preparedness of any eventuality. This provides the reason that why Japan regarded as one of the best-prepared countries in the world. No matter early warning system of earthquake or swaying skyscrapers in Tokyo prove the efforts that Japanese have been made effort to protect life and property from damage. It could be one of the reasons that why Japanese Industries are always advance with the times and developing every day.

Since Japan is just lying on the edge of Pacific Ring of Fire, large and small earthquakes will always occur from time to time. In order to prevent the supply chain risk that causes by geographic reason, large industries like Toyota, Honda, Canon and Nikon built there plants in global map comprises USA, Canada, European countries and other Asia countries in order to achieve risk sharing. For companies in the rest of the world, analyzing where suppliers located, and limiting the number of critical component suppliers that are geographically situated in a risky area is also important. When some plants in one region or country suspend production by irresistible reason, companies can still lower the loss by focusing on their other plants out of affected region. This is no doubt a positive approach for large enterprises and the only choice they could have. For those medium sized companies, they may have several plants which locate in neighbour countries to help them lower the risk level. Only those small and local companies bear the greatest risk from geographical reason. In this view, we can clearly recognize that why Japanese companies try their best to become bigger and stronger and enter into global market one after another. This is a proactive risk mitigation approach they choose after assess the situation and options. This is the only way to help them survive from a small, earthquake-prone country. This is also the reason why many companies are not
serious blew by some damaged production plants in affected region. Generally speaking, in geographical perspective, Japanese industries did really well on proactive supply chain risk management.

5.1.2 Key Techniques and Products Risk

As we know, Japan is famous for its high techniques and technical products especially electronic techniques. Many of those techniques can only provide by domestic Japanese companies. However, those techniques or high technique products are just on the upstream of the supply chain globally. Many of the downstream members from America, Canada and European countries rely on their supplying to finish own products. The companies who possess those key techniques and products might already identify the big risk of supplying disruption and assessed the result that would happen if their supplying disrupt. Even there is a big risk from geographic reason, however, for some reason like confidentiality, they still choose to remain there core technology plant in Japan. No matter printer industries or Automobile industries who build their factories and plants over the world, they still remain their core technology or components plants in Japan. Due to this reason, after Tohoku earthquake, even factories of GM and Toyota in America did not affected directly by disaster, they still did corresponding cut on production because of key component shortages from Japan. We can’t say that Japanese industries did not have any proactive mitigation strategies according to key techniques and products disruption. They spent amount of money and did a lot of work on their facility construction to achieve as high degree earthquake as they can protect from. However, it may only work against certain degree attack. Nature itself is still an unpredictable and horrible strong thing that can cause greater disaster than you prepared. Therefore, with key techniques and products, they still have big space to make effort to reduce their supply chain risks. They need to start to change their limited thought on protection of core technique or product and start to do some real protect work in broader way as cooperate with companies from other side of the world in area of technique share or outsource their core technique or product to some trustworthy companies out of Japan. In this way, Japanese Industries and Japanese techniques could get prepared to survive in any eventuality.
5.1.3 Just-In-Time (JIT) Approach

Just-in-time (JIT) which also called the Toyota Production System (TPS) is a production strategy that strives to improve business return on investment by reducing in-process inventory and associated carrying costs. It’s Toyota who developed TPS system and brought up conception of Just-in-time (JIT). It pushed the situation of supply chain moving fast from high inventory cost type towards ideal situation-0 inventory. The reason is that in philosophy of JIT inventory is waste. Industries in Japan grew fast since 80 years and benefited greatly from this strategy. Then, American and European companies started to follow steps of Japanese industries and use JIT strategy. However, the latest big earthquake sheds light on JIT’s inherent risks. Majority companies who followed the well-functioning JIT systems with fewer inventories hit hard indirectly by quake due to suspension of supplying. Many downstream companies over the world who rely on Japanese core products supplying got into problem. They cannot get sufficient supply from Japan and hard to get alternate supply from other countries in short time. For the reason that Japan in the overwhelming share of the market in some sectors such as automobile industry, printer industry and industries that produce some advanced components, supply chain globally on these industries got into badly disruption. The turmoil of supply chain globally which caused by Tohoku earthquake could apparently show that JIT approach is just a double-edged sword. Once company get into this kind of disruption trouble, they pay back what they saved several years from less inventory benefit.

Since JIT strategy introduced to supply network globally, many scholars has pointed out that without certain amount of safe inventory, supply chain will always run in high degree risk of disruption. In this view, global industries have identified this big process vulnerability. And I believe most of the industries had assessed the level of risk in both likelihood and impact perspectives according to risk matrix. Perhaps they did some proactive mitigation work on their business to reduce risk that may bring by JIT. However, from this big earthquake, it seems many of global enterprises are still badly affected by their few inventories.

There would be always risk for domestic as well as global industries face suspension someday. Some industries like Konica started to think about reduce risk without change the root of JIT approach. They moved some machine manufacturing and production plant in China. In view
of this, there are some options for Japanese Industries to choose from: to remain core plants in Japan with a certain amount of inventory or to build core product plants to different countries to reduce risk and keep their JIT benefit.

5.1.4 Strategy of Supplier Relationship

How to improve the proactive supply chain risk planning and management is a significant step for Industries in Japan as well as global. When supply chain disrupted for a company, there may not only suppliers fault, downstream member which is company self has responsibility as well. They may could have avoid or deal this kind of disruption proactively. Many companies who got into this trouble because of their supplier strategy. In order to face the situation and meet strong demands of lower price with higher quality and flexible manufacturing, try to become system suppliers which refer to Original Equipment Manufacturers (OEMs) seems a trend in global market. Companies comprise large, middle and small sized all prefer to choose system suppliers instead of single component supplier due to OEMs’ broad competences. Some companies give hundred percent work to one system supplier and think alternate suppliers are not necessary since the system supplier is enough strong and flexible. When this kind of heavy disruption occur, OEMs who usually provide sources for all kinds of companies will only try their best to support very important partner like those global and large enterprises. The other middle sized or small sized companies who use the same system supplier with large enterprises will not get any resources. In the Tohoku quake, many companies who only rely on supply from Japan forced to shut down their plants over the world owning to supply disruption. Some other companies who have alternate suppliers from China or India got less affect. We could say companies got less affected are either lucky or did better on proactive SCRM. Even those lucky ones could not always rely on their luck. Therefore, proactive SCRM is the only approach that will help companies systematically avoid, reduce or transfer risks. Companies should identify and assess the single supplier risk or risk of multi suppliers in same country and use mitigate strategies to lower the risk level. A suggestion for this kind of situation is that to give 70percent of the work to a system supplier (primary supplier) and 30 percent to a secondary vendor that located in another part of the world. A part of contingency plan should include the provisions for ramping up production of the secondary supplier when supply disruption occurs to primary
supplier in some emergency situation. In this way, companies no matter middle-sized or small-sized will possible to survive during this kind of heavy supply chain disruption after big disaster.

5.2 Reactive SCRM after Tohoku Earthquake

Although reactive SCRM mainly focus on processes of coping with supply chain disruptions that caused by various incidents and accidents, we cannot completely divide it from proactive SCRM. Because more and more companies coping with present supply chain disruptions while take actions of proactive plans for future risks at the same time. According to Kleindorfer and Saad (2005), a three-step framework called SAM which refers to Specifying, Assessment and Mitigation is considered as foundation of supply chain disruption management. The source of the disruption from Japan this time is apparently – nature disaster.

Many market analysis companies have already did assessment and released data of the possible loss and cut of production in the global market according to different industries and companies. The only thing left is mitigation measures of different companies after assessment. However, due to the some reason of confidentiality, many companies did not give any information of their measure coping with the disruption of supply chain caused by Tohoku earthquake. We could guess that they may found alternate suppliers in other regions out of Japan like Taiwan, China, Korea or India.

For the long-time perspective, some reactive actions are predicted to be taken by the influence of this big disaster. Many America companies would plan shorten supply chain to move their manufacturing plant from low-cost Asia countries back to U.S. or Latin America. There are many reasons can support this suspect. The first is the continuer’s rise of international oil price raised international costs of logistics and transportation, thereby weakening the Asian labor cost advantage. The second is to simplify the supply chain and shorten supply chain could reduce or avoid some risk that caused by long distance and time. The third is to provide stronger customized service and fulfill the customer requirement of shorter deliver time and more convenient after-sales service. The earthquake could accelerate the pace of their removal.

For Japanese companies, they would abandon old strategy of “technical non-proliferation” and start strategy of technology export after this big earthquake. If they still choose to remain the technologies in domestic plant, there will be two consequences: they will lose trust and
business of many international partners or they will involve into one and another disasters thus suspending their technical production from time to time. These are not only reactive actions of companies to face affection of Tohoku risk; they are also proactive strategies of them to prevent or reduce the coming risks of supply chain disruption in the future.

5.3 Global SCRM face the test of natural disasters

Supply chain globally is facing different types of nature disaster now and then. How to develop SCRM strategy to find vulnerabilities in supply chain and mitigate risks proactively and reactively is a very important step for all of the companies over the world. More and more factor should be take into consider when companies establish or run a supply chain. Nature disasters as environmental risk is the risk that cannot predictable and usually cause butterfly effect leading to supply risk, process risk, control risk. To avoid nature disasters is an unachievable target for any companies. No one can tell where will be the next destination for nature disasters next second. However, to successfully transfer, reduce or mitigate risk when it occurs in order to reduce losses and keep running is already the best condition. The ABB Company has 5500 suppliers over the world. ABB keep contact with all those suppliers through data network and could adjust supply allocation at any time. From this, we could see that to establish a resilient supply chain which can touch the goal of flexible, agile and able to recover after risks occur is the ultimate goal to confront nature risks. However, a supply chain is a network comprises hundreds or thousands of entities. To establish a resilient supply chain requires all the members in a supply chain cooperate actively with sharing information. A resilient supply chain may not protect individual companies or facilities in the region that affect by disaster, however, it can be a powerful weapon to protect supply chain globally from not only earthquakes but also various nature disasters over the world.

6 Conclusions

This chapter covers conclusions from this study. It comprises the analysis of the findings connected with theoretical framework. Author will look to reach the purpose and answer the research questions that stated in the start of the study.
The most powerful known earthquake of the Japanese history: Tohoku earthquake struck the north-east coast of Japan on 11th March 2011. It caused many Japanese companies suspended production thus shocked global supply chain by shortage of various products. In my study, I did a lot of work to find out the answers of my three research questions. The result may not comprehensive or perfect, however, I reached the purpose of this study and did my best on the whole process. Now, we can come to the conclusion of the study. Conclusion will be done according to each research question as following.

My first question is about how global supply chain affected by Tohoku earthquake. I searched big amount of data from internet and other media and summarized four badly affected parts of both Japan and global market which refer to import and export, printer industry, automobile industry and electronic industry. When talk about import and export, the most affected was Japan itself due to damaged facilities and docks. America, Canada, European countries and China also got problem with importing goods from Japan. In printer industries, Canon, Epson and Ricoh who produce printer related products had been hit hard by earthquake. All three firms have built their substantial production units in the region that heavily attacked by earthquake. Compare with the first quarter of 2010, both Epson and Ricoh’s net income marked a decline over 29 percent. In automobile industries, many Japanese companies who produce auto parts had suspended production. It directly affected Toyota, Honda, General Motors and Nissan etc Auto industries’ production plan. Due to the sharp drop of production in Japan worldwide vehicle production cut to 600,000 by the end of March. Toyota Motors and Honda both forecast a big decline on their net annual income in the 12 months ending 31st March 2012. Compare to the estimated 31 percent decline of Toyota Motors from $5.1 billion to $3.5 billion, Honda forecast a bigger-than-estimated 63 percent decline to $2.4 billion. In electronic industry, companies who manufacture panel, chip, LED and cameras etc got different degrees of shock. Badly hit industries are chip and camera industries which shocked global electronic market. Since Chip can be component to various electronic products, the related financial losses are hard to investigate.

The second research question is how industries response to the earthquake. In proactive SCRM perspective, author analyzed supply chain situation confronting earthquake from four aspects: geographical risk, key techniques and products risk, Just-in-time approach and
strategy of supplier relationship. It provides a clear view of how Japanese Industries and global industries prepared for the earthquake. In proactive stage, Japan has been doing well for years on predict earthquakes and avoids or decreases the effect or it. They have successfully done proactive SCRM for years. However, in Tohoku earthquake, they got shocked may by the reason of still ignored some risks in the environment and vulnerabilities in their supply chain. In reactive SCRM, emergency measures included shut down plants, cut production or lay off workers to treat the temporary situation. Although, damaged facilities and plants had been reconstructed in short time, however, due to limited power and transportation, the production in Japan could not return to normal level. Many oversea companies had to find other way instead of looking forward to Japanese supplying. After this big risk,

The third research question is how to improve the supply chain management system against natural disasters. From the analysis of supply chain disruption caused by Tohoku disaster, we can see the power of natural disaster and consequence of having supply chain risks. Therefore to establish a resilient supply chain which can touch the goal of flexible, agile and able to recover after risks occur is the ultimate goal for supply chain globally to confront natural risks. To achieve this goal requires all the members in a supply chain cooperate actively with sharing information and sharing values.

From this earthquake, many companies from American, Canada and Europe countries got big shock by disruption of upstream supplying from Japan. Although supply chain has been resumed, companies won’t easily believer that there won’t be the second or third “Tohoku” in Japan. Since Supply Chain Risk Management is still a very new conception in supply chain management, there is still big space for it to develop and will be more important role for it to play in the future. Although, the thesis only focused on four deeply affected industries, there are still many other industries got different degree of influence. Therefore, to study and apply SCRM approach is becoming more and more urgent for all of the industries. Both proactive and reactive approach should be applied to keep supply chain in a highly protected mode. Industries can change or rebuild their supply chain mode regarding the lesson which given by this heavily supply chain disruption. A resilient supply chain should be the ultimate goal for all of the industries to achieve.
6.1 Discussion & Future Suggestions

The deficiency in my study from my perspective was non-availability of much literature on supply chain risk management and contingency measurements of affected industries in Tohoku disaster. I think there is still a big space in the SCRM area for people to explore. Since supply chain collaborations have been developed in to a more efficient and effective level, however, complexity and changeability are also increased. To study and apply supply chain risk management is very important for the industries that depend on high collaborative supply chain.

My study only focused on the supply chain disruption that caused by the Tohoku disaster. There will be more natural or human element disaster in the future. Different disasters may bring new problem on supply chain system. Therefore, to establish a resilient supply chain system is the ultimate goal of industries over the world. However, a resilient supply chain is still stay in the theoretical stage, the question for future scholars will be how to drag it into a practice phase to verify the feasibility of the theory. Another question for following people can be to subdivide the supply chain risk management regarding to different kinds of disasters or risks.

7 List of references

Actionable Intellegence. (2011), *Tohoku earthquake wreaks havoc on printer industry supply chain*, Available online: 

Actionable Intelligence, (2011), *Epson sees revenue and income declines in Q1*
Available online: 


Available online: 
http://www.automoblog.net/2011/03/12/effects-of-japan-earthquake-on-the-auto-industry/

Carlsson Inga-Lill. (2007), *Towards system capability: Identifying logistics and manufacturing demands for small suppliers*, University of Gavle and University of Linkoping. Mekanotjanst Industrier AB


Juttner Uta and Ziegenbein Arne. (2009), Supply chain risk management for small and medium-sized businesses, *Supply Chain Risk – a handbook of assessment, management, and


Noson Lawrance Linda, Qamar Anthony and Thor sen W Gerald. (1988), Washington state earthquake hazards, Washington division of geology and earth resources information circular 85


SCC, The supply chain council risk research team. (2008), Managing risk in your organization with the SCOR Methodology


The New York Times (NYT), Toyota plans to reduce production for 6 weeks


Trevor Hale and Christopher R. Moberg. Improving supply chain disaster preparedness- A decision process for secure site location, International Journal of Physical Distribution &
Logistics management, Vol. 35 No. 3. 2005, pp. 195-207

Available online: www.unep.org 2011-07-09


