

World Maritime University

The Maritime Commons: Digital Repository of the World Maritime University

World Maritime University Dissertations

Dissertations

8-22-2015

Disruption risk early warning analysis of Qingdao port service supply chain

Mingni Wang

Follow this and additional works at: https://commons.wmu.se/all_dissertations



Part of the [Marketing Commons](#), [Operations and Supply Chain Management Commons](#), and the [Technology and Innovation Commons](#)

Recommended Citation

Wang, Mingni, "Disruption risk early warning analysis of Qingdao port service supply chain" (2015). *World Maritime University Dissertations*. 1578.

https://commons.wmu.se/all_dissertations/1578

This Dissertation is brought to you courtesy of Maritime Commons. Open Access items may be downloaded for non-commercial, fair use academic purposes. No items may be hosted on another server or web site without express written permission from the World Maritime University. For more information, please contact library@wmu.se.



WORLD MARITIME UNIVERSITY

Shanghai, China

**Disruption risk early-warning analysis of Qingdao
port service supply chain**

By

Wang Mingni

China

A research paper submitted to the World Maritime University in partial fulfillment of
the requirements for the award of the degree of

MASTER OF SCIENCE

In

INTERNATIONAL TRANSPORT AND LOGISTICS

2015

DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

.....

(Wang mingni)

.....

Supervised by

Professor Liu Wei

Shanghai Maritime University

Assessor

World Maritime University

ABSTRACT

Title of Dissertation:**Disruption risk early-warning analysis of Qingdao port service supply chain**

Degree: **Master of Science in International Transport and Logistics**

With the development of the shipping industry, more and more enterprises realize that market competition is not the competition among individual enterprises, but the competition in the whole supply chain. So it is very important for an enterprise to make full use of various resources and ensure the supply chain management. Port service supply chain is a kind of supply chain that taking the port enterprises as the core of port supply chain, and it is a functional chain that integrate all kinds of service providers(including warehousing, transportation, loading and unloading, processing, distribution,etc.) and customers (including owners and shipping companies, etc.) effectively. The port as the core of the service supply chain, it should offer different kinds of service for all kinds of members in supply chain to make the port supply chain competitive.However, with the increase of uncertainty of supply and demand, market globalization, shorter life cycle of products and technology, and strong drive of knowledge economy, all of these change the internal and external environment of enterprise' supply chain operation rapidly, from the product structure, production process, management mode and organizational structure. It not only bring a higher efficiency for the enterprise supply chain, but also increase the supply chain risk. So, risk control is particularly important to do a good job in the supply chain management. While with the increase of man-made damage and natural disasters, supply chain disruption risk has become the most important supply chain risk.Once the risk occurs, a variety of problems will happen, and even push a healthy enterprise from safe to the danger.

The first part in this paper is the analysis of the seriousness of the supply chain risk and the research status in domestic and abroad. The second part in this paper gives a

brief introduction to the theory of supply chain risk such as port service supply chain. The third part in this paper lists a series of risk factors of port supply chain disruption, and then gives the operation model of port supply chain risk early warning. After that, through the form of questionnaire investigation and expert scoring, this paper can make a qualitative analysis of each risk factor in Qingdao port. The fourth part in this paper use the AHP to calculate the weight of various influencing disruption factors. The paper gets the risk probability and the risk consequence of supply chain risk disruption through the weight. Finally, the paper can get the index grade of supply chain disruption risk by the method of two factor model, and then start the strategy of the supply chain disruption risk early-warning for the higher index grade disruption risk factors. The fifth part in this paper gives a summary and some suggestions and deficiency.

KEY WORDS:supply chain risk,AHP ,risk factors,disruption risk,two factor model

TABLE OF CONTENTS

DECLARATION.....	i
ABSTRACT.....	ii
TABLE OF CONTENTS.....	iv
LIST OF TABLES.....	v
LIST OF FIGURES.....	vi
CHAPTER 1 Introduction.....	1
1.1 background and significance.....	1
1.2 research status.....	3
1.2.1 abroad research status.....	4
1.2.2 domestic research status.....	8
1.2.3 a literature review of supply chain risk management at home and abroad	
1.3 research contents and technical route.....	14
1.3.1 research content.....	14
1.3.2 research methods.....	15
1.3.3 technical route.....	16
CHAPTER 2 related theories of supply chain risk management.....	17
2.1 the theory of supply chain management.....	17
2.1.1 general definition.....	17
2.1.2 port supply chain theory.....	18
2.1.3 the sketch of port service supply chain.....	20
2.2 the related theories of supply chain risk.....	22
2.2.1 the general definition and characteristics of supply chain risk.....	22
2.2.2 the port supply chain risk based on the domestic environment.....	23
2.2.3 characteristics and occurrence of port supply chain disruption risk.....	25
CHAPTER 3 the construction of risk early-warning operation model for port	
supply chain disruption.....	28
3.1 factor analysis of supply chain disruption risk.....	28
3.1.1 general supply chain disruption risk factors classification.....	28
3.1.2 port supply chain disruption risk factors classification.....	32

3.2 model introduction.....	40
3.2.1 model construction.....	42
3.2.2 questionnaire survey of Qingdao port.....	54
CHAPTER 4 case study of risk early-warning operation model for port supply chain disruption.....	55
4.1 analysis of container supply chain in Qingdao port.....	55
4.2 framework model of risk assessment of supply chain disruption.....	57
4.3 using AHP method to determine the weight.....	60
4.3.1 AHP model.....	60
4.3.2 empirical analysis.....	65
4.3.2.1 the establishment of hierarchical structure.....	65
4.3.2.2 structure and assignment judgment matrix.....	65
4.4 calculation of risk early warning indicators in various areas.....	71
4.4.1 likelihood evaluation of risk probability in manufacturing area.....	72
4.4.2 likelihood evaluation of risk consequences in manufacturing area.....	73
4.4.3 index calculation of risk factors in manufacturing area.....	74
4.4.4 analysis and alarm of early warning indexes.....	74
4.5 risk early warning strategies of Qingdao port supply chain disruption.....	75
4.5.1 risk retention--planning area, supply area, distribution area.....	75
4.5.2 risk avoidance - manufacturing area.....	77
4.5.3 risk transfer --- manufacturing area, returned purchase area.....	79
CHAPTER 5 conclusion.....	80
5.1 summary.....	80
5.2 suggestion and deficiency.....	81
REFERENCES.....	82
APPENDIX.....	86
Appendix 1 : evaluation of index in port supply chain disruption risk factors....	86

LIST OF TABLES

Table 1.1 abroad research status
Table 1.2 domestic research status
Table2.1 a comparative analysis of traditional manufacturing industry and port supply

chain

Table2.2the characteristics of supply chian node anf interrupt event

Table3.1 supply chain disruption risks

Table 3.2 the amend supply chain disruption risk factors

Table3.3 Qingdao port's supply chain risk management model

Table4.1 China's main port container throughput in 2014

Table4.2 classification of index level of supply chain disruption risk

Table4.3 the level of possibility assessment

Table 4.4 the level of impact assessment

Table4.5The scale method

table4.6 Mean random consistency index RI

Table4.7 the level of total ranking

Table4.8 the Judgment matrix of different areas

Table4.9 matrix table of planning area

Table4.10 matrix table of supply area

Table4.11 matrix table of manufacturing area

Table4.12 matrix table of distribution area

Table4.13 matrix table of returned purchase area

Table4.14 weight of all factors

Table4.15Index and numerical table of risk early-warning

LIST OF FIGURES

Figure 1.1 figure of technical route

Figure2.1 general definion of supply chain management

Figure 2.2 the structure model of port supply chain

Figure3.1 management framework of supply chain disruption risk

Figure 3.2 control modules of supply chain disruption risk

Figure4.1 container throughout of major ports in China in 2014

Chapter 1 INTRODUCTION

1.1 background and significance

With the development of shipping industry, port industry has been developing rapidly. Port terminals, parks, yards and other facilities have increased year by year, besides, dock throughput capacity and handling efficiency have also been improved. However, in addition to the construction of the port, in such a fierce competition in the global market, more and more enterprises recognize that, they must carry out the supply chain management and make full use of various resources. Then they strengthen the competitiveness for enterprises themselves and the overall, and make a quick response to market changes to meet customers' demand better. In twenty-first Century, the market competition is no longer the competition among individual enterprises, but the competition among the supply chains, so a good supply chain management is very important for an excellent enterprise. Because of the unique nature of the supply chain and the close contact for enterprises in supply chain, the risk for the damage degree of the whole supply chain is much more serious than the single enterprise.^[7] Supply chain risk has become the key of great difficulty in supply chain management, supply chain risk has seriously restricted the operation and development of the supply chain.^[16]

Supply chain risk management is a new and important research field, because it has a great impact and harm on the global market environment. Such as: In 1993, "the Japanese semiconductor raw material suppliers explosion" led to supply interruption, it caused huge losses to the downstream of many semiconductor manufacturers; In 2000, "American chip factory fire events" caused serious impact to Ericsson's supply chain; 2002 "strike movement event occurred America West Coast" is a typical symbol for supply interruption. The west coast of the United States is the main portal

for COSCO Group to enter the United States, but the port was closed for two weeks due to the strikes event and then the container ships from COSCO Group arrived in the United States can not be unloaded and return, which led the COSCO Group lose at least 24000000 dollars in two weeks, at the same time, the customers from COSCO Group also had suffered losses heavily. The series of the supply chain risk events led the supply chain managers not only focus on maximization of enterprise profit, but also pay more attention to the various possible risks in supply chain.^[22] For the research object, I mainly take into account that, first of all, superior geographical position and port condition of Qingdao port made the government introduce many policies beneficial to the port development; secondly, container transportation is one of the main business in Qingdao port, and the demand quantity for Qingdao port container transportation is very big, so the introduction of relevant policies provides a lot of opportunities to the combined transport of container in Qingdao port, and the management is also in the forefront of the domestic ports; finally, there are some typical lack of container transport, including the backward management system for container transportation, the slow development for container transshipment business, a large number of ocean containers transshipping in the overseas, the lack of liberal policy environment, the immature port comprehensive supporting functions, the unperfect transport laws and regulations and so on.^[27] All these problems affect the benefits for the enterprises in the upstream and downstream of the supply chain and also affects the healthy and sustainable development of the whole supply chain.

In the background of supply chain management, it is very important to manage the supply chain risk. To establish a relatively complete supply chain risk management is significant for the health, stability, sustainable development in a supply chain. It can be followed by these aspects:

- (1) The study of supply chain risk can provide the basis for the planning and formulation in a supply chain. It also can improve the relationship about

cooperation and competition among the enterprise and its upstream or downstream enterprises. Use this way to maximize the supply chain operational efficiency and reduce the cost of supply chain.

- (2) Through the study of supply chain risk, we can help the members together in a supply chain to cope with the risk from the uncertainty of internal and external environment better. We can improve the ability to resist the risk of port supply chain and then establish a stable, sustainable and win-win supply chain development scheme. We can make a rapid response to the market and in order to make a further improvement of the global comprehensive competitiveness in ports.
- (3) The research of supply chain risks can build a safe supply chain for the enterprises and prevent the supply chain crisis. Besides, it also can provide a new method for the identification, assessment and control in a supply chain risk.
- (4) The further research on supply chain risk management can make up for lack of the theory of supply chain management, so as to further perfect the enterprise risk management system. Traditional port enterprise management theory can not meet the requirements of the developments of modern ports. The domestic ports also need a new kind of management strategy.

1.2 research status

Although there are a lot of research literatures in domestic and foreign countries at present, but generally speaking, there are more research on these fields for supply chain, such as construction industry, retail industry and traditional manufacturing industry, while it is immature for the port supply chain. However, with the integration of world economy and the upgrading for port function, scholars inside

and outside china pay more and more attention on the global status and influence for port supply chain.

1.2.1 abroad research status

table 1.1 abroad research status

Researcher	Research Area	Research Contents
Raul. Lopez (1998)	port logistics supply chain	He considered that the port logistics supply chain can provide a safety and door-to-door service for the suppliers or customers, and he also pointed out that it must be a positive impact for the suppliers,customers and port hinterland economy when the port provided efficient service in the supply chain.
Dananld.Bowersox and David.Closs ^[1]	port logistics supply chain	They made the concept of Integrated supply chain management be extended from a single node to all the nodes in a supply chain. If each node is a company,then in this whole chain, every company need to increase the efficiency of the whole chain through effective allocation of resources. The companies use this way to reduce their cost and risk and to enhance the competitiveness.
H.MEERSMAN, F.MOGLIA (2000) ^[29]	Port logistics supply chain	They put forward the port and shipping industry in the market trend—the role orientation should be faced when to strengthen the control of the whole logistics transport chain. They also pointed out that the port enterprises need to deal with longitudinal and

		transverse cooperation agreement based on the integration of the entire logistics chain, and locate their own roles reasonably in logistics chain.
Kuby and Reid ^[2]	Port logistics supply chain	They mainly studied the effects of technical change on port logistics system. Because of containerization, large scale ship for cargo transport, port logistics system in American gradually developed to the centralized mode.
Brain Hoyle and Jacques Charlier ^[3]	Port logistics supply chain	They took the case of East African countries as an example, they analysed the cooperation-competition of port system in developing countries. They believe that the rapid growth of port system in developing countries reflects internationalization of the internal port competition and globalization of the port cooperation.
Roger Bennett, Helen Gabriel (2001) ^[30]	research model	They established a relationship structural modal between a port and its customer (such as a shipping company). And they use SPSS statistical tool to test the IMPG model. Research shows that factors of trust have a decisive effect on the close type, contribution degree and investment tendency between these two parties. The port's reputation and experience can affect the trust degree in the shipping company, so when the port enterprises want to establish a long-term cooperation with their customers, they should consider the reputation and experience factors priority to ensure a higher cooperation trust degree.

<p>Peter B. Marlow, Ana C. Paixao Casaca (2003)^[32]</p>	<p>research model</p>	<p>They put forward the concept of the total quality management system of port enterprise and redesign its performance index based on the external environment of logistics chain of port enterprises. Except for the last few quantitative indexes (throughput, quay berth etc.) they introduced the standardized service index for various aspects of logistics chain to strengthen the integration of the various elements of the whole supply chain better.</p>
<p>Dong et al^[13]</p>	<p>research model</p>	<p>They proposed a method for modeling the dynamic behavior of a supply chain of the port, and evaluated the strategic and operational for the relevant port supply chain introduced. Through this evaluation, we can determine the most effective strategy and operation strategy in terms of easing the supply chain uncertainty.</p>
<p>Cohen M.A et al</p>	<p>research model</p>	<p>They established the network model of supply chain by using the quantification method. They evaluated the performance of supply chain on the basis of relevant development strategy proposed.</p>
<p>Wouter Jacobs, Peter V. Hall (2007)^[33]</p>	<p>deep research of port supply chain</p>	<p>They pointed out that the competitiveness in the modern port enterprises more and more depend on the strategic partnership in the port supply chain. The studies show that port geographical location, system arrangement and management structure has become the important conditions of port enterprises in the discourse power and</p>

		leadership of the supply chain.
Khalid Bichou ^[14]	deep research of port supply chain	He proposed and analyzed the main risk factors and security threats of ports, after the review of risk management of shipping industry and the control methods of economics cost, he pointed out the insufficiencies of these methods from the angle of port logistics and supply chain security. Through the "channel design and layout"; "risk assessment and management"; "cost control and performance", can he integrate and optimize the port supply chain.
Christopher.M	deep research of port supply chain	the port is a complex and dynamic entitie. There were a large differences among the ports, so the port activities often performed by different participants. At the same time he mentioned the vertical integration and horizontal integration strategy.
BrandenburgerA M. and NalebuffB.J ^[4]	informationization construction of the port supply chain	They pointed out from their book in <the Co opetiton>: the collaborative information of supply chain abroad mainly concentrated in the collaborative information theory, information technology and its practice.
Angulo et al ^[10]	informationization construction of the port supply chain	They studied the value of information sharing under the environment of VIMI. And they pointed out that in the case of stochastic demand, retailers and suppliers share information can improve the order fulfillment rate of retailers significantly.
Williamson et al ^[12]	informationization construction of the port supply	They hold the views that using the information system combined with Internet is an

	chain	effective means to realize the integration of supply chain. Internet technology, including now the popular SOA framework, XML technology and so on, can make it feasible for the enterprises to realize the dynamic information integration.
Romano ^[17]	the development status of each node enterprise in a supply chain	A port is at the core position in the port supply chain, the development of a port has a decisive impact on the supply chain. Research on the development environment of port supply chain mainly use the PEST analysis, including the political, economic, cultural and technological environment in the port supply chain, and focuses on its external competition environment.
Peggy.D.Lee ^[18]	the development status of each node enterprise in a supply chain	He used three examples to illustrate that a port supply chain is actually a social network. This paper lays a foundation for the future use of social network theory to study the port supply chain and supply chain integration.

1.2.2 domestic research status

The domestic research on port supply chain started later than foreign research, concentrated in concept and structural research, development strategy research and risk management research etc.

table 1.2 domestic research status

researcher	Research Area	Research Contents
------------	---------------	-------------------

<p>Jiuhe Wang(2005)^[34]</p>	<p>concept and structural research field</p>	<p>He combined with the theory of supply chain management in a book "the structure analysis and optimization in the supply chain of the port enterprises", analyzed the structure model of supply chain, and gave the definition of port supply chain.</p>
<p>Lingfeng Xie, Changxin Xu (2006)^[35]</p>	<p>concept and structural research field</p>	<p>They made a study for the development mode of the ports along the Yangtse River in Jiangsu Province from the horizontal level of the supply chain. They put forward the basic structure model of the double leaf type supply chain. And they designed the Jiangsu Port Group supply chain from the structure design, port supply chain partner selection, organizational design and implementation plan.</p>
<p>Huanbiao Chen</p>	<p>concept and structural research field</p>	<p>He did the research on the characteristics and functions of port supply chain in the "port supply chain and its construction".</p>
<p>Fengshan Sun (2004)^[36]</p>	<p>development strategy</p>	<p>He did a research on how to select the strategic partners in supply chain for the port enterprises. He put forward that the port enterprises can establish a strategic partnership with the upstream and downstream enterprises, railway, shipping companies, business outsourcing and brother ports to shorten the total supply chain cycle of port strategic partners, reduce the cost of the management of each link, improve asset utilization and customer satisfaction, and highlight the</p>

		competitiveness of the port.
Gang Zhao (2007) ^[37]	development strategy	He did a research on the development strategy of supply chain in Rizhao port. The study shows Rizhao port based on the mode of supply chain management of strategic alliance. And also shows the three major supply chain development strategy for coal, iron ore and crude oil.
Jingping Ren, Yuqin Sun ^[21]	development strategy	They did an effective performance evaluation of port supply chain.
Huang Peiqing et al ^[28]	development strategy	They discussed the reorganization of supply chain, and put forward the direction of further study.
Xiaowei Pan	development strategy	He proposed the development strategy of port from the internal and external port respectively in the book "construction of the port supply chain management system", and analysed how to make a effective cohesion among the upstream and downstream members.
Lirong Shi (2007) ^[19]	field of risk management	She did a research on the strategic management of port enterprise supply chain in the book "Initial construction of port supply chain and the study of management", and she pointed out that the goal is to reduce and cut down the uncertainties and risks in the supply chain, and pointed out that the port supply chain goal is to reduce and reduce the supply chain uncertainty and risk, strengthen the collaboration among the

		supply chains.
Li Xiaoying et al.(2003) ^[24]	field of risk management	They did a research on the emergency management mechanism of port logistics supply chain. Through the establishment of port logistics supply chain model to quantify the impact of risk caused by unexpected events on the supply chain, and they put forward a series of improvement measures, such as: establishment of emergency management mechanism of port logistics supply chain, information communication with manufacturers and suppliers.
Cuihua Zhang et al.	information construction of port supply chain	They gave a brief analysis of the differences between the collaborative management of supply chain and the traditional management of supply chain. The analysis be focus on the strategic synergy, strategy coordination, collaborative technology and development trend of collaborative management in supply chain.
Qing Zhang and Zhixue Liu	information construction of port supply chain	They analyzed the relationship between information collaboration and information sharing, and came to conclusion that the information collaboration not only includes information sharing, but also the value of sharing information.
Jing Liang, Shuqin Cai et al	information construction of port supply chain	They used the third party logistics supply chain as the background, contrast the role of information sharing in supply chain in two cases (without the introduction of

		third party logistics and the introduction of third party logistics). And they designed 4 information sharing areas in supply chain based on the third party logistics.
Guangqin Sun, Dequan Min	cooperation mode of Each node of port	They did the in-depth analysis of the value and mode of cooperation on port and shipping.
Yaming Zhuang et al. ^[23]	cooperation mode of Each node of port	They sum up the mechanism of supply chain coordination, then analysed influence factors of supply chain collaboration from two aspects.

1.2.3 A literature review of supply chain risk management at home and abroad

Compared with other risk management, the research on risk management of supply chain is limited relatively. The main reason mainly because the supply chain area is a new field in recent 20 years, people have a limited ideas about the supply chain and people need a gradual process for the risk management of the supply chain. But due to some of the frequent occurrence of risk management of supply chain mentioned above in recent years, the interruption of supply chain happend, and that is a great disaster. The scholars have started to pay attention to the exploration and research on supply chain risk management.

Foreign scholars mainly focus on the two parts of risk identification and risk management, their management methods are tend to option and contract theory. For example: Leindorfer (2004) considers the mismatch risk of supply and demand in the supply chain can be managed by introducing option and theory of contract. Grey.W from Massachusetts Institute of Technology (2003) also introduced the idea of option to manage the disruption risk in supply chain in the "Supply Chain Response to research Global Terrorism". Andreas Norrman and Ulf Jansson (2003) did a research

on Ericsson's "Albuquerque", it gives us the method of mechanism of risk warning mainly based on the framework of risk management of supply chain.

While the scholars at home focus on the research on the two angles of the theory of mechanism and system model. Liu Yongsheng (2004,2006) did a research on the construction of the mechanism of risk warning of supply chain and the early warning index system respectively. He considers the construction of the mechanism of risk warning of supply chain is an important part of supply chain risk management, and is also an important means to prevent the risk of supply chain. Hu Yutao from Wuhan University of Technology (2004) did a research on the system of supply chain risk management, which has certain practicability and maneuverability. Chu Yangjie (2006) did a research on the risk warning of supply chain and prevention mechanism by using data mining method, and also put forward the research conclusion for risk prevention by the method of information sharing and excitation mechanism. By carding and summarizing the existing literature, and the paper combine the supply chain risk management of the actual port industry, the following aspects are described in this paper:

1. There are lack of study on the supply chain model of core ports in previous literature. Due the port enterprise is the core node of the carriage of goods, each core port should have different characteristics from other ports according its own feature. So the main purpose of this paper is to sum up for risk early warning strategies of the port supply chain disruption through the analysis on characteristics of Qingdao port.

2. The previous literature rarely take supply chain risk management in port supply chain application, but the research of supply chain risk management mainly in the traditional manufacturing industry supply chain. There is still a lack of sufficient attention to the service nature of the port supply chain. Therefore, this paper mainly discusses the risk early warning of port supply chain disruption.

3. Due to the insufficient research of port supply chain risk early warning based on previous studies, so this paper will manage the supply chain interruption risk through establishing a system model. And also give some specific risk early warning strategies combined with the case of Qingdao port container supply chain.

1.3 research contents and technical route

1.3.1 research content

The main contents of this paper can be concluded as followed:

First, this paper introduces the theory of supply chain management, supply chain risk theory, supply chain disruption risk factors, and then combines them to the port, then the paper introduces the theory of port supply chain management, the theory of supply chain risk, the disruption risk factors of port supply chain, and then I developed 41 risk factors indexes according to the 8 supply chain risk factors. And then I combined the actual situation of the port and the field research, communicated with the relevant person to exclude the unimportant factors, and finally got the related 28 indexes with the port supply chain disruption factors.

Second, this paper mainly introduces the management framework of the port supply chain disruption risk, and use the actual situation in Qingdao port container supply chain, then collect data, and finally get the various index grade of container supply chain disruption risk in Qingdao port according to the framework model of risk assessment in port supply chain interruption, AHP calculation and the risk probability and the risk consequences of likelihood evaluation. Then, the port can start the risk early warning strategies according to the higher grade of supply chain disruption risk index in Qingdao port.

Third, Some suggestions are put forward to this paper, and this paper will sum up what kind of situation need to adopt the strategies of port supply chain risk early warning. And also we can get what conclusions and shortcomings in this paper.

1.3.2 research methods

1. the method of literature review. Through the literature learning and thorough understanding of Chinese and foreign scholars, can I clear my investigation of the purpose and the method. To screen out the papers related to my own paper according to reading these literatures, and as references in this thesis to be the theoretical basis of this thesis.

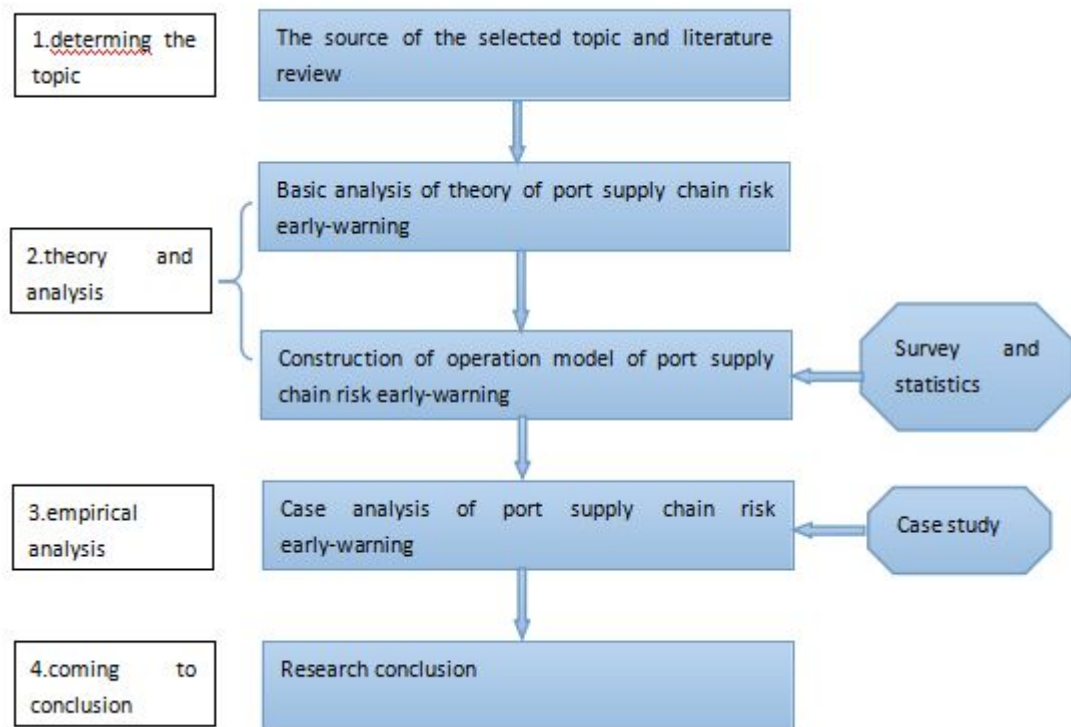
2. research method. Through the deep understanding of the related port enterprises and their upstream and downstream enterprises, the paper make a sample survey of the port enterprise and its upstream and downstream suppliers and its stakeholders. In order to provide a factual basis for the calculation of the data.

3. statistical method. This paper is focused on the construction of risk early warning index system of supply chain. This paper is based on the evaluation framework model of two factor model of supply chain risk interruption, and obtain the risk probabilities and risk consequences through prior data. And then the paper can get the supply chain disruption risk early warning index level.

4 case study method. This paper selects Qingdao port as the core subject, and conducts a case study on the container supply chain. Integrated with its upstream and downstream enterprises by its own resource advantages, and then form the development mode of the whole supply chain.

1.3.3 technical route

figure 1.1 figure of technical route



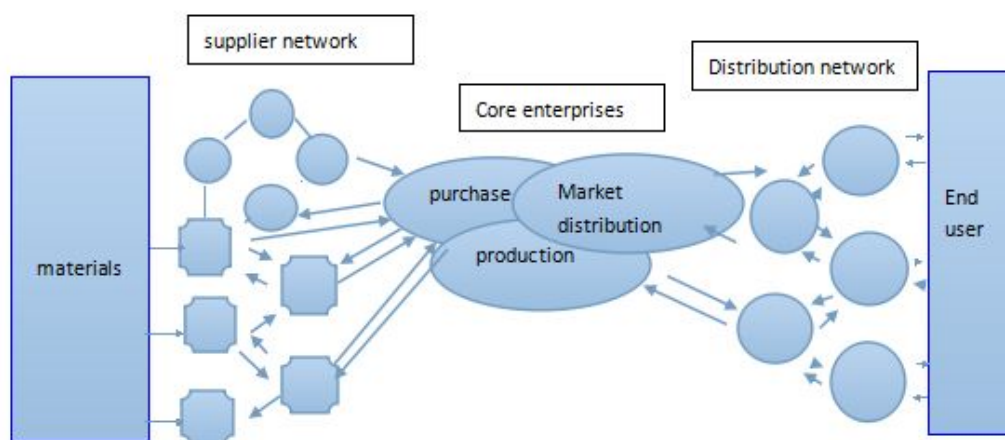
Chapter 2 related theories of supply chain risk management

2.1 the theory of supply chain management

Supply chain is an integration control of information flow, logistics and cash flow around the core enterprises. It is a functional net structure model of integration chain from the raw material purchase to the intermediate produce then to the final product and at last pass the product to the consumers. It is a process from the suppliers to the manufacturers and to the distributors and to the end users at last. So the theory of supply chain management is important for the whole supply chain structure.

2.1.1 general definition

figure2.1 general definition of supply chain management



We can see from the supply chain structure model, the supply chain is a functional network structure model or network structure model, with the core business activities as the center, through the control of information flow, product flow, service flow, capital flow and knowledge flow, starting from raw materials procurement, then made of intermediate products and the final product, and finally send the products to consumers by the distribution network. The process involves the suppliers, manufacturers, distributors, retailers and end-users.

Supply chain management is based on synchronized, integrated production as planning guidance, be based on various kinds of technique as support, and it is implemented by the contents of supply, production operation, logistics, and to meet the demand of the end-users. And the supply chain management is an integrated management process of planning, organization, coordination and control of the information flow, capital flow and value-added flow. The goal of supply chain management is to reduce the users' total transaction costs and improve the user' service level, and then strike a balance between these two goals.

2.1.2 the theory of port supply chain

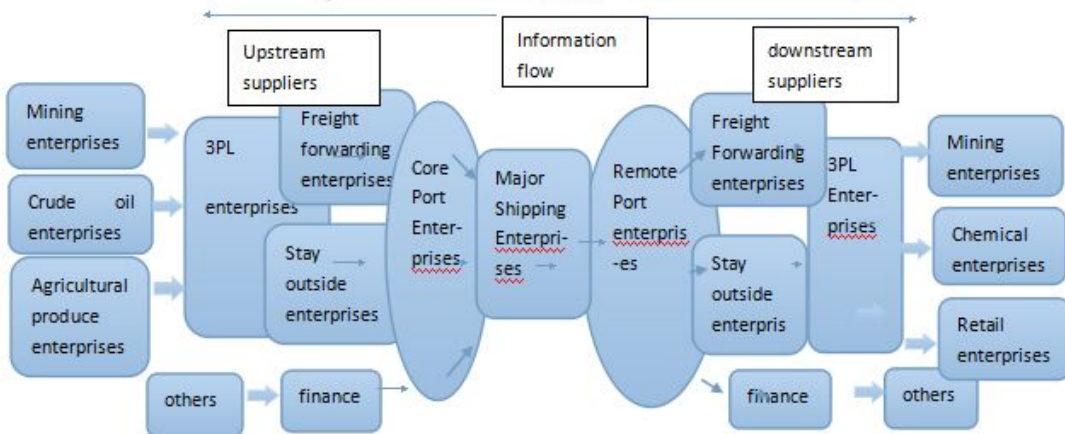
At present, there have been a lot of research on general supply chain problems in domestic and abroad, but in different industries, the research on supply chain system is different. It is very weak for the research on the port supply chain.

Based on the previous research results, this paper gives a study on the difference between the port supply chain and the traditional manufacturing supply chain, then gives a structure model of port supply chain, and then put forward the concept of port supply chain.

table2.1 a comparative analysis of traditional manufacturing industry and port supply chain

Types of projects/supply chain	Traditional manufacturing supply chain	Port supply chain
Business objective of supply chain members	The same objective (low level conflict)	Different objectives
Added value of supply chain operated	--suppliers:inventory	--shipper:dock residence time
Supply chain operation target	--distributor:inventory	--shipping companies:return time
The main body of supply chain operation	--manufacturer:inventory	--port enterprises:resource management
	Manufacturing and assembly	logistics (loading,unloading,processing,etc.)
	Lower inventory cost	Lower port operation time
	manufacturer	Port enterprises
Supply chain members	Suppliers,manufacturers, suppliers,distributors,etc.	Suppliers,shipping companies,port enterprises,logistics and distribution business,customers,etc.

Figure 2.2 the structure model of port supply chain



In summary, this paper gives a definition of port supply chain: port supply chain is to make the port enterprise as the core main body, for the related core goods in the port. Through various forms of cooperation and cooperation with its members, (upstream suppliers, downstream customers, in the tour of the shipping companies, the logistics service providers, highway railway, waterway transportation and other departments),

to the whole supply chain efficiency optimization as the goal, to provide high value-added logistics and commercial service to the members of the supply chain, and accompanied by the logistics, capital flow and information flow flow of service supply chain model.

2.1.3 the sketch of port service supply chain

1.general definition

Port enterprises as the core in the supply chain, they integrate all kinds of logistics service providers (including warehousing, transportation, loading and unloading, processing, distribution,etc.) and customers (owners and shipping companies, etc.) to form a functional chain structure. It can provide the "one-stop" logistics service, and realize the minimization of the cost of supply chain at the same time.

2.characteristics of port service supply chain

Value added method of supply chain. The traditional product supply chain mainly creat the value through the process of production,processing and assembling. But service supply chain does not produce the actual commodity, it obtain value-added through the service. The profits of the port are mainly gained by providing logistics services.

Different members of the supply chain have different goals. In the port service supply chain, the target conflicts are relatively large among shipping companies, the owner of cargos and the port enterprises. The port needs to improve the degree of satisfaction in the whole supply chain as far as possible.

The collaborative core of supply chain. Port service supply chain is a kind of service supply chain which is based on the ability of cooperation. The port service supply chain is a process of the logistics service product from the initial customers to the

final customers. It is a process of multi service. The key to its operation is based on the coordination of capacity.

3. the members of port service supply chain

Port enterprises. Port as the starting point and the ending point of the ocean, it is the distribution center of large quantities of goods, its function has gradually from the original land and sea transport interim to the international service trade and economic development centre. ^[6]Ports are at the core position in the whole supply chain, which can provide the basic facilities and environment for the operation of the port service supply chain, and they can also have the ability of integrating other members of the supply chain.

Different kinds of logistics service providers. Port service supply chain includes a variety of logistics service providers, such as warehousing companies, transportation companies, packaging companies, loading and unloading companies, etc.. These enterprises are not only dependent on the port, but also independent, they have their own business objectives. Port service supply chain integrates all these different kinds of services to provide a service for the owners of cargo.

The owners of cargo and the shipping companies. The owner of cargo is the starting point and end point of the port service supply chain. The entire service supply chain service for the owner of cargo. The goal of supply chain is to transport the right number of goods of the owners to the right place in the right time. The process may be accompanied by the links of loading and unloading, transporting and distribution, etc.

The shipping company is a customer for the port, while it is a service provider for the owner of cargo. Shipping companies and port services are all services for the owner of cargo. In the supply chain, the ship company is the enterprise in the downstream of the port, while the upstream of the terminal enterprise.

2.2 the related theories of supply chain risk

After the supply chain theory we understand, the supply risk in supply chain is a serious problem we should pay attention to. Because there are many risks in a supply chain, the solution to deal with the risks is very important for the core part in a supply chain.

2.2.1 The general definition and characteristics of supply chain risk

Supply chain risk is a potential threat, it will use the supply chain system vulnerability to cause damage in supply chain. Supply chain risk can cause the supply chain deviate from the intended target.

Supply chain risk characteristics can be followed as these four points:

(a) objectivity

Supply chain risk is objective and universal existence, not with people's will for the transfer, people can control it, but can not eliminate it.

(b) dynamic

Supply chain risk is a constant change, the stable supply channel and distribution network, a strong strategic partnership is relative.

(c) interactive game and cooperation

The internal risk of supply chain mainly comes from the relationship among all the links in the supply chain system, which is caused by the potential interaction and cooperation among all links. All members in the supply chain as the independent market main body have their different interest orientation. In order to compete for system resources and pursuit of maximizing their own interests to go a fierce game;

at the same time, there is a certain degree of cooperation based on the part of information disclosure and information sharing.

(d) transmission

Because the supply chain has a plurality of nodes involved from product development, production and circulation process. The information among the node enterprises is relatively isolated and the risk factors can transfer and accumulate among all enterprises through supply chain and influence significantly the whole risk level in supply chain.

(e) complexity

Supply chain system involves a number of levels, multi node enterprises, including the production, transportation, warehousing, and many other specific business processes, so that the risk is bound to be complex and diverse.

Because of the uniqueness of the supply chain, the enterprises is closely related to each other in supply chain, the degree of damage of the whole supply chain is far more serious than that of a single enterprise. Supply chain risk has become a different key link in supply chain management, the supply chain risk has seriously restricted the operation and development of supply chain.

2.2.2 The port supply chain risk based on the domestic environment

In the global economic integration of the background and trend requirements, China's port enterprises join the global supply chain system actively.^[11] However, there are imperfections in some links in the supply chain in supply, transportation, warehousing, distribution processing and information management. It seems to be not many ways to deal with risk events in response to the frequent changes in the external market environment, policy environment and natural environment. It can cause a great loss to the enterprise and its upstream and downstream enterprises. The port supply chain risk is faced with the domestic environment:

(1) the concept of supply chain system has not yet been fully highlighted

The whole supply chain performance depends on each node enterprise performance in the supply chain, but each node enterprise has different goals in the supply chain, even conflicting, it will inevitably lead to decrease of port supply chain performance. As the third point mentioned in the supply chain risk characteristics previous, this is mainly due to the lack of the system concept. And this loss will make the development of the port supply chain facing a major risk, it is not conducive for long-term stable development.

(2) there is a lack of effective coordination mechanism between the upstream and downstream

There are lack of good communication and coordination platform for port enterprise and its upstream and downstream enterprises. The stable alliance relationship has not been established, and the uncertainty risk in supply chain often lack the necessary prevention mechanism and emergency measures. The information required by quality service cannot be transferred continuously and smoothly in the supply chain, so that the supply chain can not be real-time response to customer s' demand.

(3) the imperfection for degree of information transmission network among port enterprise and its upstream and downstream enterprises

In port supply chain, demand forecast, inventory, production planning are such important data among all node enterprises. These data are distributed in every node enterprises in the supply chain. To achieve rapid response to customer demand, all these enterprises must strengthen construction of the transmission of information system. However, in the existing port supply chain, when the port enterprises need to know the needs of downstream customers, the information often be delayed and inaccurate, enterprises and users did not do full sharing for the internal and external environment information. the port enterprises and customers did not make full use of EDI, Internet and other advanced technology, the level of information processing

was layer difference, so there is missing a reasonable response scheme when facing uncertain risks.

(4) the consciousness of the risk management of port enterprise supply chain is not strong

The supply chain is a combination of several independent interest body. The port enterprise as the core enterprise of supply chain but it did not put the risk management in an important position. Lack of the main body of supply chain risk management resulted in ineffective coordination in the whole supply chain risk management.

Supply chain disruption is often expressed as the suspension or failure of the supply chain logistics, production, information flow and capital flow, or the change of supply chain system structure. In this paper, it will explore the factors causing disruption of supply chain from the point of the suspension or failure of the supply chain logistics, production, information flow and capital flow.

2.2.3 Characteristics and occurrence of port supply chain disruption risk

According to definition of port supply chain disruptions by the current scholars, which is defined as: port supply chain disruption is an event with lower probability of occurrence and larger negative impact on the performance. Including the internal events in port supply chain system (for example: port node occurs accidents, bankruptcy, strikes, supply chain network fracture), and the external events in port supply chain system (such as natural disasters, political unrest, fluctuations in the economic cycle, etc.). Port supply chain disruption will have a major impact on production planning, supply, manufacturing, shipping and returned purchase.

Port supply chain disruption risk is that can occur in the supply chain and can influence the normal flow of port materials. And it is one of the most important and the most cited concern of a class of risk. Port supply chain disruptions will lead to

many problems, such as the early extension, out of stock, higher cost, and can not meet the customer's needs. Sometimes once in port supply chain interrupt risk, even lead to disastrous consequences. Therefore, doing a good job of port supply chain disruption warning is an important task in supply chain risk management.

According to the definition of port supply chain disruption, there are two main sources of disruption, they are the internal and the external of the port supply chain system. There are many kinds of risk in port supply chain disruption, including terrorist attacks, war, pirates, natural disaster, fire, transport delay workers sabotage or shutdown, trade sanctions, embargo, epidemic, etc.

The internal interrupt event in the port supply chain system may come from two aspects: node port enterprise and the whole supply chain network. For example, from the perspective of the supply chain, interrupt events may occur in the upstream enterprises, downstream enterprises, customers, third party companies and target companies. The possible disruption event can be followed below:

Table 2.2 the characteristics of supply chain node and interrupt event

supply chain node	Interrupt event
upstream enterprises	supply shortage or interruption, suddenly fluctuations on production costs
downstream enterprises	The product is not delivered and the supply of the goods is not enough.

customers	unable to pick up and return goods on time;breaking a contract;demand mutation
port enterprises	Ability to fall (natural disasters, etc.); product quality issues

The external interrupt factor of the port supply chain system can be divided into the environment and the emergency of the port enterprise. Regardless of the environmental factors such as a natural disaster or sudden destruction incident, there are five main aspects in supply chain caused by interrupt events: planning, supply, manufacturing, transport, returned purchase.

In transport hub, port is the core node of the supply chain in the whole network, because the 90% of the global trade through water. Once the port strike leads to a devastating blow, customers can't find the products they want, they will turn to other places. Moreover, the cost of restoring containers and transportation is nearly millions of dollars. Therefore, it is necessary to do a good job of port supply chain disruption risk early warning. Prevention of supply chain disruption is not only related to a port enterprise, but also related to the upstream suppliers and downstream distributors and other stakeholders and government agencies.

Chapter 3 the construction of risk early-warning operation model for port supply chain disruption

3.1 factor analysis of supply chain disruption risk

The risk factors are very important for the analysis of the supply chain risk. Because we must realize what the risk factors are, then we can know how to response to these risks. Only after we know the specific risks can we solve the problems in a supply chain.

3.1.1 general supply chain disruption risk factors classification

There isn't an authority and united method for the identification of risk factors of supply chain, so the paper divided these factors by experience and reference to the previous scholars' results. We can divide the supply chain disruption risk factors from these three aspects: the external environment (natural environment, social environment), economic environment and internal environment. We can divide into these 8 factors: natural environment and political environment factor, organization and relation factor, strategic factor, cultural factor, process factor, demand factor, of purchasing and supply factor, finance and controlling factor.

According to the 8 key supply chain disruption risk factors, and the analysis of various industries, 41 risk factors can be extracted. Then I eliminated and corrected these 41 indexes, as shown in the following table:

table3.1 supply chain disruption risks

	natural environment and political environment factor	natural disasters, terrorism and war; government industrial policy restrictions; political instability and government intervention; strike
	organization and relationship factor	default behavior of self interested partners; partners distrust; unfair distribution of benefits among partners; unreasonable structure of supply chain
	strategic factor	inaccurate strategic plan; Strategic objectives are not consistent among supply chain members; failure on strategic investment (terminal construction, etc.)
internal environment	cultural factor	weak risk awareness in enterprises; Managers have little awareness of risk of multicultural conflict

	process factor	labor disputes and talented people loss; insufficient production capacity;The integration of business process is improper; failure on IT and software system;lower than the standard of product quality and low quality product service
economic environment	demand factor	big change of customers;Key customer churn; the insufficient management ability of customer relationship;the deterioration of financial conditions of customers or bankruptcy;sudden change in the demand of the customers; deviation risk of demand forecast
	purchasing and supply factor	Purchase price is too high (loading and unloading equipment, goods); fluctuation on exchange rate; single supplier risk; improper selection of supplier (equipment and raw

		<p>materials, shipping); Supplier fails to deliver (equipment, shipping providers, deficiency of terminal logistics capacity); Key supplier loss or bankruptcy; insufficient production capacity of suppliers; products damaged risk in period of transportation; the risk that product delivery may not be on time; information transfer risk</p>
	<p>financial and controlling factor</p>	<p>nonstrict inventory control (shortage of safety inventory, dock yard resource allocation); improper cost control; financial failure; failure on risk corresponding mechanism and emergency response plan; the risk of lower net assets income rate; the risk of lower asset turnover; inflation risk</p>

3.1.2 port supply chain disruption risk factors classification

For the 41 indicators listed previous, due to the particularity of port supply chain, not all risk indicators can be applied to the port industry, it is necessary to amend the original indicators and remove some indicators, and then retain a portion of the indicators. The study do a survey interview from some management personnel of the main business in port supply chain. The paper provides a questionnaire for the managers in port supply chain to let them score on the importance of port supply chain, and then delete the less important indexes. After that, some important factors are obtained as following according to some previous literatures:

(1) Cranfield (2002), Harland (2003) proposed the natural disasters and other resistance are the key factors on the failure of the supply chain through the research; political instability can also be an important risk factors in supply chain. Port enterprises must take into account the binding of policies in the operation of the supply chain; and the industry and trade policies of the country will have a great impact on the port enterprises, customers and shipping companies. While the possibility of strike is very small, the impact is not obvious. Therefore, the extraction of "natural disasters, terrorism and war", "the government's industrial policy restrictions", "political instability and government intervention" can be as the disruption risk indicators in environmental factor.

(2) the partnership must adhere to negotiation and communication, commitment, performance obligations and mutual trust. In that

way, the cooperation can be last for a long time. Partnership is one of the major disruption risks in supply chain. In the port supply chain, port enterprise and its downstream customers and upstream suppliers in the form of loose cooperation, just stay at the level of cooperation agreement and be lack of effective binding. This often lead to the uneven distribution of benefits, information sharing not timely, and even partners to seek personal gains generated default behavior, and that can bring the risk of the supply chain operation. Therefore, the extraction of "the default behavior of selfish partners", "untrust among partners", "distribution unfair of partners benefit" can be as the disruption risk indicators in the relationship factor.

(3) The inaccurate strategic plan can increase the costs and losses of the supply chain's direct stakeholders. For example, port enterprise as a core enterprise in a port supply chain, if it can't communicate well with its upstream and downstream enterprises and shipping companies, it can result that its port production plan cannot match with customers' demand production planning and the shipping company capacity scheduling plan. That can lead to an increase in the total cost of the supply chain, and may even lead to port supply chain disruption.

Port enterprises often have some differences on target with their upstream and downstream members, for example: Port enterprises hope ship berthing time can be shortened to increase efficiency, they want to make an convenience for allocation of the yard resources and strive for unit time throughput; While the shipping companies

want to berth as long as possible to guarantee the berth utilization ratio and reduce the cost.

Through the investigation, the paper learned that the container port now use the mode of diversified investment. That means the shipping companies and large customers do a co-investment and construction. So “the risk of failure on strategic investment” had been eliminated. failure risk index. So, the extraction of "inaccurate strategic plan" and "the differences on strategic target among supply chain members" can be as the disruption risk indicators in the strategic factor.

(4) Through on-the-spot investigation, the paper learned that each members in port supply chain have their own cultural values, so the management culture is also different in actual. It also can reduce the efficiency of supply chain operation and cause serious disruptions in the supply chain. So the extraction of “the weak awareness of enterprise risk”, “little awareness of risk of multicultural conflict among managers” can be as the disruption risk indicators in the cultural factor.

(5) The study of Cranfield (2002), Harland (2003) shows that labor disputes and talented people loss is one of the risk factor of supply chain; The research of Wang Ying (2000) shows that information transmission efficiency can affect the efficiency of the organization.

Some port companies and shipping companies in port supply chain can occur cargo damage due to mismanagement of their own storage and transit. So the risk of abnormal production often be emerged. Therefore, the extraction of "failure on IT and software system", "labor disputes and talented people loss", "lower than the standard of product quality and low quality product service" can be as the disruption risk indicators in the process factor.

(6) In pull mode of supply chain, if the customer demand increases sharply, supply will be inadequate; if there is a sharp reduction in demand, the product will be a surplus, additional inventory management fees and the product deterioration will be emerged, it will form an interrupt between the suppliers' downstream nodes.

Suppliers want a large and stable procurement by downstream enterprises, downstream enterprises hopes the upstream suppliers can ensure flexible supply to achieve flexible production and sales, so, accurate demand forecasting is necessary. Demand forecasting is an important indicator for enterprises to predict the ability and to make an agile response to market demand. Therefore, the extraction of "big change of customers", "deviation risk of demand forecast" can be as the disruption risk indicators in the demand factor.

(7) Through field surveys and interviews, I learned that, procurement cost in port supply chain mainly be reflected on the customers and the port enterprises. For customers, if the CIF contract be used, it is difficult for them to avoid fluctuations on purchase cost caused by fluctuatuons on sea freight; For port enterprises, quality

defects of loading and unloading equipment can also lead to an increase on the purchase cost;the fluctuation on exchange rate can also bring risk of fluctuations on the purchase cost of the port supply chain members,in more severe cases,it can lead to disruptions in the supply chain.

Products in information age tends to homogenization,if customer enterprises still take a single vendor model when they purchase products,it may cause the asymmetric price between the buyers and the sellers.Once there are some problems in the selected suppliers' operation,customer enterprises will not be able to obtain the required products.Supply chain interrupt.Besides,if the logistics distribution can not be on time in shipping companies,default phenomenon occurred in the upstream suppliers,these situations can all destroy the production plan of customers and port enterprises and then affect the port supply chain.In addition,if the port enterprise and the relevant government departments don't cooperate well and then lead to shortage allocation of logistics transport,and then many products will stock in port.These phenomenon can also affect the port throughput and have some bad effects on customers.

The key of transport is to transport the product to the customer in good condition.Preventive measures must be done good in the period of transportation.^[26]Besides,how can the products timely delivered to the hands of customers is an important indicator of measuring the transport capacity.In addition,information sharing is difficult to achieve when the information flow in the

supply chain passes from the end client to the original suppliers, so that the information is distorted, thus affecting the whole supply chain plan. In summary, the extraction of "purchase price is too high", "fluctuation on exchange rate", "single supplier risk", "improper selection of supplier," "Supplier fails to deliver", "products damaged risk in period", "the risk that product delivery may not be on time", "information transfer risk" can be as the disruption risk indicators in the purchasing and supply factor.

(8) Now a lot of enterprises pursue the "zero inventory", but the risk is not small if there is insufficient safety stock. The safety stock has a direct impact on the out of stock rate. The higher the out of stock rate, the smaller the customer service level, and the risk of insufficient safety stock is more bigger. Improper inventory will cause the unreasonable allocation of the yard resources, and it will have an impact on enterprises' inventory cost.

Net assets income rate reflects the ability of the enterprises in supply chain to get returns by investment, the higher the values, the higher ability for enterprises to get returns by net asset, the lower risk for financial; Turnover ratio reflects the utilization efficiency of the total assets management in the enterprises. The higher this value means the more asset income used in the coming year, and the lower financial risk. The direct result of inflation is the rise of prices, the higher the inflation rate, the greater the risk. Therefore, the extraction of "nonstrict inventory control" (shortage of safety inventory), "improper cost control", "the risk of lower net assets income

rate”, ”the risk of lower asset turnover”, ”inflation risk” can be as the disruption risk indicators in the financial and controlling factor.

Therefore, after the elimination of unnecessary factors ,the risk factors of port supply chain disruption:

table 3.2 the amend supply chain disruption risk factors

	natural environment and political environment factor	“natural disasters, terrorism and war“, “government industrial policy restrictions“, “political instability and government intervention“
	organization and relationship factor	“default behavior of self interested partners“, “distorted information of partners“, “partners distrust“, “un fair distribution of benefits among partners“
	strategic factor	“Inaccurate strategic plan“, “Strategic objectives are not consistent among supply chain members“
internal environment	cultural factor	“weak risk awareness in enterprises”, ”Managers have

		little awareness of risk of multicultural conflict”
	process factor	“failure on IT and software system”, “labor disputes and talented people loss”, “lower than the standard of product quality and low quality product service”
economics environment	demand factor	“big change of customers”, “deviation risk of demand forecas”
	purchasing and supply factor	“Purchase price is too high”, “fluctuation on exchange rate”, “single supplier risk”, “improper selection of supplier”, “Supplier fails to deliver”, “products damaged risk in period of transportation”, “the risk that product delivery may not be on time”, “information transfer risk
	financial and controlling factor	“nonstrict inventory control (shortage of safety

		inventory) ”,“improper cost control”,“the risk of lower net assets income rate”,“the risk of lower asset turnover”,“inflation risk”
--	--	---

3.2 model introduction

The framework of supply chain risk management generally developed from the traditional risk management model, and combined with the characteristics of the supply chain and then be reconstructed. It formed a supply chain risk management framework including risk strategy, risk identification, risk assessment, risk management and risk supervision. Because the existing supply chain risk management framework has insufficient analysis for the entire supply chain operation process, it is mainly some qualitative description, while it is lack of pertinence, systematic research for the risk. So, this paper will give a research on the framework of supply chain risk management based on the following model. This model will give a study on the supply chain risk strategy, risk identification, risk assessment, risk management and risk supervision these 5 aspects from the planning, purchasing, production, distribution, and return these 5 business process perspective.

Figure3.1 management framework of supply chain disruption risk

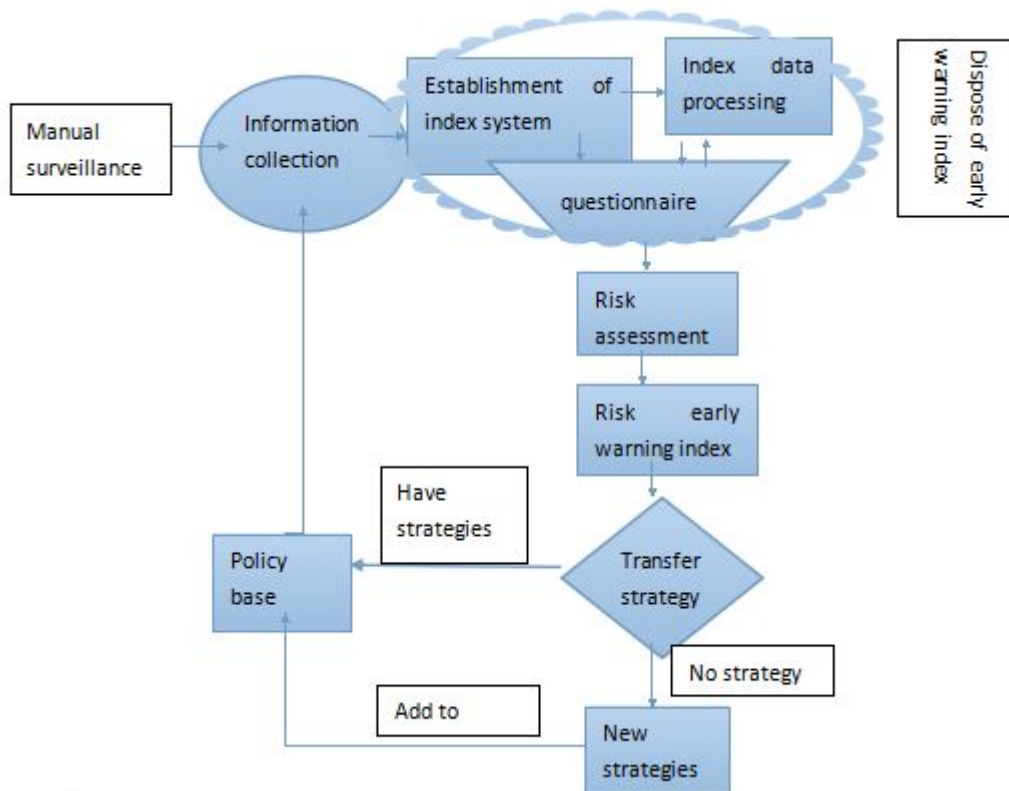


According to this model, we can build a control modules of supply chain disruption risk as shown in figure 3.2. It has been shown which kind of risks can lead to the supply chain disruption and also shown the related risk factors. As shown in figure, I put the risk factors in the fields for five major categories, namely: planning, supply, manufacturing, distribution and returned purchase areas. These five fields involve 20 risk factors mentioned above.

After identify the risk of supply chain disruption, then calculate the risk indicators according to the expert scoring and formulas. By this way to see what the risk indicators in which grade, high index or general index or low index. Then we can develop different strategies according to the different risk factors, the strategies such as risk avoidance strategies, risk retention strategies, risk transfer strategy. These strategies are mainly devised in accordance with risk strategy, risk identification, risk assessment, risk management and risk supervision these 5 aspects. After developing

these strategies, then we can decide when to start these supply chain risk early warning strategies based on the situations which risks may occur.

Figure 3.2 control modules of supply chain disruption risk



3.2.1 model construction

According to the framework of supply chain risk management in figure 3.2, we should amend the port supply chain disruption risk factors according to the actual situations about Qingdao port as shown in table 3.3. I cut some original risk factors and classify the Qingdao port's risk disruption factors from planning, purchasing,

production, distribution, returned purchase these five business process perspective. We can get the table as following:

table3.3 Qingdao port's supply chain risk management model

target field	risk field	risk factors
port supply chain risk	planningt area	Inaccurate strategic plan
		Strategic objectives are not consistent among supply chain members
		Managers have little awareness of risk of multicultural conflict
	supply area	Purchase price is too high (loading and unloading equipments,goods)
		fluctuation on exchange rate
		improper selection of supplier
		Supplier fails to deliver
		shortage of safety inventory
	manufacturing area	nonstrict inventory control
		improper cost control
		distorted information of partners
		partners distrust
	distribution area	natural disasters, terrorism and war
		political instability and government intervention

		failure on IT and software system
		labor disputes and talented people loss
		products damaged risk in period of transportation
		the risk that product delivery may not be on time
	returned purchase area	low quality product service
	lower than the standard of product quality	

In the target field, that is to minimum the risk of Qingdao port supply chain. This field includes five parts: planning area, supply area, manufacturing area, distribution area, and returned purchase area. These fields can be classified to the different risk factors.

These five areas including the different stages in a whole supply chain of the products. That means an object in the whole process of the supply chain, so we can summarize in these five areas based on the possible risks in a whole supply chain, namely five kinds of risk events. In the entire supply chain, any area can cause a serious risk disruption. A kind of risk event may have a number of potential factors, and we must identify the influence degree of each factor. Only through the control of these factors can we early warn the disruption risk.

1. Planning area, that means demand / supply plan. This module can provide a comprehensive information of port supply chain status through the information system, artificial surveillance survey (including the cooperation and operational status of all the members of upstream, middle and downstream). And it can also provide the

function of information storage,classification management,to provide the necessary basic data for early warning.Through the database of supply chain management information system or artificial monitoring and so on to collect and monitor all the risk information of a supply chain.And then a strategic management plan will be gived.

Planning area is the unified planning by core enterprise according to the demand forecast data in the supply chain to balance the demand and supply, the purpose is to give a better service for other processes.There are 3 risk factors in this area.

1) the inaccurate strategic plan

The inaccurate strategic plan can increase the costs and losses of the supply chain's direct stakeholders. For example,port enterprise as a core enterprise in a port supply chain,if it can't communicate well with its upstream and downstream enterprises and shipping companies,it can result that its port production plan cannot match with customers' demand production planning and the shipping company capacity scheduling plan.That can lead to an increase in the total cost of the supply chain, and may even lead to port supply chain disruption.

2) Strategic objectives are not consistent among supply chain members.

Port enterprises often have some differences on target with their upstream and downstream members,for exemple: Shipping companies offten want to make the shortest stay for the ship in port to reduce costs and increase profits.Port enterprises hope ship berthing time can be shortened to increase efficiency,they want to make an convenience for allocation of the yard resources and strive for unit time throughput;While the owner of the cargo want to berth as long as possible to guarantee the berth utilization ratio and reduce the cost.If the Qingdao port as the core in the supply chain,but it doesn't regulate all parts' need,it may lead the supply chain not smooth when it operate.It may lead to supply chain disruption when it is serous.

3) Managers have little awareness of risk of multicultural conflict.

Through on-the-spot investigation, the paper learned that each member in port supply chain has their own cultural values, so the management culture is also different in actual. It also can reduce the efficiency of supply chain operation and cause serious disruptions in the supply chain. Especially as goods transportation is now becoming more and more internationalized, the managers in different ports may come from different countries. And they have different ideas for management in the whole transportation, so they often have some split. And this can lead to the unfluent of the carriage of goods, and even cause disruptions in the supply chain if it is serious.

Therefore, it can give a huge impact to the members in the supply chain. Arland (2001) and Protiviti (2004) considered that in a variety of supply chain strategy environment, it can also decline the competitiveness of members in supply chain if the strategic target of the supply chain members is not the same. The adjustment of supply chain's procurement strategy, marketing strategy, logistics strategy and new product strategy is essential for the operation of the supply chain, it is the key to the success of supply chain management. Protiviti (2004) pointed out that the inaccuracy of sales, operation plan and strategic plan can lead to the increase in the cost and loss of the direct stakeholders in supply chain. Herbig (1997), Loosemore (1999) give a research that the multi-cultural conflicts in the supply chain have a significant impact on the operation of the supply chain. Therefore, the planning area involves 3 risk factors, they are: Inaccurate strategic plan, Strategic objectives are not consistent among supply chain members, Managers have little awareness of risk of multicultural conflict. If the container supply chain in Qingdao port doesn't do well in these three parts, it will hinder the development of the planning area of Qingdao port container, and increase the risk of port supply chain.

2. Supply areas, that means to find the suppliers/ material collection. This module contains the index set reflected the whole supply chain and each component

units. Port supply chain members can adjust inventory needs, supplier selection and price according to their own needs. By this way to affect the upstream suppliers and then affect the whole supply chain. This module can develop a reasonable supply plan by the expert data and the judge of risk assessment model.

Supply area, that means the process of obtain, receiving, testing, rejection and sending material. It includes: supplier evaluation, procurement management, procurement quality management and procurement of spare parts management. Procurement and supply risk has a great impact on supply chain, especially in quality, cost and availability. There are 5 factors in supply area.

1) Purchase price is too high

Through field surveys and interviews, it can be learned that, procurement cost in port supply chain mainly be reflected on the owners of cargo and the port enterprises. For consignee, if the CIF contract be used, it is difficult for them to avoid fluctuations on purchase cost caused by fluctuations on sea freight. Frequent fluctuations on procurement cost will make the owners of cargo difficult to avoid the risk and may lead to serious disruption; For port enterprises, defects of loading and unloading equipment quality will lead to an increase in the cost of purchasing, cost increase will lead to the lack of funds for port enterprises, and it may lead to disruptions in the supply chain if it is serious.

2) fluctuation on exchange rate

Fluctuations on the exchange rate will also bring the fluctuate risk of purchase for the port supply chain members. It may lead to the lack of cost and funding and even lead the supply chain disruption. Due to fluctuations on exchange rate, every members in the supply chain may not agree on freight, the price of goods, etc. It can let some owners of cargo not find the corresponding shipping companies or customers, and this can cause the transport may not be able to go on, which lead to supply chain disruptions.

3) improper selection of supplier

Products in information age tends to homogenization,if the owner of cargo enterprises still take a single vendor model when they purchase products,it may cause the asymmetric price between the buyers and the sellers. If the price of suppliers is too high,it will lead the owners of cargo unacceptable; in addition, if the goods provided by suppliers does not match the needs of the owners, they may refuse the products.Once there are some problems in the selected suppliers' operation,customer enterprises will not be able to obtain the required products.Supply chain interrupt.

4) Supplier fails to deliver

If the logistics distribution can not be on time in shipping companies,default phenomenon occurred in the upstream suppliers,these situations can all destroy the production plan of customers and port enterprises and then affect the port supply chain. Zsidisin (2003) indicates that whether the supplier can complete the delivery within the agreed delivery time,and the quantity, type and size of the same order, that can directly affect the ability of supply chain responding to customers.Delivery delay can make the supply chain operation crisis and may cause the consequence that the supply chain management can not reach the expected target.Therefore,the choice of Qingdao port suppliers and delivery situation is also very important.Delivery delay can make the supply chain operation crisis and may cause the consequence that the supply chain management can not reach the expected target.Therefore,the choice of Qingdao port container suppliers and delivery situation is also very important.That delay information supplied by the supplier, logistics delivery time is too long, key supplier failure or bankruptcy, will lead to failure of the supply chain.In addition,if the port enterprise and the relevant government departments don't cooperate well and then lead to shortage allocation of logistics transport,and then many products will stock in port.These phenomenon can also affect the port throughput and have some bad effects on customers.

5) shortage of safety inventory

Now a lot of enterprises pursue the "zero inventory", but the risk is not small if there is insufficient safety stock. The safety stock has a direct impact on the out of stock rate. The higher the out of stock rate, the smaller the customer service level, and the risk of insufficient safety stock is more bigger. Improper inventory will cause the unreasonable allocation of the yard resources, and it will have an impact on enterprises' inventory cost.

3. Manufacturing areas, that means receiving the material, product manufacturing and testing, packaging, etc.. This module mainly through the risk assessment model to achieve the assessment of overall operational status of the port supply chain and the experience of the various members of the management risk. If it is beyond the normal range of the risk early warning, that means the supply chain is in a state of alert. In this module, Supply chain risk early warning model should send a warning signal.

Manufacturing areas include: production status, product quality management, production scheduling, on-site equipment management, etc.. The direct stakeholders are upstream suppliers, downstream distributors and customers. Its main content is to manufacture all kinds of products according plan to the orders. Some studies show that in addition to the corresponding legal and security system, the failure on control system and risk response mechanism will affect significantly the supply chain operation management. Therefore, the improper of inventory control and cost control in Qingdao port container transportation will lead the supply chain management deviate the expected target. In daily operation of Qingdao port, there will an improper allocation of yard resource cause by improper inventory, and it can give a bad impact on inventory cost. So, we need coordinate and balance storage cost and inventory cost.

1) nonstrict inventory control

If the inventory of goods is shortage, it may not match the owners' needs, and then let the supply chain interrupt. While if the inventory of goods is too much, the capital

will be occupied too much. Because it needs a lot of expenses if the inventory goods maintained not loss and not aging. Too much funds to be taken up can also lead to supply chain disruption. In addition, too much inventory can cover up some problems in the management, if they are not be resolved in time, it will be able to lead to a disruption of supply chain.

2) improper cost control

The owners of cargo, shipping companies, port enterprises all may make an improper arrangement of funds, this can lead to improper cost control. If the inventory of goods is too much, it will occupy too much funds, which can lead the cost of goods to be reduced in other areas. This may cause some damage of goods and even lead to a risk disruption.

3) distorted information of partners

In the process of information flow from original suppliers to end client in supply chain, because information sharing is sometimes difficult to achieve, so the information becomes distorted, thus can affect the plans of the whole supply chain.

4) partners distrust

Dos and tend (1999, 2001), Ma Shihua (2003), Dupeng (2003), Ding Weidong etc. (2003) points out that partnership is one of the major risk factors in the supply chain. The technology level, management level, enterprise culture, professional ethics among the members of supply chain have much differences. These differences all affect overall competition ability and the profit ability in supply chain, and all determines the stability and security of the supply chain. The partnership must adhere to negotiation and communication, commitment, performance obligations and mutual trust. In that way, the cooperation can be last for a long time. Partnership is one of the major disruption risks in supply chain. In the port supply chain, port enterprise and its downstream customers and upstream suppliers in the form of loose cooperation, just stay at the level of cooperation agreement and be lack of effective binding. This often

lead to the uneven distribution of benefits, information sharing not timely, and even partners to seek personal gains generated default behavior, and that can bring the risk of the supply chain operation.

4. Delivery areas, including order management, product inventory management, product transportation and installation management, distribution support business. This module provides an intuitive, user-friendly warning signal output interface based on a certain set of principles. If there is a risk of early warning in the manufacturing area, this module should take the method of coordination and control, and give the plan of the collection, so that the risk can be made to ease or even eliminate.

Direct stakeholders in the distribution area are upstream suppliers, upstream manufacturers, upstream distributors, logistics service providers, downstream customers and end customers. Its main content is to ordering, warehousing, transportation, management of inventory products, designing products and production according to the order. There are 6 risk factors in this area.

1) political instability and government intervention

Cranfield (2002), Harland (2003) proposed the natural disasters and other resistance are the key factors on the failure of the supply chain through the research. Although the occurrence of such natural disasters is unlikely, but once it happens, it may be devastating blow.

2) political instability and government intervention

political instability can also be an important risk factors in supply chain. Port enterprises must take into account the binding of policies in the operation of the supply chain; and the industry and trade policies of the country will have a great impact on the port enterprises, customers and shipping companies.

3) failure on IT and software system

Ma Shihua (2003), Sunil Chopra et al. (2004) gave a research that the maturity of the technology, the use of new technology, failure on IT technology and software system is significantly related with supply chain operation management. The research of enterprise practice shows that the use of information technology and electronic commerce can significantly improve the efficiency of supply chain operation. Wang Ying (2000) study shows that the efficiency of information transmission affect the efficiency of organization. If the information of all the members in supply chain can not be shared, or information is not accurate, it will lead to an omission or loss of goods in some links in the transport process. And it may lead to disruptions in the supply chain.

4) labor disputes and talented people loss

The study of Cranfield (2002), Harland (2003) shows that labor disputes and talented people loss is one of the risk factor of supply chain. Some port companies and shipping companies in port supply chain can occur cargo damage due to mismanagement of their own storage and transit. So the risk of unnormal production often be emerged.

5) products damaged risk in period of transportation

The key of transport is to transport the product to the customer in good condition. If the shipping company delay in transit, or doesn't properly keep the goods well and make the goods damaged, and the goods cannot be completely sent to the owner's hand, it will lead interruption in the supply chain.

6) the risk that product delivery may not be on time

How can the products timely delivered to the hands of customers is an important indicator of measuring the transport capacity. If the ship company delays, and then it cause the transportation not timely, the consignee can not receive the goods within the stipulated time, it may cause some serious consequences. Because some of the goods

have a certain timeliness, if the customer does not receive timely, it will make the goods lose their utility. This can be also a manifestation of supply chain disruption.

5. The returned purchase area includes return of raw material and product. This module has a certain auxiliary function, it can find out the problems and solutions according to different kinds of cargo resources, and it can support the port supply chain managers to make the right decisions.

The stakeholders in the field of returned purchase are upstream suppliers, upstream manufacturers, upstream distributors, logistics service providers, downstream customers and end customers. There are 2 risk factors in this area.

1) low quality product service

If the suppliers of provision of goods and services (such as storage, transport or handling) provide the goods and services, but the quality of goods service is not up to the standard, it may lead to damage of goods in any links in supply chain or the goods transport is not in accordance with the delivery requirements of the consignee. And it leads the goods in consignee's hand have some differences from the demand standard of consignee. The consequence is that the goods do not reach the hands of consignee by request. And the consignee requires the damaged goods should be paid for and even ask to return purchase. It can lead to the congestion of the supply chain and make it disrupt.

2) lower than the standard of product quality

If the goods provided by upstream suppliers not up to the quality standards of downstream consignee, it makes terminal consignee require compensation for goods, or even ask to return purchase, it can lead to congestion in the supply chain and even lead to supply chain risk disruption.

3.2.2 questionnaire survey of Qingdao port

The design of questionnaire should strictly follow the principle of rationality, general, logical, clear and non transparency. ^[8]It is a method to collect research material and data from the respondent through the written form. The questionnaire survey of this object is the enterprises in Qingdao port container supply chain, it is a category of enterprise survey.

The questionnaire mainly includes the following aspects: the risk degree of the port supply chain, the risk probability of the port supply chain, the Risk hazard of the port supply chain. For the 20 Qingdao port supply chain risk factors that I listed before, according to the object of the questionnaire survey, this paper make the questionnaire and lasted for nearly 2 months. The channels for the distribution of the questionnaire are as follows

Field survey of 15 enterprises (including 10 enterprises in Qingdao port, 5 port large customers); e-mail survey of 10 enterprises(including 3 freight forwarding companies, 5 logistics enterprises, 2 port enterprises); telephone survey of the 8 enterprises (including 3 enterprises in Shanghai ports group,3 enterprises of customers.)A total of 33 companies were investigated. This survey of a total of 50 research, recycling 48, the recovery rate is 96%.

Chapter 4 case study of risk early warning operation model for port supply chain disruption

4.1 analysis of container supply chain in Qingdao port

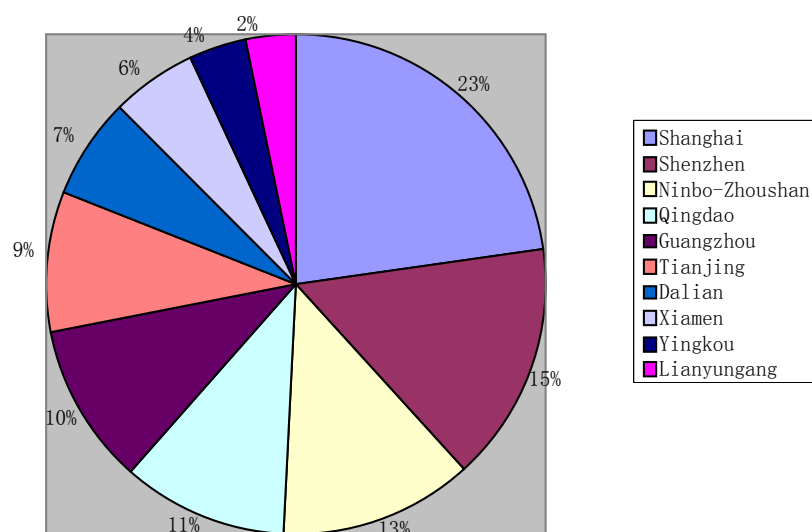
In 2006 the national "11th five-year plan" proposed a key construction project of port planning, and it pointed out that the " the construction of Dalian, Tangshan, Tianjin, Qingdao, Shanghai, Zhoushan, Ningbo, Fuzhou, Xiamen, Shenzhen, Guangzhou, Zhanjiang and other coastal Ports, especially construction of transit transport system and container shipping system of these ports' coal, imported oil and gas, imported iron ore and the container transport system should be paid attention to." The government's encouragement and the advantages of the port have made the Qingdao port in the forefront of container transport volume. By the end of 2014, the ranking of throughput in main ports in China as shown in table 4.1, the container throughput and amplification in Qingdao port are in the forefront, and the container throughput in Qingdao port is accounted for 11% of that of the main ports in China.

Table 4.1 China's main port container throughput in 2014

ranking		ports	Year 2014 ten thousand/TEU	Amplification n %	Year 2013 ten thousand /TEU	amplification %
2014 year	2013 year					
1	1	Shanghai port	3528.50	4.96	3361.70	3.34
2	2	Shenzhen port	2403.00	3.23	2327.90	1.47
3	3	Ningbo-Zhoushan port	1945.00	12.10	1735.07	7.27

4	4	Qingdao port	1662.44	7.10	1552.2	7.03
5	5	Guangzhou port	1616.00	5.54	1531.10	5.25
6	6	Tianjin port	1405.00	7.98	1301.20	5.76
7	7	Dalian port	1012.76	1.12	1001.50	24.19
8	8	Xiamen port	857.24	7.05	800.80	11.19
9	11	Yingkou port	576.82	8.81	530.10	9.28
10	9	Lianyungang port	500.54	-8.79	548.80	9.32

The container throughput of major ports in China in 2014



As shown in table 4.1, among the top ten ranking of container throughput in these ports, the top six ports had a faster growth in 2014 compared to 2013. While the post 4 ranking ports had a slower growth of container throughput in 2014 compared to 2013. Qingdao port ranked fourth and located in the forefront

We can see directly in the table, the amplification of annual container throughput in Qingdao port remains very stable at around 7%, and the amplification ranked third only behind that of Zhoushan port and Yingkou port. The reason, in addition to the policy guidance, hot market demand, and high quality of hardware condition, it also has a progress in software technology -- including the scientific loading and unloading efficiency, handling quality of "zero" damage and so on.

Qingdao port is mainly made up of the upstream container shipper, port carrier in the middle reaches and the downstream container consignee. The port as the core in a supply chain, it has the functions of transshipment center and information concentration^[5]. It must have a close relationship in time with its upstream and downstream to insure the smooth flow and transformation of the containers from the shippers to the consignee.

4.2 framework model of assessment of supply chain disruption risk

In supply chain management and decision making, risk analysis has a wide variety of forms, and the risk is a measure of the degree of risk in the sense of application. The port supply chain is in the primary stage and it is not very mature, so two factor evaluation model is used in the risk assessment module. Hallikas (2004) evaluated the index level of supply chain disruption risk from the possibility of risk events and the harm consequences of risk events these two aspects. So the index level of supply chain disruption risk is reflected through the probability of supply chain disruption risk and the harm consequence of supply chain disruption risk. The index level of supply chain disruption risk is calculated by the possibility of risk events and harm results of risk event these two values. Possibility, means the possibility that the supply chain interruption risk may happen; Consequence, means the harm results to the supply chain after the risk events. Hallikas divided into 5 levels of possibilities and harm results respectively, and gave a framework model for the supply chain risk assessment. The level of possibility assessment is the level classification of risk

probabilities, and the level of impact assessment is the level classification of harm results of risk events. The index level of supply chain disruption risk, the level of possibility assessment and the level of impact assessment are shown in the below table.

Table 4.2 classification of index level of supply chain disruption risk

level of supply chain disruption risk	index	probability of risk
small risk	0-0.2	very little possibility
Less risk	0.2-0.4	small possibility
general risk	0.4-0.6	general possibility
more risk	0.6-0.8	more likely possibility
Great risk	0.8-1.0	maximum possibility

Table 4.3 the level of possibility assessment

ranking	subjective estimation	discription
1	highly unlikely	very rare event
2	impossible	have an indirect impact on the event
3	general possibility	have a direct impact on the event
4	possible	have a direct strong impact on event
5	very likely	events occur frequently

Table 4.4 the level of impact assessment

ranking	subjective estimation	discription
1	no effect	No effect in supply chain disruption
2	little effect	Little loss
3	general effect	Cause short-term difficulties
4	serious effect	Cause long-term difficulties
5	disastrous effect	Cause discription

Therefore, from the above tables, we can see that the supply chain disruption risk is not only a function of the probability of disruption risk event, but also the function of the harm results of disruption risk event. Therefore, in the assessment of supply chain disruption risk, the two risk factors of possibility and consequence need to be considered. If the possibility of supply chain disruption risk is P_f , the harm results of supply chain disruption risk is L_f , then the function of the level of supply chain disruption risk is: $R=f(P_f, L_f)$. If the possibility of non disruption risk in supply chain is P_s , the impact level of non disruption risk in supply chain is L_s , then: $P_s=1-P_f$, $L_s=1-L_f$, and we can get the assessment model of two factors of supply chain disruption risk is:

$$R = f(P_f, L_f) = 1 - P_s L_s = 1 - (1 - P_f)(1 - L_f) = P_f + L_f - P_f L_f$$

However, in order to get the probability and consequence of supply chain disruption risk, we should calculate the weight of each risk factor, and the weight can be obtained by using the method of AHP, and the calculated figure in AHP is given by the experts' scoring.

Sum up,we can get the functions by the two factors of port supply chain disruption risk above,which can be as followed:

$$R = f(P_f, L_f) = 1 - P_s L_s = 1 - (1 - P_f)(1 - L_f) = P_f + L_f - P_f L_f$$

$$\left\{ \begin{array}{l} w_m = \left(1 + \sum_{k=2}^m \prod_{i=k}^m r_i \right)^{-1}, S_i = w^* R = [s_1, s_2, s_3, s_4, s_5], S'_i = [s'_1, s'_2, s'_3, s'_4, s'_5] \\ P_f = S'_i B^T; \text{--- likelihood evaluation of possibility of port supply chain disruption risk} \\ w_j = \{w'_1, w'_2, w'_3, w'_4, w'_5\}, K_i = w_j * r_i = [k_{i1}, k_{i2}, k_{i3}, k_{i4}, k_{i5}], K'_i = [k'_{i1}, k'_{i2}, k'_{i3}, k'_{i4}, k'_{i5}] \\ K = \begin{bmatrix} K'_1 \\ K'_2 \\ \dots \\ K'_m \end{bmatrix} = \begin{bmatrix} K'_{11} & K'_{12} & \dots & K'_{15} \\ K'_{21} & K'_{22} & \dots & K'_{25} \\ \dots & \dots & \dots & \dots \\ K'_{m1} & K'_{m2} & \dots & K'_{m5} \end{bmatrix}, M = w_j * K = [m_1, m_2, m_3, m_4, m_5] \\ M = [m'_1, m'_2, m'_3, m'_4, m'_5], L_f = M V^T. \text{--- likelihood evaluation of harm results of port supply chair} \end{array} \right.$$

4.3 using AHP method to determine the weight

In order use the two factors risk evaluation model,we must calculate two kinds of factor first,one is the probability of distribution risk factor,the other is the degree of the harm results of the distribution risk.So,If I want to get these two factors,I must get the weight of these risk factors. I can use the AHP if I want to get the weight of each risk factors.SO,I use the method of AHP to determine the weight.

4.3.1AHP model

Analytic hierarchy process (AHP), is proposed by a famous American operational research experts--Thomas L.Sssty at University of Pittsburgh in the early 80's of twentieth Century.AHP is a practical method of the combination of qualitative analysis and quantitative analysis.And AHP can be used to make the qualitative problems quantitative.It is a simple and flexible method. It can make variety factors in a complex problem organized and make a comparison between every two factors,then combine the subjective conditions and objective conditions. The premise

of the application of AHP is to divide the complex problem to many hierarchies. And then make an analysis, comparison, quantization and sorting in these hierarchies to get a total sorting ultimately. Using AHP method can solve the problem which can be divided into four steps:

(1) the establishment of a hierarchical structure of the evaluation system

The most important step in the AHP is the establishment of hierarchical structure model. First, AHP can make the complex problem to different factors, and form a multi-hierarchies analysis structure model according to the interact and relationship among the factors. The same level of factors form guidelines and they have a dominant role for the next level of factors, at the same time, they are dominated by the previous level of factors. The top level of AHP often has only one factor, it is the overall goal or ideal result for the problem analysed. The intermediate level is the criterion, and the lowest level includes the decision making.

(2) Build judgment matrix

After establishing hierarchical structure analysis, the problem is to know the priority order for various measures to the overall goal or the weight of various measures (can be realized). Subordinate relationship between upper and lower levels can be determined. On the assumption that the previous level of factor C_k as the criterion, and it has the dominant relationship for the next level of factors P_1, P_2, \dots, P_n . Our goal is to give P_1, P_2, \dots, P_n relevant weight based on their relative importance and the criteria C_k . According to the criterion of C_k , which is more important for factor P_i and factor P_j and how much important. Therefore, it is necessary to give a judgement for the relative importance of various factors in the same level. The judgement can form a judgment matrix through the introduction of appropriate scaling and numerical. The scale method is shown as follows:

Table 4.5 The scale method

Scaling	Meaning
---------	---------

1	It represents the two factors that are of equal importance.
3	Compared with the two factors, the first factor is slightly more important than the second.
5	Compared with the two factors, the first factor was significantly more important than the second.
7	Compared with the two factors, the first factor is more strongly important than the second.
9	Compared with the two factor, the first factor is more extremely important than the second.
2、4、6、8	The median value of two adjacent judgments above

According to the above scale, for the N factor, the judgment matrix of comparison with each other A can be get:

$$A = (a_{ij})_{n \times n} \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{pmatrix}$$

$$a_{ij} > 0; a_{ij} = \frac{1}{a_{ji}}; a_{ii} = 1$$

Judging matrix has the following properties:

We say that A is positive reciprocal matrix, as a matter of fact, for the n order judgment matrix we only need to make a judgment to its upper (under) triangular

factors (total $\frac{n(n-1)}{2}$), the factors in A may not have transmission, that means may not be the equation:

$$a_{ij} a_{jk} = a_{ik} \quad (4.6)$$

But when (4.6) is established, it is called A for the consistency matrix.

(3) hierarchical order and consistency check

In criterion layer under C_k , judgment matrix A can be get by the factors comparison with each other: P_1, P_2, \dots, P_n , we can solve the characteristics of value:

$AW = \lambda_{\max} W$. The W we get can be the sorting weight under the factors P_1, P_2, \dots, P_n in standard layer C_k . λ_{\max} exist and unique, W can be composed by positive

components. In addition to differential one constant multiple, W is unique, and the calculation of λ_{\max} and W is power law, the steps are

First, set initial value vector W_0 .

Second, for $K=1,2,3,\dots$, Calculated $\overline{W}_k = AW_k - 1$,

The vector is get by normalization.

Third, for the accuracy of calculation is given previous, $\max |W_k - W_{(k-1)}| < \varepsilon$,

\overline{W}_{ki} in fomular is the first component for \overline{W}_k , then the calculation stop, otherwise continue the second step.

$$\lambda_{\max} = \frac{1}{n} \sum \frac{\overline{W}_{ki}}{W_{(k-1)i}} \quad \text{and} \quad \lambda_{\max} = \frac{1}{n} \sum \frac{\overline{W}_{ki}}{W_{(k-1)i}}$$

Calculate

In the case of low accuracy, the method can be used to calculate the λ_{\max} and W,

First, the factors of A can even by row ;

Second, the get power n times square;

Third, we can get the rank weight vector W by root mean square;

Fourth, we calculate by the following formula λ_{\max}

$$\lambda_{\max} = \sum_{i=1}^n \frac{(AW)_i}{nW_i}$$

When the deviation is too large of judgement, the calculation results of the ranking weight vector will appear some problems.

So after calculate λ_{\max} , we the need for consistency check, the steps are as follows:

First step, calculate the consistency index CI

$$CI = \frac{\lambda_{\max} - n}{n - 1}$$

The N is the order of the judgment matrix

Second, the average random consistency index RI as shown in the following table

table4.6 Mean random consistency index RI

Order number	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.52	0.89	1.12	1.24	1.32	1.41	1.45

Third, calculate the consistency ratio index CR

$$CR = \frac{CI}{RI}$$

When $CR < 0.1$, it is generally believed that the consistency of the judgment matrix can be accepted, otherwise the judgment matrix will be adjusted.

(4) Overall ranking and consistency check.

The hierarchy is the result of using the same level of all the single sort. It will calculate all the combination weight of the factors in this level. Hierarchical need to be carried out by the upper and lower layers. For the highest level of the second layer, the level of the single sort is the total sort. In general, the hierarchy is shown as follows:

Table4.7 the level of total ranking

Level A	A_1	A_2	.....	A_n	hierarchical ranking
Level P	a_1	a_2	.....	a_n	
P_1	P_{11}	P_{12}	.....	P_{1n}	$\sum_{i=1}^n a_i P_{1i}$
P_2	P_{21}	P_{22}	.....	P_{2n}	$\sum_{i=1}^n a_i P_{2i}$
.....
P_m	P_{m1}	P_{m2}	.....	P_{mn}	$\sum_{i=1}^n a_i P_{mi}$

Obviously, $\sum_{j=1}^m \sum_{i=1}^n a_i P_{ji} = 1$, the level of the total ranking also conducted a consistency check. The consistency ratio of evaluation can be get as follows:

$$CR = \frac{\sum_{i=1}^n a_i CI_i}{\sum_{i=1}^n a_i RI_i}$$

The CR value should be less than or equal to 0,1, otherwise the previous judgment matrix should be adjusted. The final results of AHP is get the priority weights of overall goal of the decision. And then give the total consistency index by the sort of portfolio weights based on the hierarchical structure. And then, we can get the decision-making.

4.3.2 empirical analysis

4.3.2.1 The establishment of hierarchical structure

I evaluate the 20 risk factors in 5 areas by AHP. And then to get the biggest impact factor in supply chain risk. And then I can get the method of supply chain disruption risk early-warning. I have list 20 risk factors of supply chain disruption, these factors get the experts scoring through the questionnaire survey method. By this way to get the biggest impact factors of supply chain risk through the quantitative method.

4.3.2.2 Structure and assignment judgment matrix

For qualitative indexes through expert scoring, I use the calculation method of analytic hierarchy process (AHP); and then I can get the judgment matrix by calculation of actual data based on qualitative data. In the case of low precision, I can use the approximate method to calculate λ_{max} and W:

(1) Set up to compare planning area, supply area, manufacturing area, distribution area and returned purchase area. The impact degree of risk in these areas are get by the experts' scoring, it may exist some certain errors. The Judgment matrix can be shown as follows:

Table4.8 the Judgment matrix of different areas

Port supply chain risk	Planning area	Supply area	Manufacturing area	Distribution area	Returned purchase area	weight
Planning area	1	5/4	2/3	6/5	3/2	0.208
Supply area	4/5	1	1/2	1	4/3	0.171
Manufacturing area	3/2	2	1	8/5	7/3	0.311
Distribution area	5/6	1	5/8	1	4/3	0.177
Returned purchase area	2/3	3/4	3/7	3/4	1	0.133

(2) Set up to compare: Inaccurate strategic plan, Strategic objectives are not consistent among supply chain members, Managers have little awareness of risk of multicultural conflict. The impact degree of risk factors for planning area can be shown as a Judgment matrix as follows:

Table4.9 matrix table of planning area

Planning area	Inaccurate strategic plan	Strategic objectives are not consistent among supply chain members	Managers have little awareness of risk of multicultural conflict	weight
Inaccurate strategic plan	1	4/3	5/2	0.472
Strategic objectives	3/4	1	5/3	0.333

are not consistent among supply chain members				
Managers have little awareness of risk of multicultural conflict	2/5	3/5	1	0.195

(3)Set up to compare: Purchase price is too high, fluctuation on exchange rate, improper selection of supplier, Supplier fails to deliver, shortage of safety inventory. The impact degree of risk factors for supply area can be shown as a Judgment matrix as follows:

Supply area	Purchase price is too high	fluctuation on exchange rate	improper selection of supplier	Supplier fails to deliver	shortage of safety inventory	weight
Purchase price is too high	1	1	2/3	2/3	1/2	0.14
fluctuation on exchange rate	1	1	2/3	4/5	1/2	0.145
improper selection of supplier	3/2	3/2	1	4/3	1/2	0.214
Supplier fails to deliver	3/2	5/4	3/4	1	2/3	0.189
shortage of safety inventory	2	2	2	3/2	1	0.311

Table4.10 matrix table of supply area

(4)Set up to compare:the nonstrict inventory control , improper cost control ,

distorted information of partners , partners distrust. The impact degree of risk factors for manufacturing area can be shown as a Judgment matrix as follows:

manufacturing area	nonstrict inventory control	improper cost control	distorted information of partners	partners distrust	weight
nonstrict inventory control	1	4/5	1	2/3	0.21
improper cost control	5/4	1	5/4	4/5	0.26
distorted information of partners	1	4/5	1	2/3	0.21
partners distrust	3/2	5/4	3/2	1	0.319

Table4.11 matrix table of manufacturing area

(5) Set up to compare: natural disasters, terrorism and war , political instability and government intervention , failure on IT and software system , labor disputes and talented people loss , products damaged risk in period of transportation , the risk that product delivery may not be on time.The impact degree of risk factors for distribution area can be shown as a Judgment matrix as follows:

Table4.12 matrix table of distribution area

distribution area	natural disasters, terrorism and war	political instability and government intervention	failure on IT and software system	labor disputes and talented people loss	products damaged risk in period of transportation	the risk that product delivery may not be on time	weight

natural disasters, terrorism and war	1	3	5/2	10/3	5/3	7/3	0.323
political instability and government intervention	1/3	1	4/5	1	1/2	3/4	0.102
failure on IT and software system	2/5	5/4	1	4/3	1/2	1	0.128
labor disputes and talented people loss	2/7	1	3/4	1	1/2	2/3	0.098
products damaged risk in period of transportation	3/5	2	2	2	1	4/3	0.208
the risk that product delivery may not be on time	3/7	4/3	1	3/2	3/4	1	0.14

(6) Set up to compare: low quality product service and lower than the standard of

product quality. The impact degree of risk factors for returned purchase area can be shown as a Judgment matrix as follows:

Table4.13 matrix table of returned purchase area

returned purchase area	low quality product service	lower than the standard of product quality	weight
low quality product service	1	1	0.5
lower than the standard of product quality	1	1	0.5

After calculation of these factors' λ_{max} and W, the judgment matrixes I get all have satisfactory consistency. They all pass the consistence check. In summary, we can get the weight of every risk factors as follows:

Table4.14 weight of all factors

target area	risk area	risk factors
port supply chain risk	planning area 0.208	Inaccurate strategic plan 0.4715447
		Strategic objectives are not consistent among supply chain members 0.3333333
		Managers have little awareness of risk of multicultural conflict 0.195122
	supply area 0.171	Purchase price is too high (loading and unloading equipments, goods) 0.140415
		fluctuation on exchange rate 0.145299
		improper selection of supplier 0.213675

		Supplier fails to deliver 0.189255
		shortage of safety inventory 0.311355
	manufacturing area 0.311311	nonstrict inventory control 0.210313
		improper cost control 0.26087
		distorted information of partners 0.210313
		partners distrust 0.318504
	distribution area 0.177147	natural disasters, terrorism and war 0.322742
		political instability and government intervention 0.102266
		failure on IT and software system 0.12793
		labor disputes and talented people loss 0.098378
		products damaged risk in period of transportation 0.208421
		the risk that product delivery may not be on time 0.140262
	returned purchase area 0.132834	low quality product service 0.5
		lower than the standard of product quality 0.5

4.4 calculation of indicators of risk early-warning in various areas

4.4.1 likelihood evaluation of risk probability in manufacturing area

(1) Given a set of $B = \{b_1, b_2, b_3, b_4, b_5\}$, $= \{0.1, 0.3, 0.5, 0.7, 0.9\}$, the corresponding description of possibility of risk event is (very small, small, medium, large, vary large)

(2) the establishment of fuzzy relationship evaluation matrix

According to the questionnaire survey data, I can establish the following evaluation matrix:

$$R_3 = \begin{bmatrix} 0.729 & 0.25 & 0 & 0.021 & 0 \\ 0.563 & 0.375 & 0.021 & 0.042 & 0 \\ 0.292 & 0.375 & 0.25 & 0.063 & 0.021 \\ 0.604 & 0.229 & 0.146 & 0 & 0.021 \end{bmatrix}$$

(3) establishment of fuzzy comprehensive evaluation:

$$\begin{aligned} S_3 &= w_3 * R_3 \\ &= (0.2103, 0.2609, 0.2103, 0.3185) * \begin{bmatrix} 0.729 & 0.25 & 0 & 0.021 & 0 \\ 0.563 & 0.375 & 0.021 & 0.042 & 0 \\ 0.292 & 0.375 & 0.25 & 0.063 & 0.021 \\ 0.604 & 0.229 & 0.146 & 0 & 0.021 \end{bmatrix} \\ &= (0.5539, 0.3023, 0.1045, 0.0284, 0.011) \end{aligned}$$

The sum of each component in the S is 1, So $S_3 = S_3' = (0.5539, 0.3023, 0.1045, 0.0284, 0.011)$

(4) the calculation of possibility of supply chain disruption risk:

$$P_f = [0.5539, 0.3023, 0.1045, 0.0284, 0.011] [0.1, 0.3, 0.5, 0.7, 0.9]^T = 0.228$$

4.4.2 likelihood evaluation of risk consequences in manufacturing area

An example of the inventory control is not strict with the two level indicators

(1) establishment of the evaluation of the factor set

$C = \{\text{port service cost, port service efficiency, port service quality}\} = \{c1, C2, c3\}$

$V = \{\text{very small, small, medium, serious, much serious}\} = \{v1, V2, V3, V4, v5\} = \{0.1, 0.3, 0.5, 0.7, 0.9\}$

(2) I get the matrix after the fuzzy evaluation of the two level indexes of the non-strict inventory control:

$$r_1 = \begin{bmatrix} 0.208 & 0.313 & 0.188 & 0.208 & 0.083 \\ 0.188 & 0.167 & 0.208 & 0.25 & 0.188 \\ 0.188 & 0.208 & 0.292 & 0.146 & 0.167 \end{bmatrix}$$

(3) I get the two stage index weight of non-strict of control for inventory by AHP:

$$r_1 = (0.3068, 0.3575, 0.3357)$$

(4) Fuzzy comprehensive evaluation of the two level indexes of non-strict of control for inventory:

$$K_1 = w * r = (0.3068, 0.3575, 0.3357) * \begin{bmatrix} 0.208 & 0.313 & 0.188 & 0.208 & 0.083 \\ 0.188 & 0.167 & 0.208 & 0.25 & 0.188 \\ 0.188 & 0.208 & 0.292 & 0.146 & 0.167 \end{bmatrix}$$

$$= (0.1939, 0.2254, 0.2299, 0.2022, 0.1486)$$

Since the sum of the components in the K is 1, so

$$K_1 = K_1' = (0.1939, 0.2254, 0.2299, 0.2022, 0.1486)$$

In the same way, we can calculate the evaluation set of other 3 two-levels of risk factors in the manufacturing area.

$$K = \begin{bmatrix} K_1' \\ K_2' \\ K_3' \\ K_4' \end{bmatrix} = \begin{bmatrix} 0.1939 & 0.2254 & 0.2299 & 0.2022 & 0.1486 \\ 0.1526 & 0.2099 & 0.203 & 0.146 & 0.2886 \\ 0.1046 & 0.1702 & 0.1072 & 0.415 & 0.2031 \\ 0.1827 & 0.165 & 0.185 & 0.3383 & 0.129 \end{bmatrix}$$

$$M_3 = w_3 * K = [m_1, m_2, m_3, m_4, m_5]$$

$$= (0.2103, 0.2609, 0.2103, 0.3185) * \begin{bmatrix} 0.1939 & 0.2254 & 0.2299 & 0.2022 & 0.1486 \\ 0.1526 & 0.2099 & 0.203 & 0.146 & 0.2886 \\ 0.1046 & 0.1702 & 0.1072 & 0.415 & 0.2031 \\ 0.1827 & 0.165 & 0.185 & 0.3383 & 0.129 \end{bmatrix}$$

$$= (0.1608, 0.1905, 0.1828, 0.2756, 0.1903)$$

The sum of each component in the M is 1, so

$$M_3' = M_3 = (0.1608, 0.1905, 0.1828, 0.2756, 0.1903)$$

(5) the calculation of harm results of risk L_f is:

$$L_f = [0.1608, 0.1905, 0.1828, 0.2756, 0.1903] [0.1, 0.3, 0.5, 0.7, 0.9]^T = 0.529$$

4.4.3 index calculation of risk factors in manufacturing area

$$R = f(P_f, L_f) = 1 - P_s L_s = 1 - (1 - P_f)(1 - L_f) = P_f + L_f - P_f L_f$$

$$= 0.228 + 0.529 - 0.228 * 0.529 = 0.636$$

4.4.4 analysis and alarm of early warning indexes

I can do the evaluation for the supply chain by using the two factor comprehensive analysis model of port supply chain risk early-warning. The risk index in manufacturing area is 0.636, we can also get the other 4 index value of risk early-warning as follows:

Table 4.15 Index and numerical table of risk early-warning

different index value of risk early-warning	risk index value
planning area	0.527

supply area	0.678
manufacturing area	0.636
Supply area	0.78
returned purchase area	0.586

According to the above list in table 4.15, these main factors in these areas are concentrated in the third and fourth grades. Planning area and returned purchase area are in the fourth level (0.6-0.8), that is, the index value of supply chain disruption risk is higher, the probability of supply chain disruption risk is bigger. Supply area, manufacturing area and distribution area are in the third level (0.4-0.6), that is, the supply chain disruption risk level is general, the supply chain disruption risk may occur.

4.5 risk early-warning strategies of Qingdao port supply chain disruption

For high and low level of risk, the corresponding priority strategies of risk are different. But no matter what kind of level of risk, the emphasis we must consider is how to effectively control and manage risk. That is to choose the treatment method and avoid the loss. In enterprise risk management, the enterprises often determine the optimal combination of various strategies according to their own situation, risk management policy and total objectives, and they obtain the most effective effect by using minimum cost. Various enterprises have different handle strategies of supply chain risk. But basically can be divided into risk avoidance, risk retention and risk transfer these three methods. Here I analyze the risk early-warning strategies based on the actual situation of Qingdao port.

4.5.1 risk retention--planning area, supply area, distribution area

The so-called risk retention, is that they should bear their own risk but neither risk avoidance nor risk transfer. When they take the strategy of risk retention, the members in supply chain must adopt some strategies to response risk. This is a more active type of treatment strategy. The specific methods in the process of practice: the establishment of an efficient information sharing channel, in order to reduce the information distortion and not on time delivery; Besides, we can also design a flexible supply chain, in order to eliminate redundant links and optimize the structure of supply chain. The planning area can use strategy (a). For the supply area, I provide strategies (a) and (b). (c) and (d) strategies are that for the distribution area.

(a). Information sharing strategy. That means one party in port supply chain share the information to the other party or several parties to let them get more orders. Port enterprises and their upstream and downstream can connect the port enterprises in supply chain by use EDI or Internet technology. It can make the stakeholders in the supply chain share business planning, forecasting information, inventory data information, purchase goods information. Take the suppliers of goods of container transportation, port enterprises, customers as an example, port enterprises and customers can make suppliers of goods add to information sharing system, to get the news of inventory and production. So, on the one hand, the suppliers of goods can reduce the cost of information sharing and get more orders, on the other hand, information sharing can enable customers arrange inventory, production and sales plan more flexible, and reduce the inventory cost and transaction cost. At the same time, port enterprises can also arrange port scheduling schemes timely according to production inventory information of upstream suppliers and downstream customers. By this way to make the logistics service more Convenient and efficient.

The inconsistent goal of supply chain members can also adopt the mode of the information sharing, it can make the information symmetry in various members, and develop a better target as much as possible, to make all parties satisfied as far as

possible. By this way to strengthen communication in all parties, and adjust the target when necessary, to make the minimum loss as far as possible. And let all parties satisfaction, which also has a strict requirement on information sharing.

(b) Reduce the lead time of the suppliers. Port enterprises can reduce the lead time of container goods suppliers to encourage suppliers to actively participate in information sharing, reduce the risk of default. Port enterprises and customers can have a good agreement on yard with the supplier in advance, and to do the ready work for the suppliers, so that the supplier can reduce the lead time to lower the risk of default.

(c) Set up an emergency team. Natural environmental factors are often the least controllable factor in the external environment factors. The port enterprises and shipping enterprises may jointly set up natural disaster emergency team. When the disaster early-warning happens, emergency team should feedback information in time.

(d) Integration of information system. Existing information platform is in the forefront of the country in the import and export information integration of container. And do the success of information integration platform in the Maersk and COSCO Container to make it convenient of the supply chain management for the suppliers, ports and customers. However, the main obstacle of supply chain cooperation is Information system docking between the Qingdao port and the shippers. This requires a further integration of large enterprises information system.

4.5.2 Risk avoidance - manufacturing field

Risk avoidance mainly refers to the interruption of the risk sources, so that it does not happen or to curb its development. If there is a big potential risk and the consequence is very serious, using other strategies are not appropriate, then there is

room for a wide selection to choose, give up some action or decision, and thus a strategy to avoid the risk. By avoiding the risk, we can eliminate the risk factors in supply chain to avoid the potential loss and uncertainty.

Qingdao port as the forefront of the country's port, its upstream and downstream enterprises and suppliers are often have the situation of uneven interests, and unfair competition had occurred. This paper argues that it is necessary to implement a strategic alliance strategy to effectively prevent the occurrence of this behavior. This union can be divided into upstream, midstream and downstream. Upstream is mainly the alliance with the supplier, the midstream is alliance with the shipping company, and the downstream is mainly the alliance with the customer enterprise.

1. upstream supplier alliance strategy. Qingdao port as the core of the whole supply chain, it can seek and develop the overseas market by its superior geographical advantages, service ability and the forefront ranking of the world's container throughput. Therefore, the Qingdao port and the customer enterprises can make a alliance with the overseas upstream suppliers, and to prevent some certain problems of suppliers.

2. the midstream shipping company alliance strategy. Qingdao port should play their own advantages, make a alliance cooperation with large shipping companies actively for logistics supply chain, such as investment of yard resources, even more than a pure investment mode, also shares, and send port workers to participate the daily business management in the yard. It can make Qingdao port and shipping companies to supervise each other and improve efficiency.

3. The downstream enterprise alliance strategy. Starting from the angle of the business cooperation, based on the improper control risk of inventory in port and the customer enterprises, port enterprises and customers can do dock business collaboration, namely the terminal storage and handling operations.^[9]The enterprise

customers can also send staff to participate the daily handling and storage management in the port, to take a role of supervision and guidance for loading and unloading links. Qingdao port also can communicate with its downstream customers in time, to obtain adequate customer information, to reduce the customer's inventory costs, and to optimize the yard allocation. Through this method of mutual cooperation, it is also a competitive model, so that the customer enterprises to improve service efficiency. Port enterprises can improve their own competitiveness, so that the two sides have the common development.

4.5.3 Risk transfer --- Manufacturing field, return area

Risk transfer, as an effective means of risk disposal, when supply chain enterprises can not defuse the risks by other methods, risk transfer can transfer its own risk to other enterprises. However, the transfer of the risk is also to pay the price, which is a kind of risk sharing. Strategy of partner selection is based on the manufacturing area and the returned purchase area.

Strategy of partner selection. If the partners provide the information distortion, or partners have suspicious, doubt and distrust, it can be considered to change the partners. In a sense, through this way, the port can transfer the risk to other enterprises. For the risk factors in returned area, if the product quality below standard by the suppliers so that the customers are not satisfied with them, it can also take the strategy of choosing the other partners to lower the harmonious risk.

Because the index values of planning area and returned purchase area are higher than that of other indexes in port supply chain disruption risk (0.6 0.8), so the possibility of supply chain disruption risk is larger, so the risk early-warning in these two areas should be started. So the information sharing strategy should be started in the planning field (risk retention), and the strategies of partners selection should be started in the returned purchase. (risk transfer).

Chapter 5 Conclusions

5.1 Summary

Port enterprises should make full use of the comparative advantages of their core species and hinterland industry development to construct the development mode of port supply chain. Port enterprises as the core of the port upstream suppliers and downstream customers, they can integrate all kinds of resources through information sharing, cooperation fully with all parties to promote themselves and the region economy. By this way to remain a sustainable development.

Port enterprises as the core of the port supply chain, it should play a leading role in risk management and combined with the entire supply chain through the establishment of the Qingdao port supply chain disruption risk model. By using AHP model and the assessment model of supply chain disruption risk to calculate the index degree of supply chain disruption risk. Then different strategies should be started according to varying risk degrees. By this way to deal with the risk factors in planning area, supply area, manufacturing area, distribution area and returned purchase area these five risk areas.

For Qingdao port container supply chain, information sharing strategy can be started in planning area. Supply area can use information sharing strategy and the strategy of lower the supplier's lead time. These strategies are belong to risk retention. Manufacturing area can start the strategic alliance strategy to control the risk, this strategy is called risk avoidance; in addition, manufacturing areas and returned area can take a strategy of choosing partners to reduce the risk, this strategy belongs to the risk transfer. Distribution area can use the strategy of setting up an emergency team and integration information system, these two strategies are risk retention. We should start these different strategies when the index values are high. In Qingdao port, the

strategies in planning area and returned area should be started. Because the values of disruption risk in these two areas are higher than that in others.

5.2 suggestion and deficiency

5.2.1 suggestion-establishment of emergency lockdown mechanism

Because the natural environment factors are often the most uncontrollable risk factors in the external environment, although the probability of occurrence is not big, once it happens, it will cause serious consequences. It mainly stems from the development of disaster prediction technology and cooperation of related departments. Shipping companies, port enterprises can jointly set up natural disaster emergency-response team. When disaster information be emerged, the team should feedback information timely and accurately. And relevant risk management personnel should formulated emergency plans with the team.

Because the data collection is not very convenient and time is limited, so the is only concentrated on Qingdao port container supply chain disruptions, if it is applicable for other, it remains to be a further study.

5.2.2 Deficiency

The boundaries of the early-warning indicators are not very accurate, this paper determine the indicators by a combination of historical data and previous research results. In the future study, it should be further explored of accurate boundaries of early-warning.

Because the data collection is not very convenient and time is limited, so the is only concentrated on Qingdao port container supply chain disruptions, if it is applicable for other, it remains to be a further study.

References:

- [1] Bowersox D J, Closs D(1996). "Logistical managements: the integrated supply chain process. New York :McGraw-Hill, 1996
- [2] Kuby M, Reid N. Technological change and the concentration of the U.S General Cargo Port System:1970-1988. *Economic Geograghy*, 1992, 68(3):272-289
- [3] Brian H., Jacques C. Inter-Port Competition in Developing Countries: An East African Case Study, *Journal of Transport Geography* 3.1, 1995:87-103
- [4] Brandenburger A M, Nalebuff B J. The right game: Use game theory to shape strategy. *Harvard Business Review*. 1995
- [5] Notteboom T E. Concentration and load centre development in the European container port system. *Journal of Transport Geography*, 1997,5(2):99-115
- [6] Paixao A C, Marlow P B. Fourth generation ports-a question of agility? *International Journal of Physical Distribution & Logistics Management*, 2003,33(4):355-376
- [7] Anderson D L, Lee H . Keynote-the Achieving Supply Chain through Excellence (ASCET) project. *New supply chain business models - the opportunities and challenges* ,2001.
- [8] Akkermans H, Bogerd ,Van Dremalen J. Travail, transparency and trust : A case study of computer -supported collaborative supply chain planing in high-tech electronics. *European Journal of Operational Research*, 2004, 153:445-456
- [9] De Leeuw S, Fransoo J. Drivers of close supply chain collaboration: one size fits all? *International Journal of Operations & Production Management*, 2009,29(7):720-739
- [10] Angulo A, Nachtmann H, Waller M A. Supply chain information sharing in a vendor

- managed inventory Partnership. *Journal of Business Logistics*, 2004, 25(1):101-120
- [11] Zeng A Z, Pathak B K. Achieving information integration in supply chain management through B2B e-hubs concept and analysis. *Industrial Management & Data Systems*, 2003, 103(9):657-664
- [12] Williamson E A, Harrison D K, Jordan M. Information systems development within supply chain management. *Information Management*, 2004, 24(5):375-385
- [13] Dong W Y, Soung H K, Nak H k. Combined Modeling with Multi-Agent Systems and Simulation: Its Application to Harbor Supply Chain Management. *Proceedings of the 35th Hawaii International Conference on System Sciences*, Hawaii, 2002
- [14] Bichou K, Gray R A. Logistics and supply chain management approach to port performance measurement. *Maritime Policy & Management*, 2004, 31(1):47-67
- [15] Ross R. Ports as elements in value-driven chain systems: the new paradigm. *Maritime Policy & Management*, 2002, 29(3):241_255
- [16] Christopher M. *Logistics and supply chain management: creating value-adding networks*. London: Pearson education, 2005
- [17] Romano P. Co-ordination and integration mechanisms to manage logistics processes across supply networks. *Journal of Purchasing and Supply Management*, 2003, 9(3):119-134
- [18] Lee P D. Port supply chains as social networks. *Service Operations and Logistics, and Information, IEEE International Conference on*, 2006:1064-1069
- [19] Shi Lirong. Port supply chain construction and management of the early. *Logistics technology*, 2007 (3): 61-62
- [20] Zhao Na. Port supply chain coordination system based on Agent. *Port & Waterway Engineering*, 2009 (2): 79-82

- [21] Ren Jingping, Sun Yuqin. Analysis of port supply chain performance evaluation model based on action research. *Management aspect*, 2009 (11): 43-46
- [22] Cheng H. Port supply chain and its construction. *Shipping management*, 2009 (31): 9-12
- [23] Huang Min Yang Hongmei Wang Xingwei. Virtual enterprise risk evaluation based on fuzzy comprehensive evaluation. *Practice and understanding of mathematics*, 2004(6):34
- [24] Li Xiaoying, Chen Weizheng. Research on the formation mechanism of supply chain risk. *Chinese circulation economy*, 2003 (9): 10-13
- [25] Liu Haohua, Lu Hui. The theory of supply chain security risks and preventive measures. *Finance and trade research*, 2005 (5): 82-87
- [26] Liu Lihui. The construction of Yantai port logistics supply chain. *The group of economic research*, 2005 (19): 23-25
- [27] Gong Zhaoren. The index system with comprehensive evaluation classification structure system. *Research on financial and economic issues*, 1997 (1): 78-81
- [28] Huang Peiqing, Zhang Cunlu, Jie hui. Supply chain reengineering based on SCOR model. *Industrial Engineering and management*, 2004 (1): 60-62
- [29] H.Meersman,F.Moglia.Do mergers and alliances influence European shipping and port competition?[J].*Maritime Policy&Management*,2000,Vol.27,N0.4 *International Journal of Production Economics*,2004,90:47-58.
- [30] Roger Bennett,Helen Gabriel. Reputation,trust and supplier commitment:the case of shipping company/seaport relations[J]. *Jounal of Business&Industrial Management*,2001,Vol.16,No.6
- [31] Raul Compes Lopez, Nigel Poole. Quality assurance in the maritime port logistics chain:the case of Vlencia, Spain [J]. *Supply Chain Mangement* , 1998, Vol.3, No.1

- [32] Peter B. Marlow a, Ana C. Paixao Casaca. Measuring lean ports performance[J]. International Journal of Transport Management, 2003
- [33] Wouter Jacobs, Peter V. Hall. What conditions supply chain strategies of ports? The case of Dubai [J]. GeoJournal, 2007, 327-342.
- [34] Wang Jiuhe. Analysis and optimization of the structure of port enterprise supply chain. Qinhuangdao: Yanshan University, 2005
- [35] Xu Changxin, Xie Lingfeng. Design of port development model based on Supply Chain Management in Jiangsu along the River J. Marine engineering, 2006 (11).
- [36] Sun Fengshan. The establishment of strategic partnership of port enterprise in modern logistics supply chain [J]. Water transport management, 2004 (12).
- [37] Zhao Gang. Research on supply chain management of Rizhao Port Based on vertical strategic alliance [D]. Nanjing: Hohai University, 2007

Appendix:

Appendix 1 :evaluation of index in port supply chain disruption risk factors

The first part, the port supply chain diatuption risk factors

Here is a description of the port supply chain risk factors. Please make your choice of various risk factors according to the specific circumstances of your company and your experience , the higher the number of choices, the higher the risk level. For example, the choice of "1" indicates that the risk degree of the supply chain is very low, choose "2" indicates that supply chain risk degree is low, choose "3" shows that The risk degree of supply chain is moderate, choose "4" shows that the supply chain risk degree higher, choose "5" supply chain risk degree is very high. Please tick the corresponding number "√".

1.planning area

risk variables	risk degree				
	1	2	3	4	5
Inaccurate strategic plan					
Strategic objectives are not consistent among supply chain members					
Managers have little awareness of risk of multicultural conflict					

2. supply area

risk variables	risk degree				
	1	2	3	4	5
Purchase price is too high					
Fluctuation on exchange rate					
improper selection					

of supplier					
Supplier fails to deliver					
shortage of safety inventory					

3. manufacturing area

risk variables	risk degree				
	1	2	3	4	5
nonstrict inventory control					
improper cost control					
distorted information of partners					
partners distrust					

4. distribution area

risk variables	risk degree				
	1	2	3	4	5
natural disasters, terrorism and war					
political instability and government intervention					
failure on IT and software system					
labor disputes and talented people loss					
products damaged risk in period of transportation					
the risk that product delivery may not be on time					

5. returned purchase area

risk variables	risk degree				
	1	2	3	4	5
low quality product					

service					
lower than the standard of product quality					

The second part, the occurrence probability of port supply chain disruption risk

Here is the probability of the port supply chain disruption risks, please make a choice of possibility of supply chain disruption risk events according to the daily operation of your upstream and downstream enterprises and your personal experience. The higher the number of choices, the higher the possibility of risk. For example, selection of "1" indicates that the probability of risk occurrence is very small, select "2" indicates that the risk probability is small, "3" Indicates that the probability of the occurrence of risk is moderate, choose "4" shows that the risk probability is large, the choice of "5" shows the probability of the occurrence of risk is very large. Please tick the corresponding number "√".

risk areas	risk factors	risk occurrence probability				
		1	2	3	4	5
planning area	Inaccurate strategic plan					
	Strategic objectives are not consistent among supply chain members					
	Managers have little awareness of risk of multicultural conflict					
supply area	Purchase price is too high					
	fluctuation on exchange rate					
	improper selection of supplier					
	Supplier fails to deliver					
	shortage of safety inventory					
manufacturing area	nonstrict inventory control					
	improper cost control					
	distorted information of partners					
	partners distrust					
distribution area	natural disasters, terrorism and war					
	political instability and government					

	intervention					
	failure on IT and software system					
	labor disputes and talented people loss					
	products damaged risk in period of transportation					
	the risk that product delivery may not be on time					
returned purchase area	low quality product service					
	lower than the standard of product quality					

The third part, the degree of harm results of port supply chain disruption risk

Here is a survey on the harm results of port supply chain disruption risks. Please make a choice of different degree of harm results of port supply chain disruption risks according to your company's daily operation and personal experience. The higher the number of choices, the higher the degree of harm results of supply chain disruption risks are. For example, selection of "1" indicates that the degree of harm results of disruption risk is very small, the choice of "2" indicates that the degree of harm results of disruption risk is small, "3" Indicates that the degree of harm results of disruption risk is moderate, choose "4" shows that the degree of harm results of disruption risk is large, the choice of "5" shows the degree of harm results of disruption risk is very large. Please tick the corresponding number "√".

risk factors	assessment items	the degree of risk				
		1	2	3	4	5
Inaccurate strategic plan	Port service cost					
	Port service efficiency					
	Port service quality					
Strategic objectives are not consistent among supply chain members	Port service cost					
	Port service efficiency					
	Port service quality					
Managers have little awareness of risk of multicultural conflict	Port service cost					
	Port service efficiency					
	Port service quality					

Purchase price is too high	Port service cost					
	Port service efficiency					
	Port service quality					
fluctuation on exchange rate	Port service cost					
	Port service efficiency					
	Port service quality					
improper selection of supplier	Port service cost					
	Port service efficiency					
	Port service quality					
Supplier fails to deliver	Port service cost					
	Port service efficiency					
	Port service quality					
shortage of safety inventory	Port service cost					
	Port service efficiency					
	Port service quality					
nonstrict inventory control	Port service cost					
	Port service efficiency					
	Port service quality					
improper cost control	Port service cost					
	Port service efficiency					
	Port service quality					
distorted information of partners	Port service cost					
	Port service efficiency					
	Port service quality					
partners distrust	Port service cost					
	Port service efficiency					
	Port service quality					
natural disasters, terrorism and war	Port service cost					
	Port service efficiency					
	Port service quality					
political instability and government intervention	Port service cost					
	Port service efficiency					
	Port service quality					

failure on IT and software system	Port service cost					
	Port service efficiency					
	Port service quality					
labor disputes and talented people loss	Port service cost					
	Port service efficiency					
	Port service quality					
products damaged risk in period of transportation	Port service cost					
	Port service efficiency					
	Port service quality					
the risk that product delivery may not be on time	Port service cost					
	Port service efficiency					
	Port service quality					
low quality product service	Port service cost					
	Port service efficiency					
	Port service quality					
lower than the standard of product quality	Port service cost					
	Port service efficiency					
	Port service quality					