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WORLD MARITIME UNIVERSITY

Shanghai, China

RESEARCH ON THE STATUS QUO AND OPERATIONAL MODES OF CHINESE PETROCHEMICAL LOGISTICS

By

HOU JIA JIE

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

(INTERNATIONAL TRANSPORT AND LOGISTICS)

2007

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DECLARATION

I certify that all the material in this research paper 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 research paper reflect my own personal views, and are not necessarily endorsed by the University.

……

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ABSTRACT

Title of Dissertation: **Research on the status quo and operational modes of Chinese petrochemical logistics**

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

Developing modern logistics is of great importance to the growth of national economy. In the meantime, petrochemical industry is the backbone industry in China. Therefore, the study concerning the special features and status quo of petrochemical logistics can be of great help to the development of petrochemical industry in China. In addition, in order to survive and prosper in the fierce competition with foreign counterparts, Chinese petrochemical logistics enterprises should adopt the right strategies with a view to enhancing their core competitive advantages.

In this context, this dissertation analyzes the current situations and carries out a comprehensive study on the development prospects of the petrochemical logistics in China in detail. At the same time, the author is doing an internship in a famous petrochemical company. Based on what I learn from the advanced experience and practices, the author will also conduct SWOT analysis and put forward the future strategies which the Chinese petrochemical logistics enterprises can take and the role the Chinese government can play in it. In addition, this dissertation sets up an AHP model to evaluate which petrochemical logistics operational mode a petrochemical enterprise can select. Finally, in order to further illustrate the selection result of AHP model, the author will analyze a case to see how this logistics operational mode benefits a famous Chinese petrochemical enterprise. Hopefully, this dissertation can help Chinese petrochemical logistics service providers to better know themselves and the current situations of Chinese petrochemical industry so as to formulate the most appropriate strategies for future development.

KEYWORDS: Chinese petrochemical logistics, AHP, logistics operational mode

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LIST OF ABBREVIATIONS

AHP	Analytical Hierarchy Process
CI	Consistency Index
CNPC	China National Petroleum Corporation
CNOOC	China National Offshore Oil Corporation
CR	Consistency Ratio
CFLP	China Federation of Logistics and Purchasing
NDRC	National Development and Reform Commission

1 INTRODUCTION

1.1 Background

Developing modern logistics is of great importance to the performance of national economy. In the meantime, petrochemical industry is the backbone industry in China. The study concerning the special features and status quo of petrochemical logistics can be of great help to the development of petrochemical industry mainly because of the following two aspects.

First of all, the petrochemical production has been developing very rapidly in China. In 2006, the total amount of imports and exports of petrochemical products reached 171.55 billion USD, 27 percent higher than the previous year. Among them, the total amount of exports was 42.25 billion USD, 19.3 percent higher than the previous year. The total amount of imports is 129.3 billion USD, 29.7 percent higher than the previous year. Therefore, the fast growing Chinese petrochemical industry depends highly on the petrochemical logistics. Without the development of modern petrochemical logistics, there would be no sound and stable development of Chinese petrochemical industry to say.

Secondly, overseas companies have increased their investment in petrochemical industry in China, such as the integrated sites of Bayer and BASF in Shanghai Chemical Industry Park. In order to survive and prosper in the fierce competition

with foreign counterparts, Chinese petrochemical enterprises should adopt the most appropriate strategies with a view to enhancing their core competitive advantages. Therefore, the research concerning petrochemical logistics has become the main topic of relevant logisticians.

1.2 Literature Review

1.2.1 Current Research abroad

Currently, many world-renowned petrochemical enterprises have increased their investments in China, as a result of which, there are many dedicated chemical industrial parks. Regarding this, Hermann G. Hauthal and Tiina Salonen introduce some famous Chinese chemical industrial parks in terms of their locations, total industrial surface areas, specialties and investment scales. Jayarethanam Sinniah Pillai rejuvenates the existing discussion on the importance of cluster approach to petrochemical industry development strategies, pointing out that over the last decade, clusters have drawn substantial attention from policy makers, legislatures, business leaders, academics, economic development practitioners and development agencies. Many countries around the world have based their industry development strategies on cluster models. In this article, he uses Singapore’s petrochemical industry as an example to study the cluster approach to the development of petrochemical industry, which has some guiding significance to the development of Chinese petrochemical industry. In 1980, Saaty initially presented the Analytic Hierarchy Process (AHP) for use in solving multiple criteria decision problems. Using a systematic hierarchy structure, complex estimation criteria can be represented clearly and definitely. In this dissertation, the author will use AHP model to select the most appropriate logistics operational mode for petrochemical enterprises. In addition, Raed Hussain, Tiravat Assavapokee and Basheer Khumawala discuss the supply chain management in the petroleum industry in terms of its challenges and opportunities respectively.

They point out that supply chain management in the petroleum industry contains various challenges, specifically in the logistics area, that are not present in most other industries. The objective of his paper is to shed light on the supply chain challenges and opportunities in the petrochemical industry. In this dissertation, the author will also elaborate on some challenges and opportunities faced by Chinese petrochemical industry.

1.2.2 Current Research domestic

Academic studies in the field of petrochemical logistics are not very mature and there are some papers talking about the current situations of Chinese petrochemical logistics industry. There are also a few papers giving some advices on the development strategies for Chinese petrochemical enterprises. Nevertheless, since these suggestions are not based on in-depth studies of Chinese petrochemical logistics industry, they cannot give us a good insight into the current situations and development perspectives of domestic petrochemical logistics industry. Chen Fangjian points out that petrochemical logistics is totally different from general logistics in that the logistics operation of most petrochemical products is distinguished from that of the general products. Yin Jihai writes a thesis in the Journal of Shanghai Maritime University which is named “The strategy for the development of Shanghai petrochemical logistics”. In this thesis, he points out that systematic thought has to be established when we develop the petrochemical logistics, which is the prerequisite to streamline the logistics activities. In addition, Zhang Fen elaborates on the current situations of petrochemical logistics in China, pointing out that although the petrochemical logistics is developing very fast in China, from the overall perspective, its modernity is not high. The relatively low efficiency and incomplete functions can not satisfy the demands of petrochemical enterprises. There are still many problems remaining to be solved in terms of scale, efficiency, logistics

technology and management level. In this dissertation, the author will also give his points of view about the problems of Chinese petrochemical logistics and put forward relevant suggestions.

1.2.3 Shortages in current research

In the process of researching, the author finds that people are getting increasingly deeper understanding about the relevance between logistics and economic development. In recent years, multifarious deep explorations have been conducted concerning logistics theories and systems. Nevertheless, most of these studies are mainly focused on two aspects, namely general logistics and enterprise logistics. The former is dedicated to the general rules of logistics, the establishment of commonly applicable logistics systems and their integration with other systems, as well as logistics information systems, while the latter is mainly devoted to the management of enterprises to streamline their logistics activities, with a view to enhancing their competitive advantages. However, there is little literature about the petrochemical logistics. Almost no foreign research papers talk about Chinese petrochemical logistics industry. Domestic researches in this field are also very few in number and most papers concentrate only on a single aspect of petrochemical logistics, thus lacking systematic point of view. In addition, there is also a lack of analysis on the market environment for Chinese petrochemical industry.

1.3 Purpose and structure of this paper

The purpose of this dissertation is as follows:

(1) Analyze the current market environment and status quo of Chinese petrochemical logistics industry.

(2) Analyze Chinese petrochemical logistics enterprises through SWOT analysis and

put forward some corresponding suggestions on Chinese petrochemical logistics development.

(3) Set up an AHP model to select the most appropriate logistics operational mode for petrochemical enterprises and analyze a real case about a famous Chinese petrochemical enterprise to further illustrate the logistics economic benefits of the selection result.

The structure of this dissertation is as follows: After an introduction in Chapter One, the second chapter of this dissertation introduces the special features of petrochemical products and logistics at first, then it concentrates on reviewing the market environment and current situations of Chinese petrochemical logistics industry, on the basis of which, it conducts SWOT analysis and puts forward corresponding suggestions to promote Chinese petrochemical logistics development. After an analysis at the macro level, the third chapter sets up an AHP model to select the most appropriate logistics operational mode for petrochemical enterprises. Finally, on the basis of the result of the decision-making, the fourth chapter analyzes a real case about a famous Chinese petrochemical enterprise to further illustrate the logistics economic benefits of this logistics operational mode.

2 PRELIMINARY ANALYSIS OF THE STATUS QUO OF PETROCHEMICAL LOGISTICS DEVELOPMENT IN CHINA

2.1 Special features of petrochemical products and logistics

2.1.1 Special features of petrochemical products

Many petrochemical products are homogeneous in terms of their forms. Most petrochemical products exist in the form of liquid and gas. For example, crude oil and its derivative products such as petroleum, coal oil, lubricant, vitriol, nitric acid and hydrochloric acid exist in the form of liquid under standard conditions, while natural gas, liquefied petroleum gas and coal gas exist in the form of gas. This feature of petrochemical products determines that petrochemical products are prone to leak and not easy to store. Therefore, there are some special requirements in terms of storage facilities and transportation modes of petrochemical products. Traditional transportation modes include road tankers, bulk liquid (gas) tank ships, pipeline transportation, ordinary container iron (plastic) barrels, while new transportation modes include ISO tanks and intermediate bulk containers.

From the perspective of logistics, hazardous characteristics is the most important feature of petrochemical products, among which, many are characterized by flammability, explosive nature, toxicity and corrosion. In China alone, nearly three thousand kinds of petrochemical products are included in the hazardous name lists.

According to main dangerous characteristics of chemicals, General Administration of Quality Supervision of People's Republic of China issued Classification and Labels of Dangerous Chemical Substances Commonly Used (GB 13690-1992) in 1992. It regulates the classifications, symbols and dangerous characteristics of commonly-used hazardous chemicals. It also classifies dangerous chemicals into eight categories, namely explosives, compressed gas, liquefied gases, flammable liquids, flammable solids, spontaneously combustible materials, flammable substances when encountering wetness, oxidants and organic peroxides, toxic substances, radioactive materials and corrosive substances.

These eight categories of chemicals are different in characteristics, but all of them can cause damages if they are not handled properly. The damages fall into three categories, namely the damages to the human body, the potential of fire and explosion and the damages to the environmental pollutions. If the characteristics of these dangerous chemicals are not clearly understood and they are not packaged, stored, transported and handled properly, they can cause damages to humans and environments.

2.1.2 Special features of petrochemical logistics

There have been increasing demands in the world for petrochemical products, which has required petrochemical companies to reach more customers. The increase in global demands has made the petrochemical logistics more challenging and complicated. Although logistics management is very important, the petrochemical industry is still in the infancy stage of managing their logistics efficiently. "Just as Werner Paratorius, president of BASF's petrochemicals division said, supply chain management is the backbone of a business where logistics costs can be greater than manufacturing costs (Whitfield, 2004, p. 12)".

> The logistics management of petrochemical industry is extremely complex compared to other industries. Its supply chain is divided into two different, yet closely related, major segments: the upstream and downstream supply chains. The upstream supply chain involves the acquisition of crude oil, which is the specialty of the oil companies. The upstream process includes the exploration, forecasting, production, and logistics management of delivering crude oil from remotely located oil wells to refineries. The downstream supply chain starts at the refinery, where the crude oil is manufactured into the consumable products that are the specialty of refineries and petrochemical companies. The downstream supply chain involves the process of forecasting, production, and the logistics management of delivering the crude oil derivatives to customers around the globe (Hussain, 2006, p. 91).

Petrochemicals require some specific transportation modes, for example, vessels, tankers, pipelines and railroads. These petrochemicals are produced in some limited and specific regions in the world, but they are demanded all over the world because they are a vital source of energy and raw materials for many other industries. “Several weeks’ lead time from the shipping point to the final customers’ location is very common in this type of industry (Hussain, 2006, p. 91)”. For instance, “it takes five weeks for the Persian Gulf’s oil to make its way to the United States and up to another three weeks for it to be processed and delivered (Schwartz, 2000, p. 49)”.

In addition, “the logistics network in the petrochemical industry is highly inflexible, which arises from the production capabilities of crude oil suppliers, long transportation lead times and limitations of modes of transportation (Hussain, 2006, p. 91)”. Therefore, each point in the logistics network represents a major challenge.

The petrochemical industries are global in nature, as a result of which, these commodities and products must be transferred between locations that are sometimes continents apart. “The long distance between supply chain partners and slow modes of transportation induce not only high transportation costs and in-transit inventory, but also high inventory carrying costs in terms of safety stocks at the final customer location (Hussain, 2006, p. 91)”. The far distances between partners of supply chain are a high variability of transportation times, which can exert an influence on the suppliers’ service levels and final customers’ costs of safety stock. “Moreover, the transportation process is carried out either by ships, trucks, pipelines, or railroads. In many instances, a shipment has to exploit multiple transportation modes before reaching the final customer’s location (Hussain, 2006, p. 91)”. “Very few industries deal with that kind of complexity in shipping,” said Doug Houseman, a senior manager at the consulting firm Accenture (Morton, 2003, p. 31)”. Such limitations on the modes of transportation in petrochemical industry lead to long lead times from the shipping point to the final customers’ location compared with other industries. “Hence, considering the amount of inflexibility involved, meeting the broadening prospect of oil demand and its derivates while maintaining high service levels and efficiency is a major challenge in the petrochemical industry (Hussain, 2006, p. 92)”.

2.2 The market environment of Chinese petrochemical logistics

2.2.1 The demand of Chinese petrochemical logistics

In recent years, Chinese petrochemical industry maintains its momentum of rapid development, which makes its petrochemical logistics demand present the following characteristics.

First of all, the continuous growth of Chinese petrochemical industry enlarges the market size of petrochemical logistics demand. Generally speaking, the total amount

of petrochemical logistics demand is positively correlated with the macro indexes such as total amount of transaction. The ever-increasing types and outputs of petrochemical products, together with the enlarging imports and exports of petrochemical trade, motivate the growth of petrochemical products circulation, thus providing wide market space for the petrochemical logistics.

Secondly, the capital restructuring of Chinese petrochemical industry makes Chinese petrochemical logistics demand gradually conform to the international standards. The petrochemical industry is a capital and technology-intensive industry, which needs huge investment and complicated technology. In the past, the development of petrochemical industry mainly depends on the investment of Chinese government. However, with growing tendency towards economic globalization, the increasingly fierce competition of petrochemical products as well as the strict control of multinational companies over high and new technology, the original layout of Chinese petrochemical industry is undergoing radical changes. Our country has allowed foreign and nongovernmental capital to invest in downstream equipment. Many jointly-constructed projects, such as Yangtze-BASF Cinnamene, Philip polyethylene, Guangzhou Shell, to name just a few, had already been completed by 2005. The capital restructuring in petrochemical industry brings along the conformability of petrochemical logistics demand to international standards and poses high requirements on logistics technology and facilities.

Last but not least, the increasingly fierce competition increases the demands of petrochemical products manufacturers for outsourcing. The large quantities of imports of petrochemical products, together with the opening of Chinese markets to the outside world, intensify the market competition of domestic petrochemical products. Forced by the pressure of competition, many petrochemical enterprises pay

more and more attention to logistics. Many petrochemical enterprises, especially the small and medium-sized ones, gradually outsource their logistics business instead of operating logistics on their own, so that they can concentrate on their core business to increase their competitiveness both in domestic and foreign markets.

2.2.2 The supply of petrochemical logistics

The supply of Chinese petrochemical logistics includes many aspects, of which the situation of petrochemical logistics service suppliers is the main aspect.

Due to the special characteristics of petrochemical products, such as the dangerous characteristic, the logistics of petrochemical products was mainly run by enterprises themselves in the past. However, with the demand market presenting the tendency towards pluralism, petrochemical logistics service providers are also developing themselves towards pluralism. Generally speaking, the types of petrochemical logistics service providers in China are as follows.

1. The internal logistics departments or subcompanies established by the enterprises themselves.

There are two situations concerning this type of logistics service providers. The first situation is that these enterprises have their own specialized distribution systems, which mostly happens to big enterprises, such as Sinopec (China Petroleum & Chemical Corporation) and CNPC (China National Petroleum Corporation). In order to reduce costs, these companies adopt the methods of centralized procurement and inventory, and organize distribution according to the production planning their respective plants.

The other situation is that the petrochemical enterprises, in addition to producing petrochemical products, provide such services as transportation and storage for their customers as well, relying on their specialized equipment and technical advantages. For them, logistics services are their extended services.

2. The petrochemical logistics enterprises in transformation from traditional transportation, warehousing and forwarding enterprises.

Some traditional transportation, warehousing and forwarding enterprises, such as Cosco International Freight Corporation, China Material Storage & Transportation and Sinotrans are in the process of transforming from providing single transportation and warehousing services to specialized all-round logistics enterprises by continuously extending their business scope, relying on their original business and customer base, facilities and networks. A proportion of petrochemical products such as fertilizers, pesticides, finished oil products are transported, stored and distributed by these enterprises.

3. Specialized domestic logistics enterprises

Some specialized logistics enterprises in China, such as Paogong Logistics Group, Hua Yuntong logistics corporations, have flexible competition strategies and a profound command of specialized logistics, thus they develop very rapidly in the market competition. These enterprises mainly provide logistics services for foreign-funded petrochemical enterprises.

4. Foreign-funded petrochemical logistics enterprises

Currently, some large petrochemical logistics enterprises have set foot in China, such as Vopak, Stolt, Dovechem, Hoyer, Suttons. These enterprises conduct their logistics services in China in the form of agencies or joint ventures. They represent quite a large proportion of logistics services relying on their abundant experience, high quality services, top class management and outstanding talents.

In short, parallel to the demand market of petrochemical logistics, the services provided by petrochemical logistics suppliers are also growing towards the direction of pluralism and becoming more specialized and comprehensive. They are supposed to provide integrated logistics solutions.

2.2.3 Logistics management of Chinese petrochemical logistics

In this section, the management of the Chinese government and logistics industry associations concerning the petrochemical logistics will be discussed.

1. The governmental management of Chinese petrochemical products

The governmental management regarding petrochemical logistics mainly embodies such aspects as macro-regulation, coordination, legislation and infrastructure construction. The logistics of petrochemical products has something to do with imports and exports, production, transportation, storage, sales, utilization and disposal. At present, these links are managed by different departments. In the meantime, different petrochemical products are administered by different departments. The main managerial departments and their respective duties are described as follows.

The Chinese Petroleum and Chemical Industry Bureau is in charge of the production

management of petrochemical industry. General Administration of Quality Supervision is in charge of the formulation of hazardous chemicals. State Environmental Protection Administration of China is responsible for the environmental management of petrochemical products. The Ministry of Communications, The Ministry of Railways and General Administration of Civil Aviation of China is in charge of the highway, railway and aviation transportation of petrochemicals respectively. The Ministry of Public Security is responsible for the security management of explosives and hazardous petrochemicals. The Ministry of Commerce is in charge of the trade management, imports and exports of petrochemicals.

All relevant ministries and commissions independently administer the production, utilization, operation, transportation, imports and exports of petrochemical products within the scope of their own duties according to the national regulations. The biggest problem of this kind of management system is too much division and overlap of work, which needs coordination by the government. This problem will be discussed in depth in the SWOT analysis.

2. The management of the logistics industry associations

At present, there are more than ten most influential and far-reaching logistics associations in China, such as Chinese Communication and Transportation Association, Chinese Logistics and Procurement League, Chinese warehousing Associations. However, specialized petrochemical logistics industry associations have not been established as yet.

During the writing of this dissertation, the author finds that the data in the field of

petrochemical logistics is quite deficient. This is mainly because there is no specialized organization to conduct surveys and collect the relevant information. On the one hand, the Chinese government is supposed to give full play to the functions of existing logistics associations and promote their managerial levels, on the other hand, it should establish specialized petrochemical logistics associations to promote the development of petrochemical logistics.

2.3 SWOT analysis of Chinese petrochemical logistics

SWOT analysis is a very useful tool in the strategic studies, which is widely used in the strategic management, market analysis and competitor analysis, etc. In fact, SWOT is a method to summarize the internal and external conditions, on the basis of which to analyze its own strength, weaknesses, opportunities and threats. Among them, strengths and weaknesses are mainly focused on its own advantages and the comparison with its competitors, while opportunities and threats are devoted to the changes of external environment and their effects on the company itself. The purpose of SWOT analysis is to provide future development strategies and directions. By forming SWOT matrix, the analyzer can obtain four strategies, namely SO, WO, ST, WT strategy respectively. SO strategy is to take the advantage of strengths and opportunities. WO strategy is to overcome weaknesses and make use of opportunities. ST strategy is to make use of strengths and avoid threats. WT strategy is to make up for weaknesses and avoid threats.

Table 2.1-SWOT matrix

	Opportunities	Threats
Strengths	SO strategy	ST strategy
Weaknesses	WO strategy	WT strategy

2.3.1 Opportunities faced by Chinese petrochemical logistics development

1. The overall macro-environment of Chinese logistics industry is becoming increasingly favorable.

The macro-environment of Chinese logistics industry has improved a lot in recent years. As a branch of logistics, petrochemical logistics is inevitably affected by these macro factors, and at the same time, it also enjoys the benefits of these improvements.

First of all, the continuous economic development lays a solid foundation for logistics development. Since the reform and opening up policy, Chinese economy has been developing very rapidly. In 2006, Gross Domestic Product reached 20.9407 trillion RMB, 10.7 per cent higher than the previous year. GDP figures from 2001 to 2006 are listed in the following figure. With the rapid growth of national economy, the social demands of logistics have also been increasing very fast. During the Tenth Five-year Plan, the total amount of social logistics increased by 23 percent, the growth rate of which was obviously faster than GDP in the same period. Not only does this indicate that Chinese logistics is at the stage of rapid development, but it also demonstrates that the dependence of social economic development on logistics is becoming increasing higher.

Secondly, foreign trade has been developing very fast, providing capacious space for international logistics development. The continuous deepening of open economy promotes the development of Chinese logistics. The fast pace of economic globalization, together with the continuous deepening of open economy, provides capacious prospect for Chinese logistics to step into the global market, which also

bridges the gap between our country and advanced countries. The economic globalization requires more trade and commodities exchange, which in turn, needs more high quality and efficient logistics services.

In 2006, the total amount of foreign trade reached 1.7607 trillion USD, 23.80 per cent higher than the previous year, maintaining rapid growth rate of more than 20 per cent for five successive years. The total amount of imports and exports from 2001 to 2006 are listed in the following figure. The fast growth of Chinese foreign trade has a profound effect on the competitiveness of national economy, while the development of international trade will inevitably bring along the growth of both international logistics and domestic logistics demands, thus promoting the competitiveness of Chinese logistics industry in the global market.

2. Chinese petrochemical industry is developing prosperously.

In China, the huge market demands for petrochemical products will vigorously promote the development of petrochemical industry, which will in turn, provides promising future for the development of petrochemical logistics. It is reported that in the future 20 years, Chinese petrochemical industry will enter the era of rapid growth. By the year 2010, the consumption of main petrochemical products in China will have accounted for one third of the total amount in the whole world.

According to Sun Weishan, the deputy secretary-general of Chinese Petroleum and Chemical Association, in the Tenth Five-year Plan, Chinese petrochemical industry developed very fast, including all the main economic indices. In 2005, the total output of Chinese petrochemical industry was 3 trillion RMB, 138 per cent higher than that of 2000, which means that the annual growth rate was 15.61 per cent. The

total profits of petrochemical industry in 2005 were 350 billion RMB, increasing by 222% compared with those of 2000, meaning the annual growth rate was 21.56 per cent.

3. Foreign enterprises have increased their investments in Chinese petrochemical industry.

Large-sized domestic petrochemical logistics parks are developing at full speed, thus attracting foreign enterprises to increase their investments in China. In Shanghai, the representative one is the Shanghai Chemical Industry Park, which is located in Caojing and covers an area of 29.4 square kilometers. In the Tenth Five-year Plan, it is one of the largest industrial projects with the most investments. Since the reform and opening-up policy, it is the first park that specializes in petroleum and chemistry. After completion, its production value is estimated to reach 100 billion RMB.

Shanghai Chemical Industry Park adopts the advanced concept of “integration” of world-class large chemical parks, meaning that it provides the investors with the most favorable investment environment through the integration of products, projects, infrastructure, logistics, transportation, environmental protection and management services. Because of its favorable infrastructure and prospects, it has attracted the investment of a great many world-renowned petrochemical companies, such as Bayer, BASF, Sinopec, CNPC, Degussa, American Huntsman and Holland Vopak, to name just a few. As of August 2006, the total project investment reached 9.23 billion USD. The goal of Shanghai Chemical Industry Park is to become one of the largest, most centralized top class petrochemical base in the world.

In addition, other famous Chinese petrochemical parks include Nanjing Chemical

Industry Park, Yangtzi Chemical Industry Park, Shangyu Chemical Industry Park and so on. The rapid development of Chinese petrochemical logistics parks not only provides a number of business opportunities for foreign enterprises, but also provides a promising future for the development of petrochemical logistics.

4. Chinese petrochemical enterprises are improving their core competitiveness.

Influenced by the traditional planning economy, Chinese manufacturing industry is characterized by its multilayer and comprehensive management and organization style, as a result of which, not only logistics function but also other non-value-added functions are mixed with the core functions of an enterprise. Not only will this weaken the attention of the enterprise on the production, but it will also increase the logistics costs, thus offsetting the competitiveness of the enterprise. Therefore, at present, many enterprises have begun to outsource their logistics businesses to focus on their core businesses, with a view to promoting their competitive advantage both at home and abroad.

It is also a question faced by Chinese petrochemical enterprises how to operate logistics. It is estimated that the calculation costs from completion through storage and transportation to customers account for nearly a half of the price of a product, worse still, those costs of petrochemical products incredibly account for 70 to 80 percent of the sales price. Although developing modern petrochemical logistics is not the only way to solve these problems. However, it will undoubtedly play an active role in improving the specialization and production efficiency of the enterprise concerned.

As far as the three largest petrochemical enterprises in China, namely CNPC,

Sinopec and CNOOC are concerned, their management levels have all come to the same conclusion that confronted with the fierce global competition, it is high time that they restructured their corporate hierarchy to focus on their core businesses. Only when petrochemical enterprises promote their logistics efficiency and understand logistics management from the strategic level can they integrate more social resources, improve their core competitiveness and escalate the enterprises to a higher level.

2.3.2 Threats faced by Chinese petrochemical logistics development

1. The competition for the share of petrochemical logistics markets is becoming increasingly fierce.

In the past, many enterprises have fallen into a habit that every time they conduct a reform, they hope to gain some preferential policies. This is also the case with some petrochemical logistics enterprises. However, our country has entered WTO, as a kind of service industry, logistics industry does not fall into the protective category. Therefore, it is unrealistic to expect the Chinese government to put forward some protective and preferential policies regarding taxation and investment.

Under the framework of WTO, due to the market access of logistics industry, the competition for the Chinese petrochemical logistics market share is becoming increasingly fierce. With regard to the market access of logistics industry, China made the following promise at the point of entry into WTO that it would provide overseas companies with the trade rights and sales rights. Trade rights would be carried out in three years' time gradually. More specifically, when it comes to fertilizers, crude oil, and petrochemical products, the restrictions on storage, transportation, warehousing, packaging, would be cancelled in three years' time.

Furthermore, foreign-funded logistics service providers are allowed to be established in China, which means that in 2005, overseas large-sized petrochemical logistics enterprises have already been allowed to establish solely-funded braches in China, thus competing with Chinese ones for the petrochemical logistics market share.

Currently, there are already a host of overseas petrochemical enterprises establishing representative offices or joint ventures in China, such as Holland-based Vopak, which is one of the largest petrochemical logistics services providers in the world, England-based Stolt, Hoyer and Suttons. Depending on their strong financial strength, advanced technology, managerial experience and global networks, they try to not only enter Chinese petrochemical logistics markets but also increase their petrochemical logistics market shares in China. Competition is inevitable. Chinese petrochemical logistics enterprises are faced with the competition of large multinational logistics enterprises.

2．Too much division and overlap of work in logistics management system inhibits the sound development of petrochemical logistics.

In spite of the fact that central and local governments lay much emphasis on the logistics development, there is too much overlap and division of work in the logistics management system, which inhibits the logistics development.

Since Mr. Deng Xiaoping began to carry out new policy in 1978, China’s economic structure has undergone radial changes. But the political structure remains almost unchanged, which is nearly the same as the former planned economy. This leads to many overlapping functions among different departments and administrations.

Under the State Council, there are several departments, or ministries, that are in charge of part of the logistics industry or supply chain sectors. Among them, there is an integrated planning administration called the National Development and Reform Commission, or NDRC, which is responsible for the macroeconomic control and overall planning and reform of China's economic system. Its departments manage and control every sector of the logistics and supply chain industries, and it sets policies for China's overall economic development.

The Ministry of Communication is primarily in charge of the highway and water transportation and port administration. The Ministry of Railways is in charge of planning, construction, and operation of the railway system. General Administration of Civil Aviation of China is in charge of all air transportation administrative issues. The Ministry of Commerce is in charge of domestic and international trade, including service and investment related to logistics and transportation. The Ministry of Information Industry oversees planning, regulation, and standardization of the information industry.

Other ministries and administrations that control part of the logistics and supply chain industries are the Ministry of Public Security, Customs General Administration of China, State Administration of Taxation, State Administration for Industry and Commerce, Ministry of Finance, General Administration of Quality Supervision, Inspection and Quarantine of China and Standardization Administration of China ("Global perspective," 2005, p. 7).

Too much division of work imposes some restrictions on the petrochemical logistics development, mainly from two aspects. On the one hand, it increases transportation costs and prolongs transportation cycles, thus reducing logistics efficiency. On the other hand, it increases transportation links and numbers of loading, unloading and movements, thus increasing the risks of petrochemicals transportation. For instance, a certain petrochemical logistics company transported petrochemicals from Shanghai to Yunnan, using containers. When the container arrived in Yunnan, the local railway department claimed that unloading was not allowed without the prior approval from upper management level. In order to save time, the company had to transport the petrochemicals to Shantou, and then transported them to Kunming with trucks. Not only did this result in the increase of logistics cost, but it also increased the risks of petrochemicals transportation.

3. The proportion of inhousing logistics is too large and there are insufficient demands for logistics outsourcing.

In spite of the fact that more and more petrochemical enterprises have come to realize the importance of logistics and the advantages of the third party logistics, inhousing logistics still accounts for a very large proportion in the petrochemical logistics. Worse still, the situation is difficult to be improved radically. The main reasons for this situation are as follows.

First of all, the sunken costs are the restrictions for inhousing logistics to exit. When an enterprise is prepared to exit an industry, it is restricted by many factors, one of which is sunken costs. In the past, most petrochemical enterprises operate their logistics on their own. They establish their own warehouses, buy their own trucks, thus having a lot of logistics facilities, as a result of which, when they decide to

outsource their logistics, these facilities are major obstacles for them.

Secondly, the third party logistics companies have not formed scale economies, the operational costs of which are still quite high. At the same time, the services they provide are sometimes disappointing.

Thirdly, because petrochemical products are characterized by their volatilization, combustion and explosion, there are highly strict service standards and technical levels as well as limitations with regard to the selection of logistics service providers. However, most petrochemical logistics service providers do not have the specialized equipment to handle these dangerous petrochemical products.

It is the above-mentioned factors that restrict petrochemical enterprises from exiting inhousing logistics. In spite of the rapid growth of petrochemical industry, the corresponding service level of petrochemical logistics service providers has not developed well.

2.3.3 The advantages of Chinese petrochemical logistics service providers

The variations of petrochemical logistics market provide different opportunities and challenges for different logistics service providers. These differences are determined by their own advantages and disadvantages. As for Chinese petrochemical logistics service providers, they have the following advantages.

1. They have the advantage of domestic logistics networks.

In the past, because the Chinese government adopted the exclusive policy in the logistics field, it was difficult for overseas logistics service providers to gain the

market access. During that time, domestic logistics service providers formed their own powerful logistics networks.

2. They have domestic customer resources.

Just as the same reason why they have the advantage of domestic logistics networks, domestic logistics service providers have long been serving domestics petrochemical enterprises. Therefore, they have already formed stable customer bases in the long-term cooperation.

3. They have a localized management team.

One of the biggest advantages of domestic petrochemical service provider is that they have an outstanding localized management team, which is more familiar with Chinese petrochemical logistics market, regulations, culture and national conditions. These are their precious resources. However, overseas logistics companies will attract these distinguished talents by means of attractive salary and their advanced technology. Therefore, it is a problem that is well worth considering how to regulate encouraging human resources policies. Otherwise, these talents will in turn become the competitors of domestic petrochemical logistics enterprises.

4. They have the advantage of labor costs.

The average income of employees in domestic petrochemical logistics enterprises is much lower than that of overseas ones. However, it must be realized that this advantage of labor costs is mainly because China is a developing country. With overseas logistics enterprises entering Chinese market, domestic ones must face the

fierce competition for talents. They have to change their salary policies and raise their salary levels. However, with the localization of overseas logistics enterprises, this advantage of labor costs will disappear ultimately.

5. Their service price is low.

Because of the low labor costs and the low management level of domestic petrochemical logistics enterprises, they have the advantage of low service price. For instance, Yunnan YunPhos Corporation is a company specializing in the imports and exports of phosphor, which once exported phosphor to Europe and US. There were two companies bidding for the contract, namely England-based Stolt Corporation and Shanghai Milky Way International Container Transportation Corporation. Although the former has its own global networks, better management and technical level, Shanghai Milky Way Corporation won the bid because of its 30 percent lower price.

However, this price advantage is established on the basis of low management and service level. In the long run, it is certain that price is an important competitor factor, but for the petrochemical logistics service providers, the core competitiveness is more based on technical and service level. Therefore, the correct way is to improve their technical and service level and maintain the price advantage by means of scale economy.

2.3.4 The weaknesses of Chinese petrochemical logistics service providers

Compared with their advantages, the weaknesses of domestic petrochemical logistics service providers are more obvious, the most prominent of which are as follows.

Firstly, they have few overseas distribution networks. In contrast with their

advantage of domestic network resources, overseas logistics networks are their disadvantage.

Secondly, they have few overseas customer resources. Domestic petrochemical logistics providers have always been serving domestic customers. Some of them are even transformed from the logistics departments of petrochemical companies. In addition to that, foreign-funded petrochemical companies tend to choose the services of overseas petrochemical logistics service providers. It should be admitted that in terms of technical and management level, there is a huge gap between domestic logistics companies and overseas ones.

Thirdly, their service senses and methods are lower than domestic petrochemical logistics service providers. The integration of logistics services is far from satisfactory in China. It is a common phenomenon that the logistics service providers are only in charge of the transportation. When petrochemical companies want to store their products, they have to find another warehousing company. Lack of integration is the bottleneck of domestic logistics companies.

Last but not least, they have less advanced and specialized logistics facilities than overseas petrochemical logistics service providers. In order to transport and store dangerous petrochemical products, some specialized facilities are needed. However, the facilities of most domestic logistics companies are for general transportation purposes.

2.4 Suggestions concerning Chinese petrochemical logistics development

2.4.1 Measures which individual petrochemical logistics service providers can take

According to the SWOT analysis of the previous section, the matrix of Chinese petrochemical logistics enterprises will be established.

Table 2.2-SWOT matrix and corresponding measures

Opportunities and Threats / Strengths and Weaknesses	Opportunities	Threats
	1.Favorable macro logistics environment 2.Rapid growth of petrochemical logistics 3. Big foreign investment 4.Concentration on core competitiveness	1.Rising market competition 2.Too much division of work 3.The obstacles to exit inhousing logistics
Strengths 1. Domestic distribution networks 2. Domestic customer resources 3. Localized management team 4. Cost advantage 5. Price advantage	1. Give full play to the advantage of domestic customer resources to occupy logistics markets and improve market share. 2. Integrate internal logistics resources to form nation-wide distribution networks.	1. Cooperate with overseas logistics companies to develop together, converting from competitors to partners. 2. Domestic logistics companies cooperate or merge with each other to give full play to their respective advantages.

Weaknesses	1. Formulate their positioning and development plans to find their own core competitiveness and target customers. 2. Formulate competitive human resources policies to attract logistics talents to improve service senses.	1. Convert pressure into impetus and bring “catfish effect” into play. 2. Widen financing channels and purchase inhousing logistics and become partners of customers, thus forming scale advantage.
1. Overseas distribution networks 2. Few overseas customer resources 3. Lower service senses and methods 4. Less specialized logistics facilities		

Now each item will be elaborated on.

1. SO strategy

(1) Bring the advantage of domestic customer resources into full play to further occupy logistics markets and improve market share.

Domestic petrochemical logistics enterprises have relatively stable domestic customer resources, on the basis of which they can bring their price advantage into full play and grasp the advantage of the rapid development of petrochemical industry to further occupy domestic market and increase market shares.

(2) In terms of large-sized petrochemical enterprises with abundant resources, they can form nationwide service networks by integrating internal logistics resources.

Take Sinopec as an example, it has a huge base of logistics resources, including

warehouses, loading and unloading facilities, logistics information systems and experienced management team. In the meantime, it has huge market business volume. Therefore, this kind of enterprises can integrate their current logistics resources to establish a distribution network which covers the whole country. In the last chapter, the author will analyze a case concerning the economic benefits improvement after a famous and huge Chinese petrochemical enterprise restructured its logistics systems.

2. ST strategy

（1）Cooperate with overseas petrochemical logistics companies to develop together, converting from competitors to partners.

The reasons to cooperate with overseas advanced logistics companies are that overseas logistics companies can gain such advantages as domestic distribution networks, market access, and localized management team. Correspondingly, domestic logistics companies can gain the advantage of advanced logistics technology, strong financial support and overseas distribution networks. What is more important is that they can learn the advanced logistics operational experience and service senses of overseas logistics companies. Therefore, domestic petrochemical logistics enterprises should seek cooperation with overseas logistics enterprises and convert from competitors to partners, thus complementing their respective advantages.

（2）Domestic logistics companies cooperate or merge with each other to give full play to their respective advantages.

Faced with increasingly fierce market competition, domestic petrochemical logistics

enterprises can cooperate or merge with each other to complement their respective advantages. In this way, large-sized logistics companies with scale advantage and high core competitiveness can be established. These companies should step into the global market to integrate into overseas petrochemical markets.

3. WO strategy

Faced with the opportunities brought by the huge petrochemical logistics market demands, how to avoid weaknesses and grasp the opportunities?

(1) Formulate their own positioning and development plans to find their own core competitiveness and target customers.

Logistics activities are ubiquitous. Although domestic petrochemical logistics enterprises are disadvantaged in many aspects, they can find their own target customers by analyzing domestic petrochemical logistics demands. For instance, they can segment the markets to know what the respective logistics demands of large-sized and small and medium sized petrochemical companies are. On the other hand, they can know what the different logistics demands of petrochemical companies producing different types of petrochemical products. On the basis of market segmentation, they can know their own service characteristics, fields and directions to avoid the market segments which fit into their competitors' advantages. This is company-positioning, on the basis of which they can formulate their development plans. By well-defined market segmentation and market development plans, domestic petrochemical logistics enterprises can find their own target customers and have their own market shares.

(2) Formulate competitive human resources policies to attract high level logistics talents for the purpose of improving market senses and methods.

Specialized logistics talents are extremely important for the long-term development of the company. Therefore, domestic petrochemical logistics enterprises should formulate competitive human resources policies to attract these talents, which are essential to improve their service senses and methods, using the specialized and advanced knowledge of these talents.

4. WT strategy

(1) Convert pressure into impetus and bring “catfish effect” into play.

The “catfish effect” is that a Japanese fisherman lived by selling tuna. Other fishermen’s tuna were easy to die during the transportation to the market. Only his tuna were mostly alive and sold well. The secret was that before transportation, he always put some fierce catfish into the tuna. The catfish liked to eat tuna, making lazy tuna swim continuously. In this way, in spite of the loss of some tuna, others survived because of the dread and pressure.

Tuna are lazy and prone to die in peaceful environment, while in adverse and dangerous conditions, they are energetic and strive to survive. This is similar to the situations of domestic petrochemical enterprises, which are challenged by many overseas ones, whose entry into Chinese market makes the competition of logistics markets increasingly fiercer. However, they also bring us advanced logistics concepts and management technology. If domestic petrochemical logistics enterprises can improve themselves continuously in the competition, they will

become the “living tuna”.

(2) Domestic petrochemical logistics enterprises can widen financing channels and purchase inhousing logistics and become partners of their customers.

Many petrochemical logistics enterprises have the intension to outsource their logistics and focus on their core businesses, which is a good opportunity for domestic petrochemical logistics enterprises to purchase their logistics functions. Through high-quality services, they can become partners of their customers.

2.4.2 Measures the government can take to promote Chinese petrochemical logistics development

In the preceding section, the measures which can be taken by the petrochemical logistics service providers themselves are discussed. In this section, based on the SWOT analysis, the role which the Chinese government can play to promote Chinese petrochemical logistics development will be discussed.

1. The Chinese government should establish a system which is favorable for the petrochemical companies to exit inhousing logistics.

In order to promote the petrochemical logistics development, the Chinese government should encourage petrochemical enterprises to outsource their logistics functions to improve production efficiency through division and specialization of work. Just as is mentioned before, there are many obstacles for petrochemical enterprises to exit inhousing logistics. So the key point is to establish a system which is favorable to them to exit inhousing logistics. For instance, some special depreciation rate or financial compensations can be given to them to encourage them

to eliminate logistics facilities or create some job opportunities for those who are laid off because of the corporate restructuring.

2. The Chinese government can establish a calculation system to calculate logistics costs independently.

According to the current accounting system of our country, there is no independent accounting subject called logistics costs, meaning that logistics costs are not calculated independently. Instead, they are distributed into procurement costs, management costs, production costs and storage costs, transportation costs and sales costs and so on. The disadvantage of this calculation system is that the management level of an enterprise can not gain the clear statistics of logistics costs. Neither can they control, assess or analyze the logistics costs effectively. In order to overcome the disadvantage of logistics costs calculation, the current accounting system should be improved to calculate logistics costs independently.

If the logistics costs are calculated independently, there are two choices which current logistics calculation system can select. The first choice is that the relevant regulations of current accounting system are abolished. More specifically speaking, logistics costs are separated from the original mixed accounting subjects to set up an independent accounting subject called logistics costs. The other choice is that logistics costs are still calculated according to the regulations of current accounting system. But another management accounting record book is set up to summarize logistics costs on the basis of their items. In this way, the concrete contents of logistics costs should be analyzed and ascertained. Since enterprise logistics is composed of supply logistics, production logistics and sales logistics, logistics costs can be divided into three categories accordingly, namely supply logistics costs,

production logistics costs and sales logistics costs. Thus, logistics costs can be analyzed and assessed correctly.

No matter which method is used, the necessity of calculating logistics costs independently is becoming more and more obvious. The Chinese government should make great amendments to the regulations of current accounting calculation system to meet the requirement of logistics development.

3. The Chinese government should change the situation of too much division of work.

As is mentioned in the threats faced by Chinese petrochemical logistics development, there is too much division and overlap of work in the logistics management system. Not only does this affect the coordinative development of various logistics functions and services, but it also wastes logistics resources. In order to solve these problems, a unified management organization should be established. This management organization can be a united body of the existing agencies to implement their respective functions.

In most advanced countries, usually a single department is in charge of the formulation and implementation of regulations regarding the transportation of dangerous petrochemicals. For instance, United States Department of Transportation is in charge of the formulation and unified management of regulations with regard to highway, railway, airline and inland waterway transportation.

In China, a feasible way is that on the basis of respect for the functions of various departments, under the leadership of national comprehensive economic management

departments, a high-level coordination organization is established to lead and coordinate national logistics development harmoniously. In future reform, the governmental functions regarding logistics can be centralized to improve the management efficiency, thus creating an environment which is favorable for the sound development of logistics industry.

2.5 Some conclusions

In this chapter, the market environment and status quo of petrochemical logistics development in China is elaborated on. At first, the market environment of Chinese petrochemical logistics is briefly introduced, mainly from three aspects, namely the characteristics of petrochemical logistics demand, four common types of petrochemical logistics supply and the logistics management of petrochemical logistics industry. Then, the SWOT analysis is conducted concerning the current situations of Chinese petrochemical logistics. The general environment is quite promising, but there are still some hurdles to overcome for Chinese petrochemical logistics service providers to compete with overseas ones. On the basis of SWOT analysis, the matrix is established to put forward SO strategy, ST strategy, WO strategy and WT strategy respectively which the individual petrochemical logistics service provider can take. In addition, the macrocosmic measures which the Chinese government can take to promote Chinese petrochemical logistics development are also suggested.

3 THE DECISION-MAKING OF LOGISTICS OPERATIONAL MODES OF PETROCHEMICAL ENTERPRISES—INHOUSING, OUTSOURCING OR ESTABLISHING AN INDEPENDENT SPECIALIZED LOGISTICS SUBSIDIARY

There are three logistics operational modes which a petrochemical enterprise can choose, namely inhousing, outsourcing and establishing an independent and specialized logistics subsidiary within the whole group. Inhousing means operating logistics by the petrochemical company itself. This operational mode enables the company to have full control over its logistics resources and runs minimum risks. Outsourcing means giving its logistics functions to a third party logistics service provider. This operational mode enables the company to focus on its core competitiveness and enjoy the benefits of the specialized service of a third party logistics company. But it loses control over its logistics resources completely, thus running maximum risks. The compromise form between the above mentioned two forms is to establish an independent and specialized logistics subsidiary within the whole group. This subsidiary is operated and calculated independently, but it is still affiliated to the group. Therefore, the petrochemical enterprise still has some control over its logistics functions but it can still enjoy the advantages brought by the specialized logistics subsidiary. In addition, the independent logistics subsidiary

functions as a profit center rather than a cost center in the sense that it shifts from a unit serving the petrochemical enterprise to an independent petrochemical logistics service provider not only serving its group, but also serving the society, thus creating profits for the petrochemical enterprise. Thus, this form can be considered as a kind of compromise between inhousing and outsourcing. In this chapter, the AHP model will be established to decide which form is the most appropriate when a petrochemical company chooses the logistics operational mode.

3.1 Introduction to AHP model

The Analytic Hierarchy Process (AHP) was initially presented by Saaty in 1980 for use in solving multiple criteria decision problems. Using a systematic hierarchy structure, complex estimation criteria can be represented clearly and definitely. Ratio scales are utilized to make reciprocal comparisons for each element and each layer.

After completing the reciprocal matrix, one can obtain comparative weights for each element. Tsungyu used AHP to set up an evaluation model for shipping companies. In his paper, Tsungyu generalized the main steps of AHP as follows:

Consider the criteria C_1; . . . ; Ci; . . . ; Cj; . . . ; Cn some one level in the hierarchy. One wishes to find their weights of importance, w_1; . . . . w_i . . . . ; w_j . . . . . w_n on some elements in the next level. Allow a_{ij}, i, j = 1, 2, ... n to be the importance strength of C_i when compared with C_j. The matrix of these numbers a_{ij} is denoted A,

or $\begin{bmatrix} a_{11} & a_{12} & .. & .. & a_{1j} & .. & .. & a_{1n} \\ . & . & .. & .. & . & .. & .. & .. \\ a_{i1} & a_{i2} & .. & .. & a_{ij} & .. & .. & a_{in} \\ . & .. & .. & .. & . & .. & .. & . \\ a_{n1} & a_{n2} & .. & .. & a_{nj} & .. & .. & a_{nn} \end{bmatrix}$ where $a_{ji} = 1/a_{ij}$, that is, A is reciprocal.

If one's judgment is perfect in all comparisons, then $a_{ik}=a_{ij}*a_{jk}$ for all i; j; k and one calls the matrix A consistent. Thus, when matrix A is multiplied by the

vector formed by each weighting $w = (w_1, w_2 \ldots. w_n)^T$, one gets:

$$\mathbf{A_w}=\begin{bmatrix} w_1/w_1 & w_1/w_2 & .. & .. & w_1/w_j & .. & .. & w_1/w_n \\ w_2/w_1 & w_2/w_2 & .. & .. & w_2/w_j & .. & .. & w_2/w_n \\ . & .. & .. & .. & .. & .. & .. & .. \\ . & .. & .. & .. & .. & .. & .. & .. \\ w_i/w_1 & w_i/w_2 & .. & .. & w_i/w_j & .. & .. & w_i/w_n \\ . & .. & .. & .. & .. & .. & .. & .. \\ . & .. & .. & .. & .. & .. & .. & .. \\ w_n/w_1 & w_n/w_2 & .. & .. & w_n/w_j & .. & .. & w_n/w_n \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ . \\ . \\ . \\ w_j \\ . \\ . \\ . \\ w_n \end{bmatrix} =n* \begin{bmatrix} w_1 \\ w_2 \\ . \\ . \\ . \\ w_j \\ . \\ . \\ . \\ w_n \end{bmatrix} =nw$$

Because a_{ij} is the subjective rating given by the decision-maker, there must be a distance between it and the actual values $w_i=w_j$. Thus, A_w= nw can not be calculated directly. Therefore, Saaty suggested using the maximum eigenvalue, λ_{max}, of the solution of matrix A to replace n, then $A_w=\lambda_{max}w$. By this method, one can obtain the characteristic vector, referred to as the priority vector. Obtaining an exact priority vector is complex, so this paper uses the Normalization of Row Average (NRA) method to replace the more complex operation. This method sums up each row element and standardizes it by summing all elements of the matrix. The equation is:

$W_i=\dfrac{\sum_{i=1}^{n} a_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij}}$, i=1,2,3……n. Finally, we check for consistency,

$$\lambda_{\max}=\sum_{i=1}^{n}\frac{(AW)_i}{nW_i},\quad \lambda_{\max}\geqq \mathrm{n} \qquad CI=\frac{\lambda_{\max}-\mathrm{n}}{\mathrm{n}-1} \quad CR=\frac{CI}{RI},$$

CI is the consistency index while RI is the random index. If CR<0.1, W_i is the weight for C_i. So we can get the final weight for each criterion (Tsungyu, 2001, pp.376-377).

Therefore, by using AHP, we can get quantitative weights for multiple criteria by using subjective rating scores.

3.2 Decision criteria and model

As is mentioned above, there are three forms when a petrochemical company chooses its logistics operational mode, namely inhousing, outsourcing and establishing an independent and specialized logistics subsidiary within the whole group. In this section, a decision-making model using AHP will be established for a petrochemical enterprise to choose the most appropriate form to operate its logistics business. Quantitative factors as well as qualitative factors are taken into consideration in this model. With the help of the model, decision-makers are able to evaluate and compare different logistics operational mode with both quantitative and qualitative factors for the purpose of making the final decision. This model that incorporates managerial experience and judgments of decision-makers is expected to be instrumental in choosing the most appropriate logistics operational mode. A four-level decision criteria using AHP model is displayed in the following figure.

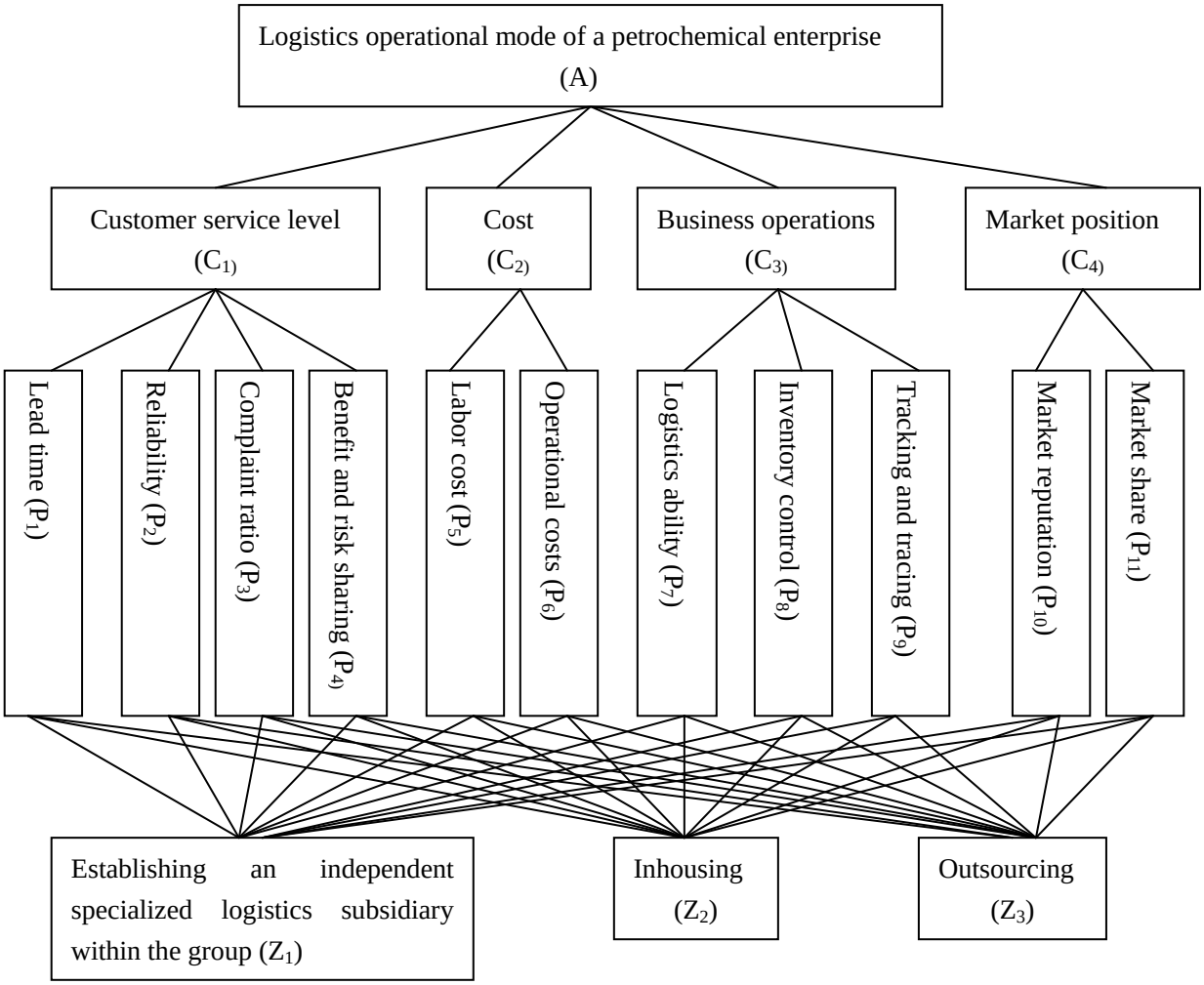


Figure 3.1-A four-level criteria system for decision-making

3.3 A numerical example using AHP model

Chinese After we have already set up the criteria system and the model, we need to fix weight for each criterion. After consulting some professional managers, senior officers and relative experts in my company, and making references to the opinions in some academic papers, matrixes of pairwise comparison ratings are constructed and relevant index are calculated as follows.

Table 3.1-A-C_1, C_2, C_3, C_4 matrix

A	C_1	C_2	C_3	C_4	Weights
C_1	1	3	4	2	0.460
C_2	1/3	1	2	1/2	0.157
C_3	1/4	1/2	1	1/4	0.089
C_4	1/2	2	4	1	0.294

λ_{max} = 4.046

$$CI = \frac{\lambda_{max} - n}{n-1} = 0.015$$

$$CR = \frac{CI}{RI} = 0.017 < 0.1$$

Table 3.2-C_1-P_1, P_2, P_3, P_4 matrix

C_1	P_1	P_2	P_3	P_4	Weights
P_1	1	2	5	1/3	0.273
P_2	1/2	1	4	1/2	0.202
P_3	1/5	1/4	1	1/5	0.064
P_4	3	2	5	1	0.461

λ_{max} = 4.182

$$CI = \frac{\lambda_{max} - n}{n-1} = 0.061$$

$$CR = \frac{CI}{RI} = 0.067 < 0.1$$

Table 3.3-C_2-P_5, P_6 matrix

C_2	P_5	P_6	Weights
P_5	1	4	0.8
P_6	1/4	1	0.2

Table 3.4-C_3-P_7, P_8, P_9 matrix

C_3	P_7	P_8	P_9	Weights
P_7	1	1/5	1/3	0.106
P_8	5	1	3	0.633
P_9	3	1/3	1	0.260

λ_{max} = 3.039

$$CI = \frac{\lambda_{max} - n}{n-1} = 0.019$$

$$CR = \frac{CI}{RI} = 0.033 < 0.1$$

Table 3.5-C_4-P_{10}, P_{11} matrix

C_4	P_{10}	P_{11}	Weights
P_{10}	1	3	0.75
P_{11}	1/3	1	0.25

Table 3.6-P_1-Z_1, Z_2, Z_3 matrix

P_1	Z_1	Z_2	Z_3	Weights
Z_1	1/2	1	3	0.525
Z_2	5	1	3	0.334
Z_3	1/3	1/3	1	0.412

λ_{max} = 3.054

$$CI = \frac{\lambda_{max} - n}{n-1} = 0.027$$

$$CR = \frac{CI}{RI} = 0.046 < 0.1$$

Table 3.7-P_2-Z_1, Z_2, Z_3 matrix

P_2	Z_1	Z_2	Z_3	Weights
Z_1	1	1/7	1/3	0.088
Z_2	7	1	3	0.669
Z_3	3	1/3	1	0.243

λ_{max} = 3.007

$$CI = \frac{\lambda_{max} - n}{n-1} = 0.004$$

$$CR = \frac{CI}{RI} = 0.006 < 0.1$$

Table 3.8-P_3-Z_1, Z_2, Z_3 matrix

P_3	Z_1	Z_2	Z_3	Weights
Z_1	1	4	3	0.620
Z_2	1/4	1	2	0.224
Z_3	1/3	1/2	1	0.156

λ_{max} = 3.109

$$CI = \frac{\lambda_{max} - n}{n-1} = 0.055$$

$$CR = \frac{CI}{RI} = 0.094 < 0.1$$

Table 3.9-P_4-Z_1, Z_2, Z_3 matrix

P_4	Z_1	Z_2	Z_3	Weights
Z_1	1	2	5	0.600
Z_2	1/2	1	1	0.229
Z_3	1/5	1	1	0.170

λ_{max} = 3.095

$$CI = \frac{\lambda_{max} - n}{n-1} = 0.048$$

$$CR = \frac{CI}{RI} = 0.082 < 0.1$$

Table 3.10-P_5-Z_1, Z_2, Z_3 matrix

P_5	Z_1	Z_2	Z_3	Weights
Z_1	1	3	5	0.648
Z_2	1/3	1	2	0.230
Z_3	1/5	1/2	1	0.122

λ_{max} = 3.004

$$CI = \frac{\lambda_{max} - n}{n-1} = 0.002$$

$$CR = \frac{CI}{RI} = 0.003 < 0.1$$

Table 3.11-P_6-Z_1, Z_2, Z_3 matrix

P_6	Z_1	Z_2	Z_3	Weights
Z_1	1	1	1/3	0.211
Z_2	1	1	1/2	0.241
Z_3	3	2	1	0.548

λ_{max} = 3.018

$$CI = \frac{\lambda_{max} - n}{n-1} = 0.009$$

$$CR = \frac{CI}{RI} = 0.016 < 0.1$$

Table 3.12-P_7-Z_1, Z_2, Z_3 matrix

P_7	Z_1	Z_2	Z_3	Weights
Z_1	1	1/2	2	0.297
Z_2	2	1	3	0.539
Z_3	1/2	1/3	1	0.164

λ_{max} = 3.009

$$CI = \frac{\lambda_{max} - n}{n-1} = 0.005$$

$$CR = \frac{CI}{RI} = 0.008 < 0.1$$

Table 3.13-P_8-Z_1, Z_2, Z_3 matrix

P_8	Z_1	Z_2	Z_3	Weights
Z_1	1	2	1/3	0.230
Z_2	1/2	1	1/5	0.122
Z_3	3	5	1	0.648

λ_{max} = 3.004

$$CI = \frac{\lambda_{max} - n}{n-1} = 0.002$$

$$CR = \frac{CI}{RI} = 0.003 < 0.1$$

Table 3.14-P_9-Z_1, Z_2, Z_3 matrix

P_9	Z_1	Z_2	Z_3	Weights
Z_1	1	6	7	0.755
Z_2	1/6	1	2	0.154
Z_3	1/7	1/2	1	0.092

λ_{max} = 3.033

$$CI = \frac{\lambda_{max} - n}{n-1} = 0.016$$

$$CR = \frac{CI}{RI} = 0.028 < 0.1$$

Table 3.15-P_{10}-Z_1, Z_2, Z_3 matrix

P_{10}	Z_1	Z_2	Z_3	Weights
Z_1	1	1/3	1/5	0.106
Z_2	3	1	1/3	0.260
Z_3	5	3	1	0.633

λ_{max} = 3.039

$$CI = \frac{\lambda_{max} - n}{n-1} = 0.019$$

$$CR = \frac{CI}{RI} = 0.033 < 0.1$$

Table 3.16-P_{11}-Z_1, Z_2, Z_3 matrix

P_{11}	Z_1	Z_2	Z_3	Weights
Z_1	1	5	3	0.648
Z_2	1/5	1	1/2	0.122
Z_3	1/3	2	1	0.230

λ_{max} = 3.004

$$CI = \frac{\lambda_{max} - n}{n-1} = 0.002$$

$$CR = \frac{CI}{RI} = 0.003 < 0.1$$

Priorities of general criteria are then multiplied by the weights of the respective secondary criteria. The results are summed up to get the overall priority of each alternative.

Table 3.17-Priority of second criteria

	C_1	C_2	C_3	C_4	Overall Weights
	0.460	0.157	0.089	0.294	
P_1	0.273	0	0	0	0.125
P_2	0.202	0	0	0	0.093
P_3	0.064	0	0	0	0.029
P_4	0.461	0	0	0	0.212
P_5	0	0.8	0	0	0.126
P_6	0	0.2	0	0	0.031
P_7	0	0	0.106	0	0.009
P_8	0	0	0.633	0	0.056
P_9	0	0	0.260	0	0.023
P_{10}	0	0	0	0.75	0.221
P_{11}	0	0	0	0.25	0.074

CI = 0.030

RI = 0.465

CR = 0.064

Table 3.18-Overall priorities of each criterion

	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	Overall weights
	0.125	0.093	0.029	0.212	0.126	0.031	0.009	0.056	0.023	0.221	0.074	
Z_1	0.525	0.088	0.620	0.601	0.648	0.211	0.297	0.230	0.755	0.106	0.648	0.412
Z_2	0.334	0.669	0.224	0.229	0.230	0.241	0.539	0.122	0.154	0.260	0.122	0.278
Z_3	0.142	0.243	0.156	0.170	0.122	0.548	0.164	0.648	0.092	0.633	0.230	0.310

CI = 0.021

RI = 0.58

CR = 0.036<0.1

As we can see from the results, the priority for Z_1 is 0.412, which is higher than the other two alternatives. Therefore, in this case, it is better to establish an independent and specialized logistics subsidiary within the whole group. The group can not only enjoy the advantages of a specialized logistics enterprise, but can also have control over its logistics assets.

3.4 Some conclusions

In this chapter, AHP model is introduced and used to analyze which logistics operational mode a petrochemical enterprise can select, namely inhousing, outsourcing and establishing an independent specialize logistics subsidiary within the whole group. In the above mentioned numerical example, a logistics subsidiary should be established. Unlike inhousing, which enables the company to have full control over its logistics resources and outsourcing, which makes a company lose control over its logistics resources completely, the logistics operational mode of establishing an independent logistics subsidiary enables the petrochemical enterprise to enjoy the advantages brought by the specialized logistics subsidiary but still have some control over its logistics functions. In addition, the independent logistics subsidiary functions as a profit center rather than a cost center in the sense that it shifts from a unit serving the petrochemical enterprise to an independent petrochemical logistics service provider not only serving its group, but also serving the society, thus creating profits for the petrochemical enterprise. Therefore, this logistics operational mode can be considered as a kind of compromise between inhousing and outsourcing. In the next chapter, a real case will be analyzed to see how this kind of logistics operational mode will benefit a famous Chinese petrochemical enterprise. Considering the business confidentiality, it is named as K Petrochemical Co, Ltd.

4 A CASE CONCERNING THE RESULT OF DECISION-MAKING--- ESTABLISHING AN INDEPENDENT SPECIALIZED LOGISTICS SUBSIDIARY WITHIN THE WHOLE GROUP

4.1 The general introduction to K Petrochemical Co. Ltd

4.1.1 The introduction to the logistics system of K Petrochemical Co, Ltd

The logistics system of K Petrochemical Co, Ltd is referred to as all units that provide storage and transportation services for its procurement, production and sales, including Shanghai Petrochemical Warehousing and Shipping Co, Ltd, Shanghai Petrochemical Railway Transportation Co, Ltd, Shanghai Petrochemical Automobile Transportation Co, Ltd, Shanghai Chemical Industry Park Logistics Co, Ltd and the relevant departments in its five divisions which are in charge of the storage and transportation of finished products. The logistics system of K Petrochemical Co, Ltd grows with the prosperity and maturity of the company. Since the logistics system was established in 1972 beside Hangzhou Bay, it has been serving the procurement, production and sales of the whole company. As a result of more than thirty years' investment and construction, the petrochemical logistics infrastructure has already been mature. For instance, the warehouse covers an area of 180 thousand square meters. All kinds of tanks reach 35 thousand square meters. There are more than 200 railway and highway tank trucks respectively. There also exist more than 200 trucks

to transport dry bulk cargos. In addition, the construction of a central procurement information system has been finished. Relatively advanced inventory management system has been applied to the warehouses storing hazardous petrochemical products. The corporation also cultivates and recruits a great many experienced manual laborers, specialized technicians and management personnel, thus laying a favorable and solid foundation to develop its logistics system. Given the growing scale of the corporation and the construction of Shanghai Chemical Industry Park, it is certain that the sales volume of the company will increase tremendously, which in turn, will lead to the rapid rise of its logistic volume. According to the tenth five-year plan of its logistics system, in 2002, the logistics volume was 11.15 million ton, among which 9.44 million ton was maritime transport, 0.535 million ton was railway transport, 0.4 million ton was inland waterway transport and 0.775 was highway transport. It is estimated that after the construction of Shanghai Chemical Industry Park, the total logistics volume will nearly double, reaching 21.7 million ton.

The logistics system of K Petrochemical Co, Ltd includes complete logistics infrastructure such as maritime transport, railway transport, inland waterway transport, highway transport and warehouses. In addition, the corporation enjoys a good reputation and some special advantages in the petrochemical logistics market. However, it was in the context of planned economy that its logistics system was established. Therefore, compared with advanced countries, there is still a huge gap in its organization structure, assets distribution, personnel quality, logistics business processes and service levels. The operation of its logistics is still mainly limited to warehousing and transportation. The decentralized distribution of logistics assets and too much management division leads to the disunited and inconsistent logistics planning and lack of integrated logistics operation. Therefore, faced with rapidly growing logistics volume and huge opportunities and challenges in internal and

external environment, it is a problem remaining to be solved how to make full use of its advantages in the petrochemical logistics market to promote the potential value of its logistics services, thus laying a favorable and solid foundation for integrating its originally separate logistics system into an independent, specialized and market-oriented third party petrochemical logistics subsidiary.

4.1.2 The original logistics structure of K Petrochemical Co, Ltd

Before the structure of the logistics system of the corporation is introduced, the corporate structure which is related to its logistics system should be illustrated at first, as is shown in the following figure.

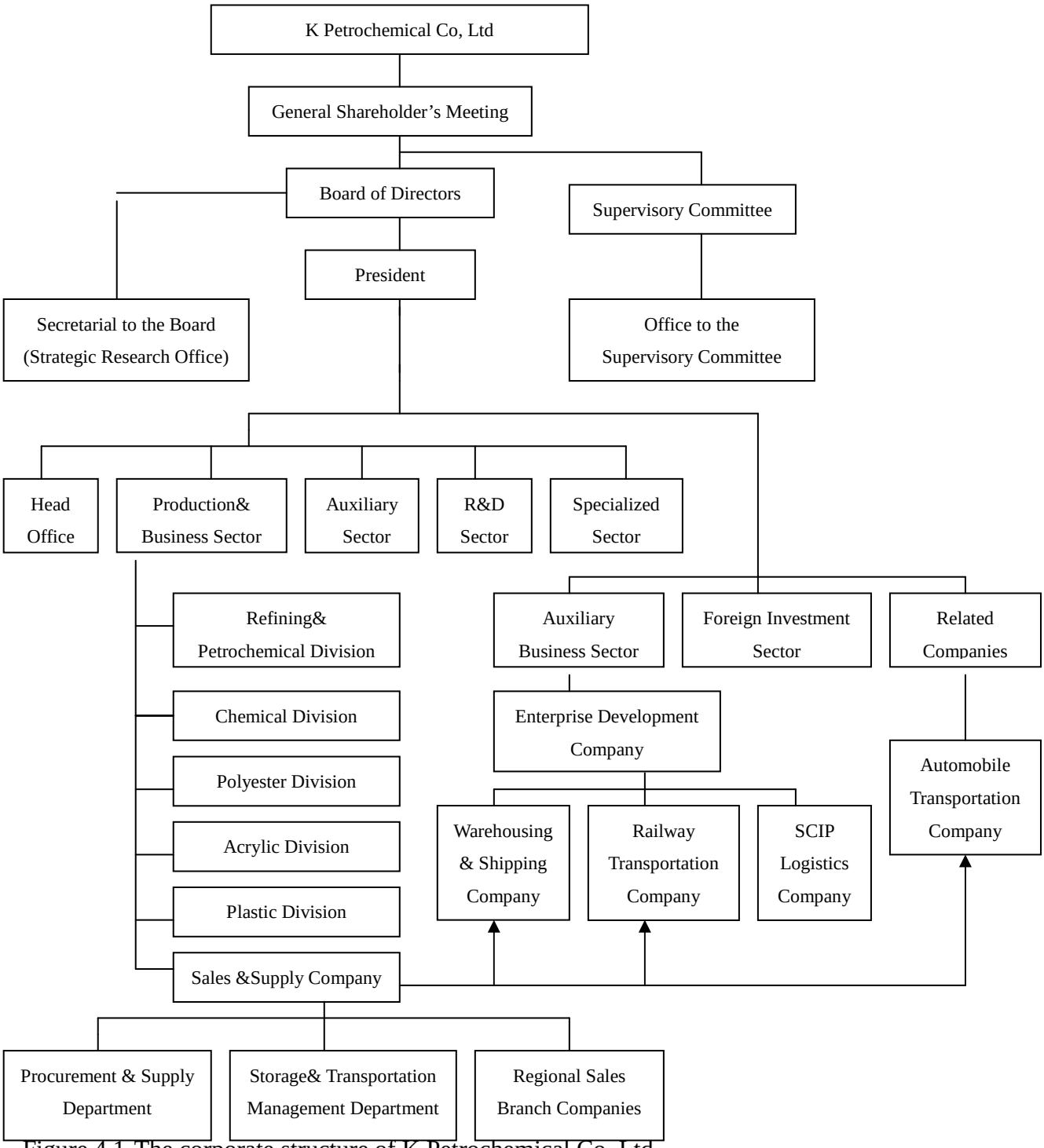
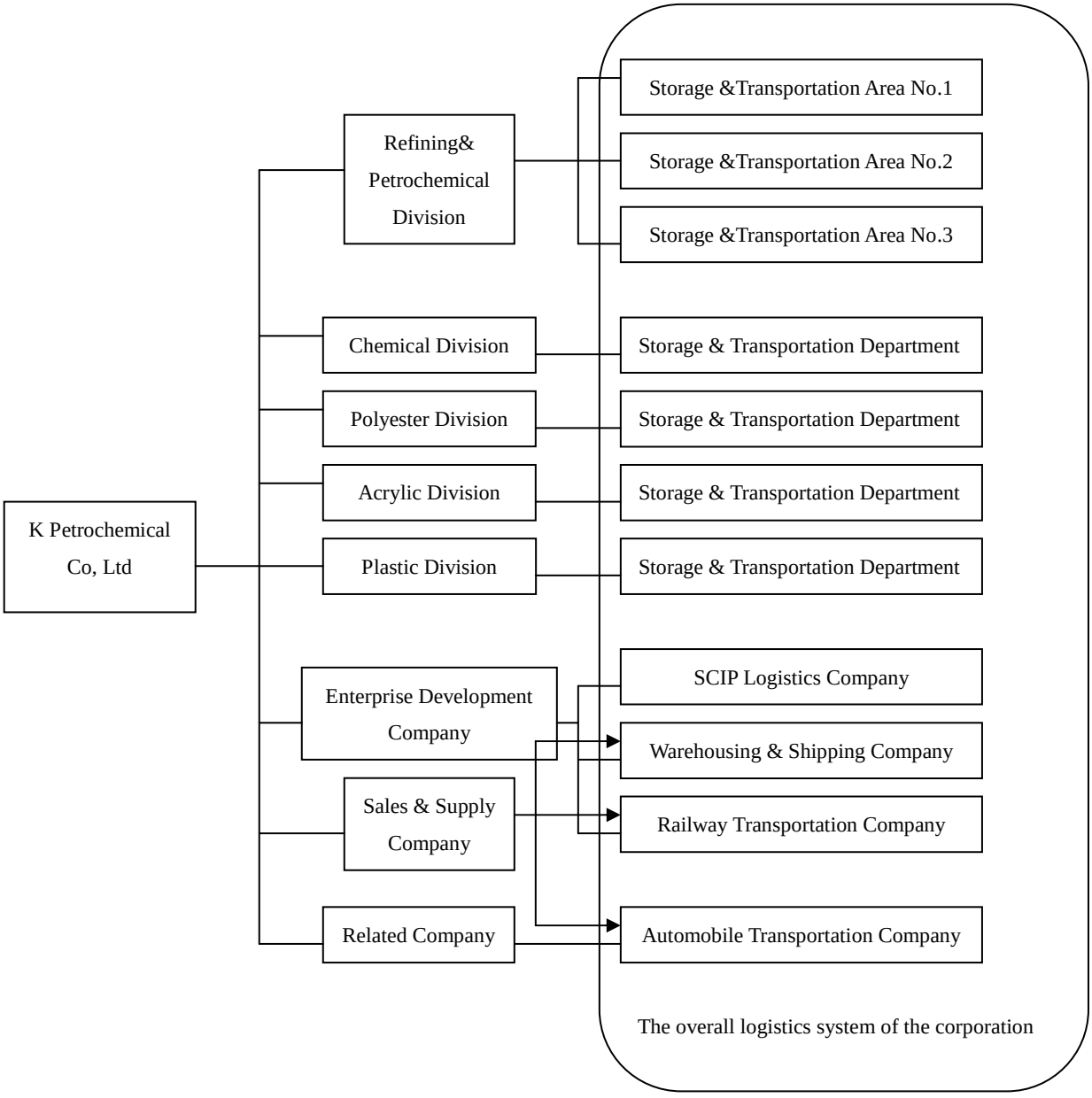


Figure 4.1-The corporate structure of K Petrochemical Co, Ltd

Source: Internal resources from K Petrochemical Co, Ltd

The corporation's logistics system can be divided into three parts. The first part is the

logistics facilities which belong to the five divisions mentioned in the above graph. They are in charge of the storage and transportation of finished products. The second part is the logistics facilities belonging to the Warehousing and Shipping Company, the Railway Transportation Company and the Automobile Transportation Company which are under the management of Sales and Supply Company. The last part is the Shanghai Chemical Industry Park Logistics Company of which the shareholder is Enterprise Development Company. Therefore, the overall logistics system of the corporation can be illustrated as follows.



The overall logistics system of the corporation

Figure 4.2-The overall logistics system of the corporation
Source: Internal resources from K Petrochemical Co, Ltd

4.1.3 The disadvantages of the original logistics structure of K Petrochemical Co, Ltd

The logistics system of the corporation has a long history of about thirty years. In terms of logistics facilities, logistics networks and logistics operations, it has accumulated a lot of experience and enjoys special industrial advantages. However, one key point is that K Petrochemical Co, Ltd is a state-owned enterprise which was established in the context of planned economy. Therefore, in terms of organization structure, assets distribution and business processes, it has some relatively backward management disadvantages of traditional enterprises, for instance, too much division, separation and overlap of logistics functions, low utilization rate, as a result of which, its logistics system has a bottleneck which inhibits its development and offsets its competitiveness.

Like K Petrochemical Co, Ltd, nowadays, many state-owned enterprises have the problems of too many logistics-related sectors and departments, leading to too many overlaps. They still have traditional vertical organization structures. Logistics assets, merely as auxiliary systems, are scattered among different departments and sectors, thus lacking integrated logistics operation and organization. In the above-mentioned logistics system of the corporation, because of the difference in department functions, a continuous logistics process must be separated to be executed by different departments, sectors and layers. Therefore, faced with rising market demands, this structure is hard to adapt to the uncertainties and requirements of quick response, mainly because of four aspects, as follows.

First of all, according to business categories, the corporation has five divisions,

namely refining and petrochemical division, chemical division, polyester division, acrylic division and plastics division, which are in separate operation and management under centralized decision of the corporation. These divisions are the basic cells to achieve the corporate goal. They operate and calculate independently. This kind of management style is favorable for the corporation's top management level to get rid of daily administrative issues to centralize decision-making. It is also favorable for these five divisions to make corresponding decisions on their own according to market variations, thus raising efficiency. However, because each division is an interest center, it tends to only consider their own interests and lacks coordination and collaboration with other divisions, thus affecting the corporate interests as a whole. Besides, in terms of assets utilization, each division may only consider the optimization of assets within its own control. Therefore, K Petrochemical Co, Ltd cannot optimize the utilization of assets within the whole group.

Secondly, there lacks horizontal communication among different divisions, as a result of which it is prone to duplicate some work. Too much division of work leads to focusing on the rise of efficiency in some minor issues rather than the corporate mission. The bureaucratic system characterized by too many layers inhibits the initiative and creativity of staff. In addition, the conflicts in interests of different divisions make the short-term individual interests more important than the long-term development goal of the corporation. There lacks communication among senior management personnel, thus diminishing the overall effectiveness of management and supervision.

Thirdly, in real work, the head of each division is reluctant to take on responsibilities. Each division only considers the tasks assigned by the supervisor as its own

responsibilities. The accuracy to finish the task serves as the criterion to evaluate the performance of the staff. In their opinion, it is the supervisor that should consider how to compete in the market and how to respond to the customer demands.

Last but not least, this kind of organization structure and hierarchy is limited by one factor. If the organization scale is expanded to a certain extent, the organization layer should also be increased to ensure effective management, which in turn, will increase the costs of transferring and sharing information. Too many layers will also make the corporation less flexible to the market variations, thus impeding its further development.

4.2 The decision-making of logistics operational mode of K Petrochemical Co, Ltd

4.2.1 The overall planning of logistics decision-making of K Petrochemical Co, Ltd

With regard to the current problems mentioned above, how to restructure its existing logistics system to establish integrated logistics operation process is the priority in the reform of its logistics system. Through the logistics reform, the corporation wants to achieve its logistics goal that on the basis of the integration of logistics assets and integrated logistics management, the corporation can centralize management and distribution, carry out a uniform calculation system and integrate information systems, thus achieving the logistics integration. Given the development of Shanghai Chemical Industry Park, K Petrochemical Co, Ltd wants to develop petrochemical logistic system drastically to provide high quality, specialized and integrated logistics services, thus becoming a third party petrochemical logistics service provider with advanced management, top-class service level and prominent performance.

In order to achieve its strategic objective, the corporation should carry out feasible plans according to its concrete situations. First of all, the separate logistics assets must be integrated to make possible the centralization of logistics management. In addition, the sense of logistics service should be cultivated. On the basis of improved logistics services, the corporation should achieve the diversification of logistics businesses and the market mechanism of logistics operation. Secondly, the business processes and operation processes must be redesigned to get rid of overlaps. The separate logistics functions should be integrated to achieve logistics integration. When redesigning its logistics processes, the optimization of procurement, packaging, warehousing, transportation and distribution should be taken into account. According to the practical conditions of the corporation's logistics system, the transportation and distribution system can be optimized first. After the transportation and distribution system become mature, then other businesses can be integrated to achieve the optimization of the overall logistics businesses. Thirdly, on the basis of integrated logistics processes, the organization structure should be restructured, the ultimate goal of which is to reduce costs, improve petrochemical logistics service level and reduce investments, meaning improving the utilization rate of internal logistics resources to minimize the investments in its logistics system.

The concrete restructuring planning of its logistics system is as follows.

(1) The integration of its logistics resources to compress its organization structure

The logistics activities of its logistics system are scattered among different departments and business sectors. In spite of the fact that the management of these activities is sometimes quite effective, there is not any internal mechanism to ensure

the integration and coordination of these logistics activities, which is not favorable to the effective and efficient decision-making in the sense that the vertical structure of its logistics system inhibits the time effectiveness of decision-making.

The purpose of its logistics restructuring of is to make the company more flexible and efficient in the ever changing and highly competitive market environment. The compressed and horizontal logistics organization structure is established according to the business processes rather than the department functions. This kind of organization structure is customer and market oriented.

The compressed and horizontal organization structure simplifies management layers. Therefore, compared with the original organization structure, it has several advantages. The speed of transferring information is much quicker and there is less possibility of information distortion, which is favorable to raising the management efficiency. The lean and effective organization structure reduces management costs. The management personnel can communicate with general staff directly so that they can be kept informed of market and business conditions in a timely manner to make corresponding decisions. In addition, the compressed organization structure is favorable for the general staff to bring their creativity and innovative spirits into full play. Therefore, the corporation’s logistics restructuring should focus on integrating its logistics resources, simplifying its layers to compress its organization structure so as to improve logistics efficiency.

(2) The establishment of its petrochemical logistics network

The establishment of its petrochemical logistics network can raise the logistics efficiency and the cost effectiveness of the whole system, thus improving the

customer satisfaction and market competitiveness. Based on the logistics infrastructure in Jin Shan Region and with Jiangsu, Zhejiang and Shanghai as the foundation, Shanghai petrochemical logistics network should be a comprehensive logistics service network radiating throughout China. The establishment of the distribution center in the intended sales region can not only bring about the logistics efficiency and huge sales profits, but can also facilitate the formation of its petrochemical logistics network and the optimization of assets structures of logistics networks, thus laying a solid foundation for the systematic logistics management. When selecting appropriate intended sales region to establish distribution centers, the corporation should focus on nearby chemical industry parks, then extend afar gradually. The construction of its petrochemical logistics network can satisfy the logistics needs of both the corporation and external markets.

(3) The establishment of logistics alliances

A stable logistics alliance with the corporation’s logistics as its core can strengthen its logistics service ability without further investments, which is favorable to reducing the transportation costs. In spite of this, for loose logistics alliances, the corporation’s logistics should handle and manage the choice of logistics alliance partners well and innovate in management concepts. In the long run, the corporation’s logistics can make full use of its advantages in information system and managerial experience to create the information platform of its logistics alliances and provide value-added services such as qualification authentication, information issuance, tracing and tracking, transaction calculations and customs clearance, thus forming mutually beneficial shanghai petrochemical logistics alliances.

(4) The construction of information systems to realize the information sharing system

of logistics networks

Up to now, the logistics system of the corporation is lacking in uniform and standardized information system. The information conveyance is still in the traditional form of written and oral communication, which inhibits the efficiency, time effectiveness and accuracy of logistics operations. Furthermore, there are various information technologies and systems which are developed and utilized independently in different departments. In the logistics restructuring of the corporation, the standardization of logistics information system should be realized as soon as possible so as to simplify the communication and operation links and update the market information, thus raising the efficiency of its logistics operations.

4.2.2 The establishment of K Petrochemical Logistics Subsidiary

On the basis of Sales & Supply Company, Warehousing & Shipping Company, Railway Transportation Company, Automobile Transportation Company and the logistics facilities of five divisions, the corporation establishes K Petrochemical Logistics Subsidiary, which means that the Warehousing & Shipping Company, Railway Transportation Company, Automobile Transportation Company cancel their legal operation qualifications and incorporate themselves into Sales & Supply Company to become K Petrochemical Logistics Subsidiary. Enterprise Development Company transfers the share rights of Shanghai Chemical Industry Park Logistics Co, Ltd to K Petrochemical Logistics Subsidiary, making it a holding company. Five divisions cancel their original storage and transportation departments and transfer their existing warehouses, transportation facilities and relevant personnel to the K Petrochemical Logistics Subsidiary. In this way, it functions as a centralized management and operation organization to conduct logistics businesses, from procurement, warehousing, storage to transportation and distribution.

The realistic significance to establish K Petrochemical Logistics Subsidiary to provide integrated logistics management and operations lies in three aspects. First of all, it makes the logistics resources of the whole group more flexible, optimizes its organization structure and shares the logistics resources, which is favorable for the corporation to reduce its logistics costs and give full play to its core advantages. Secondly, it reduces the investments of each division in logistics facilities and personnel and makes them focus on their core businesses to improve market competitiveness. Thirdly, it can improve the competitive advantage of the corporation's logistics system. The establishment of K Petrochemical Logistics Subsidiary and the adoption of market operation mechanism can satisfy the increasingly growing demands of the corporation's production and business development. On the other hand, through the establishment of the logistics subsidiary, the corporation's logistics system can function as a profit center rather than a cost center in the sense that it shifts from a unit serving the corporation to an independent petrochemical logistics enterprise not only serving the corporation, but also serving the society, thus creating profits and becoming a new profit growth point of K Petrochemical Co, Ltd..

The following figure is the organization structure of the newly built K Petrochemical Logistics Subsidiary.

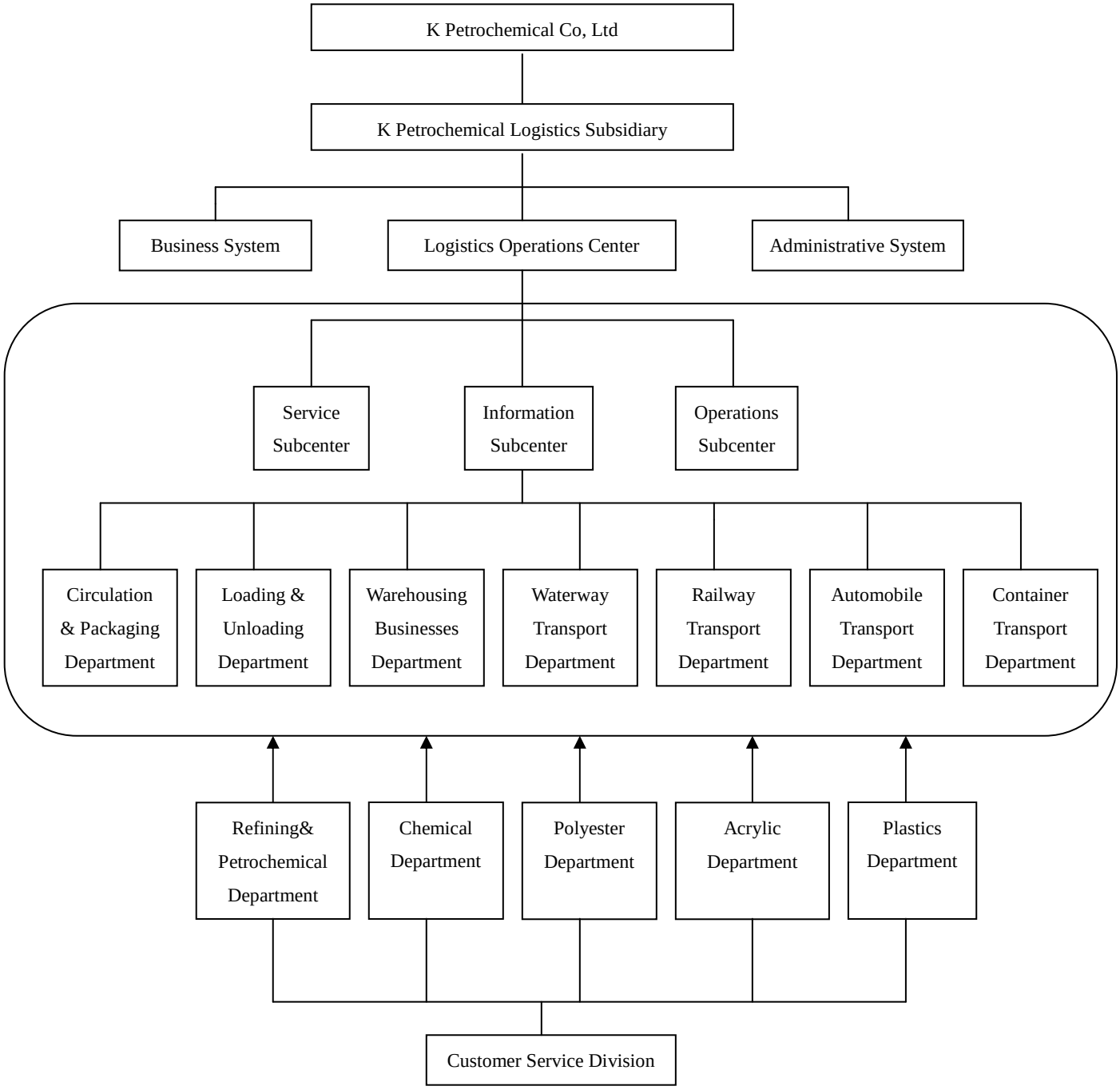


Figure 4.3-The organization structure of K Petrochemical logistics subsidiary

Source: Internal resources from K Petrochemical Co, Ltd

4.2.3 The functions of K Petrochemical Logistics Subsidiary

K Petrochemical Logistics Subsidiary is an independent and specialized petrochemical logistics subsidiary, the function of which is to act as an organization to centralize logistics management and operations to achieve the objective of four standardizations, namely standardized logistics business operations, standardized price-fixing, standardized coordination and standardized calculations.

The standardized logistics operations means that K Petrochemical Logistics Subsidiary is in charge of the overall logistics businesses of the corporation, from procurement, warehousing, transportation, distribution to sales management. This facilitates the centralization of logistics management of the corporation, thus improving the logistics efficiency dramatically.

Standardized price-fixing is referred to as the uniform management of transportation price by K Petrochemical Logistics Subsidiary. Each business sector of the corporation provides the logistics subsidiary with locations, sales quantities and other statistics of its customers. Then the logistics subsidiary estimates the costs and quotes the price. The logistics subsidiary promises to at least maintain the original logistics price and will reduce the costs step by step with the continuous optimization and integration of logistics businesses.

Standardized coordination means that under the principle of overall optimization, K Petrochemical Logistics Subsidiary coordinates the logistics businesses in a uniform manner. In addition, it is the responsibility of the logistics subsidiary to select the social carriers of different routes.

Standardized calculation means that K Petrochemical Logistics Subsidiary calculates the logistics fees with social carriers. In addition, it also calculates the internal fees with each business sector. Each business sector can not conduct calculations with social carriers on its own.

4.3 The logistics economic benefits of the new logistics operational mode

After the establishment of K Petrochemical Logistics Subsidiary, because of the integration of the corporation's logistics resources and the centralized management of four standardizations mentioned above, the corporation has achieved the scale economy, reduced the logistics costs and improved its service level. Therefore, its logistics economic benefits have improved dramatically.

Before the logistics restructuring, logistics economic benefits of the original logistics system of the corporation are listed as follows.

Table 4.1-The logistics economic benefits before logistics restructuring

Business categories	Main business revenues	Main business Costs	Main business Profits
Loading and unloading, warehousing	66.30	40.89	25.41
Railway transportation	48.36	32.60	15.76
Automobile transportation	10.48	8.68	1.80
Long distance transportation	75.00	65.78	9.22
Total	200.14	147.95	52.19

Source: Internal resources from K Petrochemical Co, Ltd (unit: million)

Because the management fee does not vary considerably each year, it is calculated based on the data of 2005. The total amount of management cost and sales taxation was 73.05 million yuan. Therefore, the actual profits were -20.86 million yuan.

After the logistics restructuring and the establishment of K Petrochemical Logistics

Subsidiary, the ability of current logistics resources and facilities has been brought into full play. The volume of long distance transportation can be increased by 250 thousand tons and the corresponding revenues can be increased by 25 million yuan. As a result of the incremental volume, its costs increase by 10.96 million. Because of the optimization and restructuring of warehouses, the warehousing volume can be increased by 150 thousand tons and the corresponding revenues can be increased by 7.05 million yuan. Correspondingly, the warehousing costs increase by 1.64 million. K Petrochemical Logistics Subsidiary also provides forwarding services, the total amount of which is 1.45 million tons and the revenues of which are 2.9 million yuan. Therefore, the total costs increase by 12.6 million yuan, but at the same time, the total incremental logistics revenues are 34.95 million yuan, which means that the profits increase by 22.35 million yuan. The details are listed as follows.

Table 4.2-Logistics economic benefits after the establishment of logistics subsidiary

Business categories	Main business revenues	Main business Costs	Main business Profits
Loading and unloading, warehousing	73.35	42.53	30.82
Railway transportation	48.36	32.60	15.76
Automobile transportation	10.48	8.68	1.80
Long distance transportation	100.00	76.74	23.26
Forwarding	2.90	0	2.90
Total	235.09	160.55	74.54

Source: Internal resources from K Petrochemical, Co, Ltd. (Unit: million)

After the logistics restructuring, the main business profits reach 74.54 million yuan. The total amount of management fees and sales taxation is 74.40 million yuan. Therefore, the ultimate profits are 0.14 million yuan.

To be noted is that the preceding figures do not include the reduction in logistics

costs after logistics restructuring. For instance, the optimization of routes can reduce railway, automobile and long distance transportation costs respectively, thus further reducing the total costs. Therefore, the actual profits may be higher than 0.14 million yuan.

After the logistics restructuring, the corporation also invests in extendable businesses. Its overall investment principle is to increase the logistics economic benefits as much as possible. Through calculation, the corporation needs to invest in specialized vehicles and necessary logistics facilities in Shanghai Chemical Industry Park. The total amount of investments is 80.80 million yuan. The details are listed as follows.

Table 4.3- Additional investment in extendable businesses

Investment items		Investment amounts
Transportation vehicles		39.90
Loading and Unloading facilities		4.90
Information system		8.00
Shanghai Chemical Industry Park	Land	16.00
	Warehouses	12.00
Total		80.80

Source: Internal resources from K Petrochemical, Co, Ltd. (Unit：million)

Through calculation, the investment reclamation period is 3.42 years. The incremental revenues will reach 54.984 million yuan, of which the details are listed as follows.

Table 4.4-The incremental revenues after additional investment

Business categories		Incremental revenues
Business revenues in Shanghai Chemical Industry Park	Long distance transportation	30.00
	Warehousing	15.00
	Procurement	8.00

	Total	53.00
Revenues of bulk cargoes		1.984
Total		54.984

Source: Internal resources from K Petrochemical, Co, Ltd. (Unit： million)

Combined with Table 5-2, the logistics economic benefits after investment in extendable businesses are listed as follows.

Table 4.5-The logistics economic benefits after investment in extendable businesses

Business categories	Main business revenues	Main business Costs	Main business Profits
Loading and unloading, warehousing	73.35	42.53	30.82
Railway transportation	48.36	32.60	15.76
Automobile transportation	10.48	8.68	1.80
Long distance transportation	100.00	76.74	23.26
Forwarding	2.90	0	2.90
Business revenues in Shanghai Chemical Industry Park	53.00	34.61	18.39
Revenues in bulk cargoes	1.984	1.00	0.984
Total	290.074	196.16	93.914

Source: Internal resources from K Petrochemical, Co, Ltd. (Unit: million)

After the logistics restructuring, the logistics resources are integrated and the logistics operational procedures are simplified. Therefore, with the incremental business volume, the management fees do not increase considerably, while the sales taxation will surge accordingly. Through calculation, the operations costs are approximately 76.70 million yuan. Therefore, the actual profits are 17.214 million yuan.

With the logistics restructuring and integration of logistics resources, and after the investment in extendable resources, compared with the logistics revenues before

logistics restructuring which are listed in Table 5-1, the incremental logistics revenues can reach 89.934 million yuan, the details of which are listed in Table 5-6.

Table 4.6-The incremental logistics revenues after logistics restructuring and investment

Business categories		Incremental logistics revenues
Long distance transportation		25.00
Warehousing		7.05
Business revenues in Shanghai Chemical Industry Park	Long distance transportation	30.00
	Warehousing	15.00
	Procurement	8.00
Forwarding revenues		2.90
Revenues in bulk cargoes		1.984
Total		89.934

Source: Internal resources from K Petrochemical, Co, Ltd.

In conclusion, before the establishment of K Petrochemical Logistic Subsidiary, the corporation's logistics system suffered a loss of 20.86 million yuan. However, after the logistics restructuring, the ability of existing logistics resources and facilities has been brought into full play. Therefore, the logistics revenues increase by 34.95 million yuan. The corresponding profits can reach 0.14 million yuan. After the logistics restructuring, the corporation also invests in extendable businesses, which leads to incremental logistics revenues of 54.984 million yuan and corresponding logistics profits of 17.214 million yuan. This means that after the establishment of K Petrochemical Logistics Subsidiary and the investment in extendable business categories, the total incremental logistics revenues are 89.934 million yuan.

4.4 Some conclusions

On the basis of the result of the decision-making of the previous chapter, this chapter

analyzes a real case about a famous Chinese petrochemical enterprise to further illustrate the logistics economic benefits of this logistics operational mode. Considering business confidentiality, it is named as K Petrochemical Co, Ltd. The logistics system of the corporation is referred to as all units that provide logistics services for the corporation. It was in the context of planned economy that its logistics system was established. Therefore, as we can see from its structure, it has some relatively backward management disadvantages, for instance, too many divisions and layers, separation and overlaps of logistics functions and low utilization rate. Logistics assets, merely as auxiliary systems, are scattered among different departments and sectors, thus leading to inconsistent logistics planning and lack of integrated logistics operation. Faced with rapidly growing logistics volume and huge opportunities and challenges in both internal and external environment, it is a problem remaining to be solved how to integrate the separate logistics resources and ultimately, promote the petrochemical logistics competitiveness.

On the basis of existing logistics assets, the corporation establishes an independent and specialized logistics organization within the whole group which is named K Petrochemical Logistics Subsidiary, the function of which is to integrate originally separate logistics resources, centralize logistics management and operations and achieve the objective of four standardizations, namely standardized logistics business operations, standardized price-fixing, standardized coordination and standardized calculations. The subsidiary functions as a profit center rather than a cost center in the sense that it shifts from a unit serving the corporation to an independent petrochemical logistics enterprise not only serving the corporation, but also serving the society, thus creating profits and becoming a new profit growth point.

After the establishment of the K Petrochemical Logistics Subsidiary, the logistics

economic benefits have improved tremendously. Before the establishment of the logistic subsidiary, in terms of logistics, the corporation suffered a loss of 20.86 million yuan. However, after its establishment, the ability of existing logistics resources and facilities has been brought into full play. As a result, the logistics revenues increase by 34.95 million yuan. The corresponding profits can reach 0.14 million yuan. At the same time, the corporation also invests in extendable businesses, which leads to incremental logistics revenues of 54.984 million yuan and corresponding logistics profits of 17.214 million yuan. This means that after the establishment of K Petrochemical Logistics Subsidiary and the investment in extendable business categories, the total incremental logistics revenues are 89.934 million yuan.

5 CONCLUSIONS

After in-depth research on the current situations and development prospects of Chinese petrochemical logistics enterprises, the author comes up with the following conclusions.

Firstly, the petrochemical industry is still in its infancy stage of managing its logistics efficiently. Due to the special features of petrochemical products, petrochemical logistics has its distinctive features, which makes its management extremely complicated. On the one hand, petrochemical products are produced in some limited and specific regions in the world, but they are demanded all over the world. A few weeks' lead time from the shipping point to the final customers' is very common in petrochemical industry. One the other hand, the logistics network of petrochemical industry is very inflexible, because of the production capabilities of crude oil suppliers, long transportation lead times and limitations of modes of transportation. Therefore, it constitutes a major challenge in the petrochemical industry how to meet the broadening prospect of oil demand and its derivates while maintaining high service levels and efficiency.

Secondly, Chinese petrochemical logistics market is now in a stage of contradiction between demand and supply. On the one hand, petrochemical logistics demand presents the development trend towards pluralism. However, the scale and service

levels of current Chinese petrochemical logistics service providers cannot meet the requirements of demand market. This situation makes it hard for inhousing logistics to exit. It also makes it slow for specialized petrochemical logistics market to become mature, which in turn, makes it more difficult for petrochemical logistics service providers to develop. This dilemma and contradiction inhibits the sound development of Chinese petrochemical logistics market.

Thirdly, Chinese petrochemical logistics development is faced with both huge opportunities and challenges. Increasingly favorable macro logistics environments, rapid growth of petrochemical logistics, huge overseas investments and the trend towards outsourcing are huge opportunities for the development of Chinese petrochemical logistics. However, too much division and overlaps of petrochemical logistics management inhibit the development of Chinese petrochemical logistics. The obstacles for inhousing logistics to exit, such as huge sunken costs for logistics facilities, further worsen this situation.

Fourthly, the Chinese petrochemical logistics demanders, suppliers, governmental management agencies and logistics industrial associations are four different and integral factors which compose the whole Chinese petrochemical logistics system. They should coordinate with each other on the basis of giving full play to their respective functions, for the purpose of optimizing the overall objective of the whole system. Concretely speaking, Chinese petrochemical logistics demanders should strengthen their communications with suppliers, while cooperating with the governments and logistics industrial associations to reflect their changes in logistics demands. Petrochemical logistics suppliers should analyze their own advantages and disadvantages, keep pace with the demand changes of their customers and formulate corresponding deferential and competitive strategies. The Chinese logistics industrial

associations should conduct more surveys concerning the petrochemical logistics industry, provide consultancy for petrochemical logistics enterprises and provide relevant data and materials for petrochemical logistics researches. The Chinese government should take macrocosmic measures such as establishing a system which is favorable for the petrochemical enterprises to exit inhousing logistics, establish a calculation system to calculate logistics costs independently and change the situation of too much division and overlaps of logistics management, thus creating a favorable macro environment for Chinese petrochemical logistics enterprises.

This dissertation also conducts SWOT analysis on the Chinese petrochemical enterprises, on the basis of which, the author establishes SWOT matrix to put forward corresponding measures which the individual petrochemical can take to improve their competitive advantages, as well as the measures which the Chinese government can take to promote the development of Chinese petrochemical industry. Hopefully, this dissertation can help Chinese petrochemical logistics service providers to better know themselves and the current situations of Chinese petrochemical industry so as to formulate the most appropriate strategies for future development.

After an analysis at the macro level, this dissertation also sets up an AHP model to select the logistics operational mode for a petrochemical enterprise. By using this model, petrochemical enterprises can use a quantitative method to choose the most appropriate logistics operational mode, thus improving logistics efficiency. In order to better illustrate the result of the selection, the author analyzes a real case regarding a famous Chinese petrochemical enterprise to see how this selected logistics operational mode improves its logistics economic benefits.

There are some other aspects relating to the development of Chinese petrochemical logistics enterprises which are not covered in this dissertation but deserve further research such as the global strategies of Chinese petrochemical enterprises and their logistics cost structure. In addition, due to the difficulties in collecting data about logistics management costs of Chinese petrochemical enterprises, this dissertation does not analyze the aspect of their logistics cost control strategies. Future research can concentrate on the analysis of logistics cost composition of Chinese petrochemical enterprises businesses and how to improve their cost effectiveness and profitability.

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APPENDIX 1

A NUMERICAL EXAMPLE

Comparison matrix

A	C1	C2	C3	C4
C1	1	3	4	2
C2	0.333333333	1	2	0.5
C3	0.25	0.5	1	0.25
C4	0.5	2	4	1
sum	2.083333333	6.5	11	3.75

Normalized matrix

A	C1	C2	C3	C4	weights
C1	0.48	0.461538462	0.363636364	0.533333333	0.45962704
C2	0.16	0.153846154	0.181818182	0.133333333	0.157249417
C3	0.12	0.076923077	0.090909091	0.066666667	0.088624709
C4	0.24	0.307692308	0.363636364	0.266666667	0.294498834

C_1	P_1	P_2	P_3	P_4
P_1	1	2	5	0.333333333
P_2	0.5	1	4	0.5
P_3	0.2	0.25	1	0.2
P_4	3	2	5	1
sum	4.7	5.25	15	2.033333333

C_1	P_1	P_2	P_3	P_4	weights
P_1	0.212765957	0.380952381	0.333333333	0.163934426	0.272746524
P_2	0.106382979	0.19047619	0.266666667	0.245901639	0.202356869
P_3	0.042553191	0.047619048	0.066666667	0.098360656	0.06379989
P_4	0.638297872	0.380952381	0.333333333	0.491803279	0.461096716

C_2	P_5	P_6
P_5	1	4
P_6	0.25	1
sum	1.25	5

C_2	P_5	P_6	weights
P_5	0.8	0.8	0.8
P_6	0.2	0.2	0.2

C_3	P_7	P_8	P_9
P_7	1	0.2	0.333333333
P_8	5	1	3
P_9	3	0.333333333	1
sum	9	1.533333333	4.333333333

C_3	P_7	P_8	P_9	weights
P_7	0.111111111	0.130434783	0.076923077	0.106156324
P_8	0.555555556	0.652173913	0.692307692	0.63334572
P_9	0.333333333	0.217391304	0.230769231	0.260497956

C_4	P_{10}	P_{11}
P_{10}	1	3
P_{11}	0.333333333	1
sum	1.333333333	4

C_4	P_{10}	P_{11}	weights
P_{10}	0.75	0.75	0.75
P_{11}	0.25	0.25	0.25

P_1	Z_1	Z_2	Z_3
Z_1	1	2	3
Z_2	0.5	1	3
Z_3	0.333333333	0.333333333	1
sum	1.833333333	3.333333333	7

P_1	Z_1	Z_2	Z_3	weights
Z_1	0.545454545	0.6	0.428571429	0.524675325
Z_2	0.272727273	0.3	0.428571429	0.333766234
Z_3	0.181818182	0.1	0.142857143	0.141558442

P_2	Z_1	Z_2	Z_3
Z_1	1	0.142857143	0.333333333
Z_2	7	1	3
Z_3	3	0.333333333	1
sum	11	1.476190476	4.333333333

P_2	Z_1	Z_2	Z_3	weights
Z_1	0.090909091	0.096774194	0.076923077	0.08820212
Z_2	0.636363636	0.677419355	0.692307692	0.668696895
Z_3	0.272727273	0.225806452	0.230769231	0.243100985

P_3	Z_1	Z_2	Z_3
Z_1	1	4	3
Z_2	0.25	1	2
Z_3	0.333333333	0.5	1
sum	1.583333333	5.5	6

P_3	Z_1	Z_2	Z_3	weights
Z_1	0.631578947	0.727272727	0.5	0.619617225
Z_2	0.157894737	0.181818182	0.333333333	0.224348751
Z_3	0.210526316	0.090909091	0.166666667	0.156034024

P_4	Z_1	Z_2	Z_3
Z_1	1	2	5
Z_2	0.5	1	1
Z_3	0.2	1	1
sum	1.7	4	7

P_4	Z_1	Z_2	Z_3	weights
Z_1	0.588235294	0.5	0.714285714	0.600840336
Z_2	0.294117647	0.25	0.142857143	0.228991597
Z_3	0.117647059	0.25	0.142857143	0.170168067

P_5	Z_1	Z_2	Z_3
Z_1	1	3	5
Z_2	0.333333333	1	2
Z_3	0.2	0.5	1
sum	1.533333333	4.5	8

P_5	Z_1	Z_2	Z_3	weights
Z_1	0.652173913	0.666666667	0.625	0.64794686
Z_2	0.217391304	0.222222222	0.25	0.229871176
Z_3	0.130434783	0.111111111	0.125	0.122181965

P_6	Z_1	Z_2	Z_3
Z_1	1	1	0.333333333
Z_2	1	1	0.5
Z_3	3	2	1
sum	5	4	1.833333333

P_6	Z_1	Z_2	Z_3	weights
Z_1	0.2	0.25	0.181818182	0.210606061
Z_2	0.2	0.25	0.272727273	0.240909091
Z_3	0.6	0.5	0.545454545	0.548484848

P_7	Z_1	Z_2	Z_3
Z_1	1	0.5	2
Z_2	2	1	3
Z_3	0.5	0.333333333	1
sum	3.5	1.833333333	6

P_7	Z_1	Z_2	Z_3	weights
Z_1	0.285714286	0.272727273	0.333333333	0.297258297
Z_2	0.571428571	0.545454545	0.5	0.538961039
Z_3	0.142857143	0.181818182	0.166666667	0.163780664

P_8	Z_1	Z_2	Z_3
Z_1	1	2	0.333333333
Z_2	0.5	1	0.2
Z_3	3	5	1
sum	4.5	8	1.533333333

P_8	Z_1	Z_2	Z_3	weights
Z_1	0.222222222	0.25	0.217391304	0.229871176
Z_2	0.111111111	0.125	0.130434783	0.122181965
Z_3	0.666666667	0.625	0.652173913	0.64794686

P_9	Z_1	Z_2	Z_3
Z_1	1	6	7
Z_2	0.166666667	1	2
Z_3	0.142857143	0.5	1
sum	1.30952381	7.5	10

P_9	Z_1	Z_2	Z_3	weights
Z_1	0.763636364	0.8	0.7	0.754545455
Z_2	0.127272727	0.133333333	0.2	0.153535354
Z_3	0.109090909	0.066666667	0.1	0.091919192

P_{10}	Z_1	Z_2	Z_3
Z_1	1	0.333333333	0.2
Z_2	3	1	0.333333333
Z_3	5	3	1
sum	9	4.333333333	1.533333333

P_{10}	Z_1	Z_2	Z_3	weights
Z_1	0.111111111	0.076923077	0.130434783	0.106156324
Z_2	0.333333333	0.230769231	0.217391304	0.260497956
Z_3	0.555555556	0.692307692	0.652173913	0.63334572

P_{11}	Z_1	Z_2	Z_3
Z_1	1	5	3
Z_2	0.2	1	0.5
Z_3	0.333333333	2	1
sum	1.533333333	8	4.5

P_{11}	Z_1	Z_2	Z_3	weights
Z_1	0.652173913	0.625	0.666666667	0.64794686
Z_2	0.130434783	0.125	0.111111111	0.122181965
Z_3	0.217391304	0.25	0.222222222	0.229871176

Priorities of secondary criteria												
	C_1	C_2	C_3	C_4	Overall weights							
	0.45962704	0.157249417	0.088624709	0.294498834								
P_1	0.272746524	0	0	0	0.125361678							
P_2	0.202356869	0	0	0	0.093008689							
P_3	0.06379989	0	0	0	0.029324155							
P_4	0.461096716	0	0	0	0.211932519							
P_5	0	0.8	0	0	0.125799534							
P_6	0	0.2	0	0	0.031449883							
P_7	0	0	0.106156324	0	0.009408073							
P_8	0	0	0.63334572	0	0.05613008							
P_9	0	0	0.260497956	0	0.023086555							
P_{10}	0	0	0	0.75	0.220874126							
P_{11}	0	0	0	0.25	0.073624709							
	CI	0.029630762										
	RI	0.465066667										
	CR	0.063712934										
Overall priorities of each alternative												
	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	Overall weights
	0.125361678	0.093008689	0.029324155	0.211932519	0.125799534	0.031449883	0.009408073	0.05613008	0.023086555	0.220874126	0.073624709	
Z_1	0.524675325	0.08820212	0.619617225	0.600840336	0.64794686	0.210606061	0.297258297	0.229871176	0.754545455	0.106156324	0.64794686	0.411891303
Z_2	0.333766234	0.668696895	0.224348751	0.228991597	0.229871176	0.240909091	0.538961039	0.122181965	0.153535354	0.260497956	0.122181965	0.27764611
Z_3	0.141558442	0.243100985	0.156034024	0.170168067	0.122181965	0.548484848	0.163780664	0.64794686	0.091919192	0.63334572	0.229871176	0.310462587
	CI	0.020833115										
	RI	0.58										
	CR	0.035919165										