The Hong Kong Polytechnic University

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STUDY ON THE THIRD PARTY LOGISTICS OF OIL INDUSTRY IN CHINA

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CERTIFICATE OF ORIGINATION

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Abstract

In the transitional period from the centrally planned economy to the market economy in China, large enterprises noticed that there were problems of low efficiency but at high costs in the logistics system. With the advantages of a third-party logistics, the functions of outsourcing logistics to a third party became an international trend prevalent in many industries the world over. Aiming to reduce the cost of logistics and enhance the efficiency, the petroleum industry in China plans to outsource all its functions of supply logistics in order to achieve more efficient management of the logistics system. The decision-makers in those enterprises however may lack the in-depth and comprehensive knowledge or understanding of the third-party logistics. Should an oil company involve in a third party as a whole logistics services provider because of the unique features of oil companies and the advantages of the third-party logistics service? Will the benefits brought by the third-party logistics be higher than the total cost? This research attempts to solve these problems and give some proposals on the efficient management of the logistics functions in the petroleum producing industry of China.

This research begins with the mining of the third-party logistics such as drivers and barriers, and focuses on the characteristics of goods supply in the oilfield in China. We study the characteristics in terms of the value, volume and specialty of the oilfield industry and the logistics activities, and proposed to give a framework for analysis and evaluation of the logistics service in the oilfields. First we make a

classification of the goods according to three standards, then build a mathematic model to measure the logistics cost for both self-service logistics (refereed as "DIY" or "Do It Yourself") and the total cost of "3PL". Related operational data and parameters are collected from an oilfield in China for analysis. The total cost of DIY and the total cost of "3PL" are compared among different classes of materials for production and products. By simulation on different parameters of the cost function, we have detected their effects on the total logistics cost of DIY and 3PL.

The analysis clearly indicates that the logistics cost is very high, and so more attention should be paid to the reduction of the cost of logistics. Logistics services for different materials or products can be given in different ways. The decision on fully outsourced logistics activities for all catagories of goods is not a cost efficient decision. Highly valued and special goods in a large volume can be more efficiently handled by DIY, while low valued and non-special goods in a small volume can be outsourced to a third-party logistics service provider.

Publications

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psychological support and encouraged me to go forward again. I am now sending my heart-felt thanks to my dear parents.

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Chapter 1 Introduction

In the production of oil, there are both inbound logistics and outbound logistics activities. This research focuses on the inbound or supply logistics procedure. The supply procedure includes the ordering goods or material from suppliers until the crude oil has been sent to the refining factories. Because the oil production is a continuous program, which can lead a great loss if stopped to wait for material, the supplying must meet all of the production requirements at any time. As a result, the logistics cost is a huge number for every oilfield in China. For China oilfields, traditionally the only goal is to maximize the oil output without considering the cost, including the logistics cost. With the process of listing on the stock market, oilfields in China began to pay attention of the gigantic annual logistics cost. In addition recent years, many international companies significantly reduce the logistics cost by outsourcing their logistics functions. So the logistics management departments of China oilfields also want to decrease the logistics cost by the third party logistics companies. This research is attempted to detect that whether outsourcing can reduce the China oilfield logistics cost based on the specific background of oilfields in China. The first chapter of introduction is to state such backgrounds for oil industry of China.

1.1 Third-party logistics background

A decade ago, the third-party logistics (3PL), relatively speaking, was a new concept. Well established in Europe, it just began to be introduced into the United

States. However, the usage of the third-party logistics has, no doubt, become an important trend in contemporary logistics management all over the world. The annual expenditure on the third-party logistics services in the United States did not go up to US$10bn before 1993 (Bards 1994), whereas today, the annual expenditure is US$80bn or so (Gecker 2004). The usage rate has increased from about 40 percentage of Top 500 in the early 1990s (Lieb 1992) to approximately 65 percent of these companies in the first years of the 21st century (Lieb and Kendrick 2002).

Meanwhile, the issue of the third-party logistics has attracted a great many of scholars' attention. As a result, a number of articles on the third-party logistics has made the definition of the term, which ranges from different aspects, from the general sense to the specific sense and from a narrow sense to a broad sense. The Here are some examples:

The third-party logistics is analogous to the outsourced or contracted logistics (lieb, Millen, and Van Wassenhove);

The third-party logistics is the use of an outside company to perform all or part of another company's materials management or product distribution (Bonney 1993);

The third-party logistics is the outsourcing of all or part of a company's logistics function. Relative to basic services, contracted logistics offerings are more complex, encompass a larger number of functions, and are characterized by longer-term and more mutually beneficial relationship (Africk 1994);

Activities carried out by a logistics service provider on behalf of a shipper and consisting of at least management and execution of transportation and warehousing (if warehousing is part of the process) (see Berglund et al. 1999).

In this research, the concept comes from the summary of the above ones as third party logistics acts as a kind of contract or a long-term strategic relationship between service providers and buyers, by which almost all the bases and value-added logistic functions can be handled.

1.2 Oil production background

Petroleum, as an essential energy, plays a strategic role for China's economic growth and political stability. In 2004, the total output of crude oil throughout the world was 3.86 billion tons, of which 4.51% (175 million tons) came from China. In contrast, China, the second largest oil consumption country, accounted for 8.19% of world total oil consumption in 2004. China's 48.5% domestic oil consumption relies on import.

The process of oil production is very complicated and so the cost is significantly high. In general, the process of oil production mainly includes four stages: The oil exploration, oilfield development, oil & gas mass transportation and refining. Exploration means to examine the history of regional geography and discover the patterns of the nearby earth crust, in which well logging and drilling test are two major steps. Well logging means by geophysics manners, information about the origin situation and changes on the rock stratum gone through can be transmitted to ground by electric cable, and experts will make a judgment of the information to decide whether there is an oilfield or not. Precision instruments are needed for the judgment of information. The drilling of a test well is the final stage for the discovery of an oilfield. If gas and oil are found in a test well, the depth and the number of oil reservoir layers can be found. As a result, the oil production capacity and reserves can be estimated eventually and after economic analysis, the decision on whether this oilfield is worthy to develop will be made by an expert panel. Oil development is a whole process based on the well known regular patterns and situations of geophysical changes, and wells are properly arranged and sequences are produced on the reservoir regions in order to mine the petroleum from underground to the ground. Drilling, in a development process, accounts for over 50% of the total investment. Every well can continue to produce oil for ten or 30 years, and so cementing the well is regarded as a primary measure to prolong the life-span of an oil well. Mass transportation means to transport oil and gas to outside refinery and gas transports to the end users after gathering all the oil and gas from scattered wells and then after necessary basic refining, making oil up to the standard. It mainly includes the separation of oil from gas, the measuring of oil and gas, the dehydration and purification of crude oil, etc. The water dehydrated from oil will be sent back to underground to fill the gaps in rock layers for oil production.

The last three stages for oil production pose an uninterrupted process in which sometimes the loss due to production suspension cannot be made up at all. In order to guarantee the continuity, the on-time delivery of logistics management seems to be an important issue. Furthermore, a large number of supplies will flow continually in the last three stages. In the development stage of an oilfield, a large quantity of different types of pipes, cements, pumps, chemicals and drilling machines is required frequently; in the stage of mass transportation, various controlling meters and seamless steel tubes are the most popular goods. In the last stage, a variety of chemicals are needed for refining crude oil. Since each well experiences such four stages and one oilfield has thousands of wells, the management of logistics operations plays an important role in the process of oil production. In the next section, a typical oilfield will be taken for example to explain this issue.

1.3 Oilfield logistics background

Here is a typical oilfield taken for example to illustrate the background. For some reasons, we cannot use its real name, but instead, it is named as the S Oilfield in this research. It is one of the largest oilfields in China. The output of crude oil reaches 33.5519 million tons annually. Its location mainly covers eight cities and

28 counties of a province. It has an advantageous geographic location, perfect infrastructure and modern transportation and communication. The petroleum production process from the oilfield development to the refining stage involves in large quantity of goods and material flows, and so efficient logistics management becomes an initial aspect based on the specific characteristics of the oilfield. The characteristics of logistics in that oilfield are illustrated in the following list. During the early stage of the establishment of China's petroleum industry, the management of the industry carried an obvious military feature that ignored the logistic costs in order to meet the needs of supply. Along with the development of modernization in the country, the oil industry becomes a modern one and the cost minimizes under the condition to meet the demand. Consequently, logistics has become a more and more critical problem in oilfield management.

1.3.1 Dispersed demand

It is related to the features of oil production. The oilfield is not a region full of oil underground as the people imagine, but consists of more than 700 sub-oilfields scattering on an area of several hundred square kilometers where some oilfields are far from others in other cities. Everyday, these sub-oilfields continuously produce oil and therefore, the production materials and equipment must be sufficiently provided every minute. However, the demands from every sub-oilfield may be totally different since they are at different development stages under different conditions. As a result, at least 700 hundred barrels of oil should be transported everyday along with all kinds of goods to be carried in on a piece of land of several square kilometers. The geographic location for production plays the role of a determinant for logistics demand dispersed.

1.3.2 Large scale and variety

As mentioned above, the lifespan of an oil well ranges, generally speaking, from 10 to thirty years. Moreover, to keep the annual output stable, new oilfields must be developed every year to make up the deficient production capacity of wells in the declining period. In the development of the past 40 years, oil wells at this place have become numerous. Therefore, the oilfield company is obliged to sink new exploitation wells to meet increasing demands for oil, while repair the existing wells. Numerous wells generates many results: A large quantity of materials and equipment is needed for maintaining continuing production; an increase of employees working for oil production and more goods coming in to meet the needs of employees (e.g., gloves for workers, office stationery for managers, etc.). From the process of oil exploitation to mass transportation, both hi-tech and precision instruments and large amounts of building materials are needed. They range from imported large-scale drilling machines of which each costs over US$10mn to a tiny nail worth below US$1.00. Since no well can skip any of the four stages in the process of oil production, all the thousands of wells require a large amount of tools, especially because it locates on a significantly complicated geographic location. Usually the production of oil depends on more complicated and advanced technologies. Consequently, some special equipment and materials must be supplied, which adds to the demand for a great variety of tools. In 2004, the total purchase of commonly used materials and equipment for the oilfield are up to RMB15bn, and the goods are over 10,000 categories.

1.3.3 Frequent emergency requirement

The oil industry is more likely to meet with emergencies than other industries. Oil exists over 3,000 meters beneath the ground where man is not able to see with eyes and it can be discovered only with the help of machine to detect and estimate. It is possible to get all comprehensive information of oil reserves and the stratum layers by means of many advanced technological instruments of measurement. Uncertainties still exist now and then. Nobody is able to make sure what will happen because he is faced with an unknown world. In the practice of oil production, uncertainty often causes emergencies. It is commonly known that once a well begins to produce oil, it cannot be stopped until sealed when there is no more oil left. Otherwise, a loss of over RMB10mn will be brought about most probably. During the process of oil production, the most frequent and dangerous emergencies are blowouts because the oil or gas flows under hundreds of times of the ordinary atmospheric pressure are out of control. If it cannot be controlled within the first several minutes, it will cost a great deal of money and workers' lives. Consequently, when an emergency happens, if the materials needed for first-aid are not available in a short period of time, not only the large investment will be lost, but also workers are in great danger. In the logistics aspect, fast transportation and distribution of materials for emergencies are the necessary conditions for oilfields. Most emergencies may not be so serious, but still happen from time to time. Emergency is one of the most distinct characteristics of the petroleum industry, perhaps of the whole exploitation industry.

1.3.4 Professional transportation

This feature can be explained by two aspects: Goods and facilities. First, we are going to discuss goods to be transported by giving some examples. In the first stage of oil production (i.e., the stage of oil exploitation), some kinds of dedicated high-value and sophisticated technological machines are transported to record and examine the underground information. Before drilling a well, at least a derrick that measures dozens of meters in height and weighs thousands of tons should be carried to the site by tractors which requires extremely professional loading and unloading skills and such large tractors should well match the big derrick. Besides the derrick, some other extra large and extra heavy pieces of equipment should also be transported. During the development process, some highly corrosive, rank and poisonous chemical accessory ingredients are used for oil production and refining. It is clear that only some special-purpose vehicles can transport such chemicals. Second, facilities used in oil production are unique. Here are two instances. Crude oil or oil products are dangerous goods because they are inflammable. Because of this, petroleum storage and transportation have to be handled with great care when using the petroleum depot, gas tank and fuel vehicle. Nowadays, very little petroleum and oil products are transported by truck, but on the contrary, almost all the crude oil and natural gas are directly transported by pipelines. For the mass transportation process, mixtures directly extracted from underground are sent by pipes to a refinery and then, the refined oil products after sent to outside petroleum storage depots appointed by SINOPEC. The construction of the pipelines is another professional project for petroleum product logistics.

1.3.5 Fixed vs. mobile logistics network

The oilfield logistics network cannot be described by a single feature. In the exploitation process of an oilfield described above, the flow of materials and goods are quite fluid and irregular. If the information about the earth stratum and economic analysis show that one place does not have oil or is not worthy development, all of the machines and equipment have to be pulled to another place，perhaps dozens of kilometers away where oil or gas is likely to be found from the very beginning. Therefore, the feature of logistics network is not determined before the oilfield goes into stable production. After that, the flow of goods is relatively fixed because an oil well has a lifespan of more than 10 years and the materials required to maintain oil production are quite similar and stable during this long period of time. Make a comparison between the inbound and outbound logistics. The inbound logistics is relatively changeable. For the sales of oil products are forbidden by the Central Government, all products except those used for energy generation are directly transported through the pipelines to the storage depots for sales by the Government. Very little products are transported by the oilfield itself, and the destinations of oil products are places in a limited number. Because there is the uncertainty for exploitation and emergencies, the inbound logistics network is unstable. As that oilfield has already gone into the phase of steady development, the logistics network can be taken as a fixed one.

1.3.6 Comprehensive logistics infrastructure

In the aspect of transportation, the S Oilfield owns convenient road network between every production unit, the airport which allows Boeing 737 airplane to land and take off, the port for transport to many cities nearby, other coastal cities and several highways that connects neighbor cities. Investment in the building of transportation infrastructure provides a sound basis for logistics services.

There are a total number of 180,000 lines for the phone exchange. The long-distance digital microwave communication extends for 981 km, and the optical fiber communication cables stretches for more than 450 km. By the end of 2004, the total number of phone customers exceeded 1.36 million, among which the number of fixed telephone users was over 30,000, accounting for over 90% users. The number of mobile phone users was 1.06 million, making up 58.9% of the population of the oilfield. In 2005, the ERP system was applied to manage daily oil production and administration and through the system, all financial settlement and material movements can be resolved. Although the present efficiency decreased because of the changes brought about by the application of the ERP system, the information level has been significantly improved.

The typical installations in the S Oilfield logistics system are large, extensive, and in a great number. There are over 158 pieces of lifting equipment, about 150 carrying machines and over 60 computers are used in warehouse. For petroleum storage, there are 59 oil tanks having a total storage volume of 56.8 thousand cubic meters, 271 sets of fixed or mobile equipment and 17,640 square-meter warehouses.

1.3.7 Irrecoverable materials

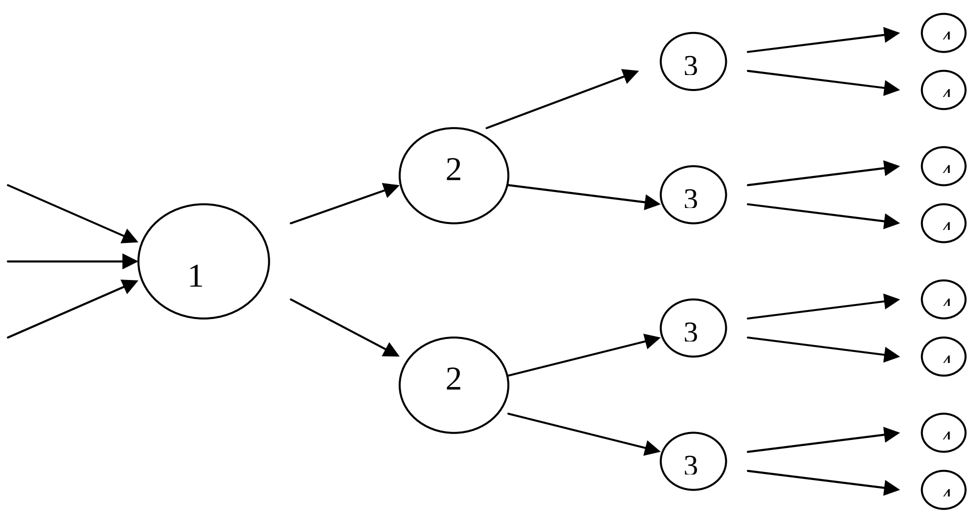
In the entire oilfield, there is almost totally no reverse logistics performance. The reasons for this phenomenon come from three different aspects: The technology limitation, cost and the environment. Firstly, the technology limitation is the essential cause. As mentioned above, oil production is typically a job of exploration within thousands of meters underground, and how to recycle materials from such a depth is a problem to be solved after overcoming numerous technological barriers. For example, oil pipes used in the drilling process account for a large part of material consumption every year and they can only be used one-time because they are fixed in the well by cement for the safety of oil pumping. Under current technological conditions, it is possible to take back these pipes off the cement from so deep underground. Such is a general situation which cannot be resolved by present technologies. Secondly, economical consideration is another obstacle for reverse logistics. The majority of materials using for oil production are one-time, and so the cost for recovering them may be higher than potential profits. Obviously, it costs highly for materials transportation, classification and collection. The most important reason is that the production of the oilfield is highly dispersed in several cities whose geographic areas are also very broad. So, to collect all of the recovered materials, one has to go from one spot to another, which cannot become a scale economy. Thirdly, it is because of the specific environmental situation. The oilfield is located in a place where crops are hard to grow. And therefore before the oilfield was found, few people lived there, and oil production is almost the only major industry until now. In view of this, there is no need to save the ground space for production, and there is not much expectation or pressure to protect the environment.

Benefits from materials recovered by the oilfield cannot cover the cost because it cannot have the scale economy especially for those low-valued goods. However, it is more efficiently for the third-party logistics company to manage. This is another gap for further meaningful research.

1.4 The current logistics system in the oilfield

The logistics and the logistics system are quite complicated, and so is the supply of timber, which is an essential material used for oil production and will be singled out as an example to explain the logistics system in the oilfield. After understanding the demands of all the production units, the supply management sector which has a central warehouse and vehicles for distribution place orders to suppliers. Some days later, the suppliers send the timber to the central warehouse to stock and the supply management sector distribute it to 60 secondary supply stations scattered in the oilfield area according to their demands. Similarly, after receiving the timber from the central warehouse, every secondary supply station will send it to every tertiary station who will distribute it to each end-user. It is obvious from Figure 1.1 that besides the central warehouse, there are three levels of warehouses before materials come to the end-users. Figure 1.1 shows the whole process of timber flow from the supplier to the end-users.

After every process of the four steps in oil production, most materials or equipment will change completely, except the precious equipment which can be repeated used and moved to another place where they are needed. All the consumable materials for one-time use cannot be recovered. All crude oil produced must be transported through the pipelines underground to the refinery, the oil tank and finally to users. Only a few oil products, such as gasoline and kerosene, are transported by trucks to gas stations or other users.



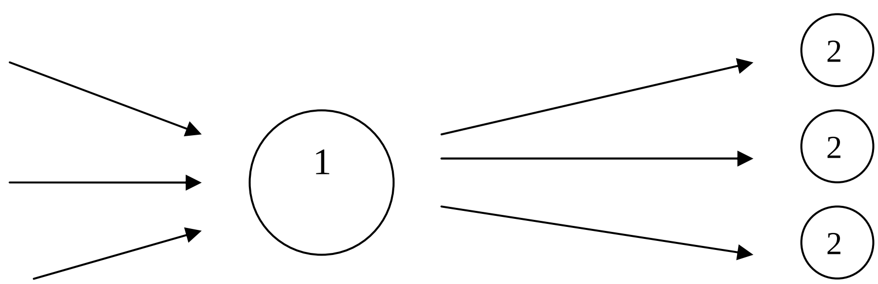
Note: 1: The central warehouse; 2: 60 secondary supply stations;
3: The tertiary supply stations; 4: End-users for Production
: Flow of Materials

Figure 1.1 The Current Logistics System

1.5 Oilfield logistics restructuring situation

The logistics industry is playing a more and more important role in China. The total value of logistics in China's oil industry reaches RMB48.1tn in 2005, up 25.1% than 2004, while the expenditure on logistics is RMB3.386tn in 2005, up 12.9% than 2004 and the revenue from logistics are RMB1.8791tn in 2005, up 12.7% than 2004. Recently many urban governments in China are aware of the benefits and recognize the importance of the third-party logistics, and consequently they invest a great amount of fund in this industry. For example, the Beijing Municipal Government includes the building of logistics centers in the recent Five-year Plan; the Shanghai Municipal Government claimed to establish a first-class logistics base; and the Shenzhen Municipal Government plans to invest RMB150bn (about US$18bn) to develop its third-party logistics into one of the three major industries in the 21st century.

With the booming development of the third-party logistics in China and the realization of interests from the third-party logistics, oilfield managers also expect to gain benefits from the outsourcing of all the logistics operations to third party companies. Besides, there is so far no oilfields outsourcing their logistics to a third party in China's oil-producing industry. A typical oilfield made an experiment. The restructuring of logistics mainly focuses on the supply system: Firstly, all the secondary supply stations will be repealed and obviously all their warehouses are recovered by the central warehouse of the supply management sector; secondly, except central warehouse, almost no other warehouses will continue to exist while all the material supply will be met by direct distribution from the supply management sector (central warehouse); and finally, the supply management sector will become an independent third party subsidiary company of a typical oilfield to undertake all the logistics performances. From the description above, three major points can be drawn: 1) Reduction of inventory until almost to the zero stock; 2) Direct distribution of all materials and equipment; 3) Outsourcing all the logistics functions to a third party company. Restructuring will bring so many changes to the logistics system and greatly effect the production of the oilfield. So logically, the question “Is such great restructuring a choice?” My research will focus on the decision-making of whether all the logistics operations in the whole process of oil production of that oilfield should be outsourced to a third party company.



Note: 1: The central warehouse: 2: End-users for production
⟶ : Flow of Materials

Figure 1.2 Restructuring the logistics system

1.6 Research Objectives

Research Object: The supply of goods and materials used for the production of the oilfield

Since the oilfield began its development in the 1960s, all the oil production performances have been under the planned economy system including logistics management. Production is the essential goal of the whole oilfield but the cost or efficiency are not taken into consideration, that is to say, the production of oil and gas are achieved regardless of the high cost. On the one hand, all the goods would be purchased each year with the funds appropriated by the Government. As the oil industry is one of the most important industries to the national economy, The Government would earmark enough and even more fund than needed in the production process purchases and cannot be used elsewhere. As a result, the funds allocated by the Government provide a basis for over purchases and over stocks in the logistics system of oilfield. Over purchases made it possible to hold the level of the inventory. While on the other hand, especially as I described in the section of the oilfield logistics background, urgent requirements for goods and materials are very frequent especially in the first two processes — the exploitation and development periods of the oilfield. In order to avoid such risks, the logistics management department has to store a large quantity of spare parts of almost every piece of equipment and continues to replenish the stock. In addition, the stock-out rate plays an important role in the annual evaluation of purchasers' work, and therefore, the staff of the logistics management department is willing to order goods more than the real needs from suppliers. The supply of goods and equipment is above 10,000 kinds, and the total stock of supplies reaches an amazingly high number.

The centrally planned economic system caused another problem in logistics performance. The oilfield had its own vehicles which were bought and maintained by the Government, and to transport all the materiasl from suppliers to production units in order to guarantee the timely delivery without considering the cost of transportation. When an urgent shortage of some important material occurred, that production unit would get them by their own trucks from the central warehouse or even from suppliers. Everyday urgent requirement of some material happened over 1,000 times totally in the whole oilfield. Obviously, there was a great waste in such inefficient logistics performance.

Besides Figure 1.1, there were four logistics management levels in the current logistics system built under the centrally planned economic system which reduces significantly the overall efficiency of the logistics system.

In the past three years, with the adoption of the market economy in large state-owned enterprises, cost in the process of oil production including the cost of logistics has been taken into consideration by the top managers of the oilfield. As the successful experience of the outsourcing of logistics from foreign enterprises is introduced to China, a strong voice of outsourcing all the logistics functions of the oilfield during the process of oil production is heard (in this case, a third-party logistics company has become an independent company, but it is forbidden to apply for the resource of the logistics of the oilfield). Is it a choice to improve the efficiency and reduce the cost of logistic while keeping the service level in such a specific industry? It is true that in some environments, logistics outsourced to a third party company can reduce the overall cost in some manufacturing industries proven by some famous foreign companies. In the case of oilfield, if all of the logistics performances are outsourced to a third-party logistics company, the inventory level can be reduced, distribution can be more efficient and three logistics management levels can be saved because of direct distribution operated by the third party company. However, in the oil industry, based on its own specific logistics characteristics such as dispersed demand and frequently urgent requirement, etc, it is not sure to be a wise decision to outsource all the logistics businesses. Furthermore, there are thousands of types of goods used in the production of the oilfield, among which different kinds have different features in the logistics aspect. Some of them are equipment or material of extraordinarily high value, such as the most advanced equipment worth RMB10,000,000, or those required (its supply cannot be delayed) without no substitute, for example, the drilling machine, or the special and professional transportation vehicle for the transportation of inflammable crude oil and gas. Goods with three features listed above may not be suitable for a third-party logistics company to carry for their distribution. By contrast, those goods for frequent supply, low value or in large demand can be outsourced to a third-party logistics company.

Nowadays, reconstructing the logistics system and outsourcing logistics in the oilfield industry in China is a general trend affected by the advantages of the third-party logistics. However, until now there are very few researchers to study whether the oilfield should introduce a third-party logistics company to perform their logistic functions or to what extent it should introduce a third party company to carry out the business even. Our research will fill in this gap and give some managerial suggestions on the introduction of the third-party logistics in terms of the oilfield logistics management.

1.7 The Scope of research

The scope of this research will only be confined to the oil industry (the state-owned enterprises) on China's mainland. The oil industry has an essential effect on the growth of China's national economy when oil acts as a strategic resource in global competition. It also has its unique logistic characteristics compared with other manufacturing industries. Logistics in the oil industry, to some degree, is more complicated than manufacturing industries in the common sense, e.g., a car making manufacturer. Some oil companies were suggested as a possible solution to the third-party logistics. Should an oil company accept a third party as a logistics services provider due to the unique features of the oil companies and the advantages of third-party logistics services? Will the benefits brought by the third-party logistics company be higher than the cost? Will the oil company perform logistics service by their internal logistics department or through outsourcing to a third-party logistics provider?

1.8 Value of research

This research has its academic and practical values. The academic value contains the following parts: Firstly, we studied the complicated process and summarize the specific characteristics of the oilfield material supplying system. Very few scholars shed their light on the logistics system of oilfields in China. In practice, the in-depth study of the logistics system for the oil industry can help logistics operations mangers to better understand the oilfield system from the theoretical logistics point of view. Secondly, a theoretical model is provided to classify the items of goods. Based on each of the special features of the goods in logistics functions, we suggest that all the goods used frequently in oil production are classified into different groups by a logistics-related standard. The present method is one of ABC classification. In this research, we select three major indicators that influence logistics operations in the oilfield to group the items of supplies into three categories in order to examine how different categories affect the decision on outsourcing.

Thirdly, we provide a framework to evaluate whether this item of supply is suitable for the third-party logistics company and find out that these factors considered suitable for making decision. A total logistics cost function is explored to measure the cost of every item under both DIY and 3PL conditions in a oilfield of China. From the results of computation and simulation, it is found that the value, volume, specialty and demand variable can exert their effects on the total logistics cost. Therefore, when determining whether one item will be outsourced, the indicators of its value, volume, specialty and demand variable should be considered.

As for the practical values, the oilfield can reduce the total logistics cost and at the same time enhance the logistics efficiency if the results of this research can be found in oil production. It is because for each item of supply, we choose the logistics operations between the oilfield and the third party company by comparing the two total logistics costs. The total logistics cost not only has the value of logistics cost but also the efficiency when the capability of meeting the requirement is considered.

Another value in practice is that the method and framework to examine whether the logistics function to be outsourced by classification and total logistics costs evaluation can be utilized in other industries. An industry with the supply of multiple types of materials can apply the model in this research to find out its total logistics cost for every item.

Chapter 2 Literature Review

"Using the services of a well-traveled third-party logistics vendor is often the shortest route to becoming a world-class global competitor", said two editors of Distribution. The third-party logistics can be divided into two main categories: Those that own transportation assets, serve their parent companies and sell the extra capacity in the market; and those that do not name non-transportation asset-owned companies, place focus on the people and take the system as the major assets. In recent years, many companies have turned to logistics outsourcing as a way to restructure their distribution networks and gain advantages for competition. The use of logistics outsourcing, in which a third-party logistics provider is contracted for all or part of an organization's logistics functions, has significantly increased. Although there are clearly pros and cons in using logistics outsourcing, both of these has not been examined to the full extent. A survey of the current literature available gives a relatively comprehensive examination of drivers and risks in the outsourcing process. In this section of literature review, the content includes four parts:

Drivers of logistics outsourcing,

Firm-specific characteristics,

Risks, and

Hidden costs.

2.1 Drivers of logistics outsourcing

"U.S. companies attempting to compete in Europe should take note of why the third-party logistics is so important here," said Brian Bolam, managing director of TNT Contract Logistics in Amsterdam, who listed 14 basic reasons for using the third-party logistics in Europe:

1. Improve financial performance by disposing assets
2. Connection to core business rather than logistics
3. Head count reduction
4. Vehicle replacement programs
5. Gaining a competitive edge
6. Adding a measurable value to the product
7. Enhancing customer service
8. Opening a new market
9. Systems development
10. Gaining the advantage of dedicated resources
11. Optimization of resources
12. Migration from domestic to international operations
13. Having access to specialists
14. Assurance of the standard of quality

By summarizing the drivers to introduce the third-party logistics to a firm to manage and operate logistics functions, the following part of literature review will mainly talk about the summaries of drivers of using the third-party logistics. The content of the third-party logistics includes six points:

Geography;

The production mode;

Emerging technology and versatility;

Strategic benefits;

Value creation; and

The impact from competition.

Geography

Many scholars hold the point of view that a geographic factor, i.e., one of the most important factors, is the outsourcing of drivers, and globalization is the most prominent trend (Byrne, 1993; Foster and Muller, 1990; Rao et al., 1993; Sheffi, 1990). The market continues to become wider and outsourcing in foreign countries becomes an increasing demand for logistics services (Bovet, 1991; Cooper, 1993). Bowersox (1992) provided four factors differentiating international logistics from domestic: 1) a greater distance involved, 2) an increasing demand for cultural-specific products and its impact on the number of inventory items, 3) accommodations for local business practices and customs, and 4) the extent to which varying rules and regulations may increase logistical complexity. Particularly, Cooper (1993) suggested that it is too expensive to duplicate best manufacturing practice in each of an organization's major markets and then manufacturing facilities have therefore become more focused, both by product specialization and geographical location. Four factors responsible for reshaping the activities of major companies include: The globalization of markets; cheaper communications; removal of barriers to trade and foreign investment; achieving economies of scale in business; innovation in logistics. As a consequence, managing logistics at a global level represents a challenge of considerable complexity and it seems fair to say that many companies have yet to come to grips with the challenge of managing global pipelines. Cooper (1993) mentioned as well that customer service, rather than cost, becomes the driver so the logistics strategy is geared to high-quality delivery in each operational theatre; neither production nor inventory is centralized, given the need to provide unfailing supply to demanding customers. Therefore, globalization leads to more international transportation, distribution and more complicated supply chains (Bradley 1994a). It is much harder to manage a global supply chain than the one within a single country, because of the lack of specific knowledge of customs and the infrastructure of destination countries. Sheffi (1990) suggested that long supply lines, global manufacturing, and worldwide distribution systems mean that the expertise needed to support manufacturers in their bid to be world class players is considerable. All of these forces corporations to acquire the expertise of third-party logistics providers. From a many-year survey made by Lieb, Peluso (2000) and Randall (1997), reported findings show that most third-party logistics users significantly increase their international operations in the last few years. In 2004, 80 percent of respondent large American manufacturing companies report that they use third-party logistics both in domestic and international operations (Lieb and Bentz, 2004).

Production mode

The production mode also greatly effects the decision on whether to introduce the third-party logistics providers to the firms. The benefits of outsourcing logistics can be considerable in some industries. 3PLs make the "build-to-order" manufacturing system possible in the computer industry such as Compaq Computer Corp. where otherwise it is somehow infeasible (Harrington, L.H. 1999). The increasing popularity of just-in-time (JIT) production type also promotes the third-party logistic services (Goldberg, 1990; Sheffi, 1990). According to Sheffi (1990) interpretation, increasing competition leads to high levels of transportation service and therefore inbound logistics system managers have to feed just-in-time production lines operating without safety inventory. Similarly, distribution executives have to serve a more demanding market place, customer's stockless production line, a retailer's exact promotion schedule, or a final customer's high expectation. Based on the survey of Chinese manufacturers (Junjie et al. 2004), the report figures out that firms using the JIT production mode are more likely to buy third-party logistics services from outside. However, those with the "mass-production" mode are intended to keep in-house logistics activities. The lack of confidence in the third-party logistics' service is a possible reason for why mass production has negative effect on the decision of using third-party logistics. With a shift to JIT delivery, inventory and logistics control become even more critical to manufacturing and distribution operations. The complexities and costs of operations in a JIT environment are prompting many of its potential adopters to supplement their own resources and expertise by using sources outside their corporate structure (Mohammed et al. 1998). The automotive industry almost relies on a third-party logistics provider to perform functions associated with JIT operations (Lynch, C. F, 2002).

Emerging technology and versatility

Suggested by Trunick (1989), emerging technology and versatility, on the one hand, are another factor for adopting third-party logistics. It is time and money consuming to build and complete new technologies for the firms by themselves, but more convenience to buy from third-party logistics provider. On the other hand, versatility of the third-party firms can easily employ them to provide an improvement in control, technology, and location, thus turning fixed costs into variable costs. They are able to reconfigure the distribution system to adjust to changing markets or technological advances. Small companies tend to be more interested in third-party logistics (Maltz, 1994) since they are in greater need for expertise and assistance in the area of technology (Harrington, 1995b). The KPMG Peat Marwick's third-party logistics benchmarking study shows that cost control, followed by information technology and inventory management are the major logistics concerns in respondent companies, and as such, results in further emphasis in outsourcing (Bradley, 1995a). Information systems mean that the transportation and logistics functions can be controlled and managed centrally even when corporations are growing larger, going through structural changes, entering and existing new and remote markets, outsourcing from new suppliers, and setting operations throughout the world (Sheffi 1990). Responded by large American manufacturers in 2004, service, cost consideration, IT capabilities and reliability are the four most important criteria used to determine if 3PL contracts are renewed (Lieb and Bentz, 2004). Companies lacking a comprehensive information system may seek to outsource their database management techniques used in the forecasting of handling the information flow loop (Richardson 1990). The application of third-party logistics enables firms to spend more time to achieve the strategic planning and management goals and focus on the core business instead of focusing on the logistics (Africk and Mareeset, 1996; Foster and Muller, 1990; Lynch et al. 1994).

Strategic benefits

In the alliances between the third party logistic companies and the users, specialization through a dedicated resource base generates economies of scale. Investments in transaction-specific assets often result in mutual dependence. The service supplier investing a special machine that can only produce components for a specific customer is, to some degree, bound to the customer in question on one hand, while on the other, the customer is also, to some degree, bound to the supplier, unless the other suppliers have the same production equipment. In situations with transaction-specific assets but with little uncertainty, the company can choose between in-house logistics and dedicated third-party logistics. As transactions with high frequency and investments in medium-specific assets, third-party logistics is an obvious choice. The reason lies in the fact that the same assets can be used in various contractual relationships and thus produces economies of scale when employed. The logistics provider has two potential advantages: the possibility of obtaining both economies of scale and specialization benefiting the customers. In situations where the transaction uncertainty is large or where there are large fluctuations in capacity utilization, third-party solutions will have an advantage over internal solutions, because the larger capacity of third-party logistic is better matched to demand. If the demand for warehousing fluctuates seasonally, it becomes an advantage for a client to use external warehousing, as the customer will only pay for the actual use of the space rather than the fixed costs of a building (Tage, 2000).

The spread of risk is another attraction of these alliances. Cooperated operations between a product marketer and a service provider offer what amounts to risk insurance. Not only is the chance of error much less because each party is focusing on its specialty, but also the partners share the consequences of a failure if the compact includes performance guarantees.

The effects stimulated by the joint efforts can create a coalition of great strength. One reason is the focus generated from a reduction in supplies by the product marketer and a limit on the service provider’s number of customers. The two organizations seek growth opportunities for each other’s mutual benefit. The fact that each views the logistics process from a different vantage point inspires creativity.

Value creation

Outsourcing can add value to the companies' systems. Operating cost in absolute dollars spent can be higher compared to the cost of in-house operations, but the value received from outsourcing may more than offset that premium. In another word, a Mercedes costs more than a Ford, but that doesn't necessarily make it a bad investment (Lynch 2002).

There are many ways for outsourcing which can add value to an efficient, cost-effective logistics network. The automotive industry with JIT uses a third-party logistics provider to collect parts from suppliers and deliver to a cross-docking. Shipments are consolidated and carried to many different assembly plants. The parts are never warehoused or in inventories at the plants. In the grocery industry, collaborative planning, forecasting and replenishment links customer demand with replenishment scheduling to reduce inventory in the system. This results in smaller, more frequent shipments. Third-party logistics companies are able to combine smaller scale of shipments into truckloads, reducing freight and handling costs and enhancing the entire distribution process.

The most important value-added offering that third-party logistics provided is information technology management. Increasing demands for new information systems, resources and real-time visibility into production and order status can be met most efficiently through outsourcing. Third-party logistics companies may assist clients in identifying logistics problems while technology is integrated and can offer solutions to end-to-end supply chain technology.

Impact on competitiveness

An increasing competitive environment forces the players of supply chain to do all they can to become the lowest cost competitors. Efficiency of logistics is particularly important for companies that are doing business abroad. The distribution cost, a percentage of revenue, is greater for international companies than for their domestic counterparts. Complexity, long order lead times, unusual product-service requirements, and differing legal and cultural factors in foreign counties combine to create a more challenging operating environment. Consequently, the headquarters are willing to use a qualified external support (Bowersox, 1990).

Seventy percent of Fortune Top 500 manufacturers report a positive or very positive impact on logistics costs, and that figure has been at least 70 percent each year since 2000 (Lieb and Bentz, 2004). The magnitude of this positive response continues to be important because, in most instances, logistics outsourcing is initiated due to cost considerations. Clearly, competitive pressures in the global market will continue to focus the attention of management on the control of logistics costs.

Summary

Besides the above factors which enable enterprises to outsource their logistics functions to third-party logistics companies, there are some other factors mentioned by scholars, such as company restructuring, productivity pressure, shorter cycle times, increasing customer demands, environmental awareness, making of new production lines and the focus on temporal aspects of logistics management. However, almost all factors can be summarized as geography, the production mode, emerging technology and versatility, strategic benefits, value creation, and the impact on competitiveness — six aspects, which should be taken into consideration in the process of decision on whether third-party logistics is used. To sum up, all above indicators mentioned are somehow related to the generally external environment, and then in the following part enterprise's internal firm-specific characteristics will be reviewed and summarized from current literatures.

2.2 Firm-specific characteristics

The full understanding of benefits of manufacturer's outsourcing logistic operations has not only led to an increase of the logistic function, but also encourages the logistics managers to learn to adapt to this new intrusion into their territory (Gooley 1994). Therefore, the question of "what firm-specific characteristics have affected a firm's decision to outsource its logistics function" has been raised quite reasonably and regarded as an important question to answer.

For the interpretation of this problem, the next part of literature review contain the following five points:

- Size;
- Degree of centralization;
- Degree of corporate control;
- Industrial type; and
- Management level at which the outsourcing decision is made.

Size

Structure realities of a firm represented by its contextual factors, such as the size, often influences decision-makers (Bobbit et al., 1980). Decision-makers process this input according to their cognitive and motivational orientations. Small companies tend to be more interested in third-party logistics use (Maltz, 1994) since the need for expertise and assistance in technology is greater than larger firms (Harington, 1995). However, they must view logistics as a profit center, not a cost center (Foster, 1993) by first adopting a strategic view of logistics that takes outsourcing as a potential source for competitive advantage. But based on a Chinese manufacturers' survey, the number of employees has a negative effect on the decision of outsourcing while the total asset impacts positively (Junjie 2004).

Degree of centralization

A moderate degree of centralization is paradigm of the traditionally organizational structure associated with strategic selection (Bowersox et al., 1995). In organizations with a centralized structure, the cognitive limits of those few who dominate will determine how comprehensive the organization is in making strategic decisions (Fredrickson, 1986). However, based on Mohammed, et al. empirical research on Singapore firms, the degree of centralization seems not to be a key factor to effect the decision of outsourcing.

Degree of corporate control

Controlling, which involves regulating organizational activities so that actual performance conforms to expected organizational standards and goals (Bartol et al., 1991), ensures that staff members behave in a way that facilitates the achievement of organizational goals. When making strategic decisions, decision-makers in firms with a high level of corporate control may behave differently than their counterparts in firms having a low or moderate level of control. A survey of manufacturers of Asian NIC- Singapore shows the findings that companies with high or moderate level of control tend to adopt third-party logistics. That means the degree of corporate control has a relationship with the decision of outsourcing.

Industrial type

The industry environment often contributes to the finding of an appropriate strategy. Organizations in an industry are influenced by the structure of and competition in that industry. Environmental dissimilarities of firms in different industries prompt them to use diversified criteria in their decision-making procedure. The research made by Mohammed et al. showed that in the following six industries of electronic products, electrical products and components, food/beverages, precision engineering products, machinery and components, fashion and garments, printing, publishing and paper products and pharmaceutical, healthcare and biotechnology seemed to have the least tendency to outsource logistics functions (Mohammed et al., 2002). In UK, food retailers dominate the dedicated distribution market. In addition, beverages and tobacco, computer and related activities, electronic, electrical equipment and machinery, chemical, oil and pharmaceutical products, automotive industry and aerospace industry are the industries which logistics functions are most probably to be outsourced (H.S. Jaafar et al. 2005). In Singapore, food, beverage and electronic, electrical products and component industries have the highest incidence of outsourcing. In China, firms producing food, beverage and tobacco, chemical products, electrical and electronic products and components are most likely to use third-party logistics, while machinery (except electrical and electronic) industry are not.

Management level at which the outsourcing decision is made

Decision to or not to outsource are likely to be made by top management since they have a broader perspective of the firm's operations. Effectiveness of any contracted logistics program depends on the cross-functional management commitment to logistics as a process involving purchasing, operations and physical distribution, as well as sales and marketing (Byrne, 1993). A conductive environment, involvement of key executives, coherent and effective intermeasurement systems, mutual respect and empathy, commitment to investment, and financial and commercial arrangements are of particular importance to successful outsourcing. However, in some situations, this task may be delegated to a lower level management that may view the circumstances differently. This variable is somewhat related to the level of centralization of a firm. According to a survey of Chinese manufacturers, only one managerial factor, i.e., a medium-level factor, significantly influences outsourcing decisions. Firms that make logistics decisions at a medium management level have a higher probability of outsourcing.

Summary

The decision made on whether a firm should introduce the third-party logistics to manage logistics functions also depends, to a large degree, on the firm's internal special characteristics. Corporate size, degree of centralization and control, industrial type and managerial-level seem to have played respectively an important role in the outsourcing decision. There are many other factors that discourage the use of outsourcing just as there are many reasons that favor outsourcing to third-party logistics.

2.3 Risks

An analysis of the disadvantages of outsourcing began a few years ago in the applications of other aspects. For instance, Earl (1996) argued on the risks of outsourcing IT of which analysis is being made based on the examination of eleven different risks both from buyers and providers in the IT outsourcing market. According to Earl, it is probably a sensible approach to balance efficiency and effectiveness in providing IT service. Cavalla (1996) and Piachaud (2002) examined the perceived disadvantages of R&D of outsourcing in the pharmaceutical industry. Based on these analyses, risks in logistics outsourcing can be described in the following aspects:

The possibility of inefficient management;

Employee factor;

Latent information asymmetry;

Loss of capability for logistics innovation;

Loss of control over the third-party logistics provider;

Problems arising from evaluating and monitoring third-party logistics provider performance;

Conflicts of company culture; and

Difficulty for user's system integration.

The possibility of inefficient management

Almost all the surveys, which ask companies why they use third-party logistics, find out that cost is among the most important determinants. A survey made in 2001 by J.P. Morgan Securities shows that cost is among the leading factors in choosing a logistics service provider. Gap Gemini Ernst & Young's third-party logistics study made in 2001 reports that 63 percent of companies that did not choose outsourcing because they believed it would not reduce their costs. The reason is: if a company has an efficient, well-managed distribution system, to outsource that system may not reduce the operating cost (Lynch 2002). When the in-house logistics service has poor operational performance, the company is tempted to outsource it to a third party. Executives of the company also have to know how to manage contracts and relationships with the third-party logistics provider. Once logistics outsourcing is initiated, to manage logistics operations is difficult. There will be a need for a more professional and highly strained purchase and contract management group (Quinn et al. 1994). If the third-party logistics provider chooses to change the way it provides logistics service, the company has to learn about how to become fit for the new system. If the third-party logistics provider changes its personnel or organization, the user has to invest in establishing new partnership and understand how things are operated in the new environment (Earl, M.J. 1996). However, in reality companies do not abandon their control as outsourcing does not take the place of users to monitor their vendors (Bowman, 1994). The two sides need to meet frequently to map out the strategy and solve problems as they arise. Byrne (1993) adds that the lack of advanced information technology, which links the manufacturer, carrier, warehouse and customer operations, has often caused hindrance to contracted logistics management.

Another major management risk is the difficulty in obtaining organizational support (Bowman, 1995). The lack of confidence of an outside company management in delivering service at a high level as the company employers is a major issue: the third party may be inadequate in its capabilities to meet users' requirements (Cooke, 1994b; Maltz, 1995). Difficulty in assessing the saving to be gained through outsourcing creates an additional management problem.

Employee factor

Outsourcing a considerable part of the logistics operations will probably result in lying off at least part of the staff who previously performed the internal functions. At the same time, these employees' competence and specific skills that have acquired through a long-time service by individuals will disappear. That is a potential loss for the outsourcing organization as well (Tage, 2000).

The use of a third-party logistics company may make user's logistics people comprehend their job-security. These people may develop a fear of being retrenched (Cooke, 1988; Muller, 1991b). According to Lieb and Bentz survey of large American manufacturers, 40 percent of the respondents reported a negative impact on employees' morals. The magnitude of the reported negative impact on using 3PL services by manufacturing employees is a cause for their concern. Is this simply a function of deeper cuts of the full-time employment base of longer-term users, or is there more to it? Users and providers should consider the potential use of regular employee survey results and/or focus groups to not only determine the extent of this problem, but also to seek ways of reducing its impact. Additionally, users should be aware that a number of 3PL contracts provide for the possible flow of qualified employees from the manufacturing company to the third-party logistics provider.

Latent information asymmetry

There exists an information asymmetry in logistics outsourcing. A third-party logistics provider rarely has complete information about the contracting company. For example, if the third-party logistics provider has incomplete information about the contracted companies' cost structure, the price it will offer and therefore its profit level can not be well matched to that cost structure.

Similarly, besides the loss of control, the company may have incomplete information about the third-party logistics provider. The company may have no access to important information, and as a result, it will fail to select or properly manage providers whose promise will become significantly unreliable (Bradley, 1995a).

Loss of capability for logistics innovation

If a company has outsourced its logistics services, its capability for logistics innovation may be impaired. In the long term, if a company wants to maintain its comprehensive competitive competence, it should develop new ways to provide logistics services for the business. Innovation needs resources, organic and fluid organizational processes, and experimental and entrepreneurial competence, and all the attributes that external sourcing does not guarantee. During the period of outsourcing, the third-party logistics provider may not recognize an opportunity to innovate as its focus may primarily be at a cost.

While it does not prove that innovation cannot be bought, it suggests that partners have their limitations and that expectations must be properly managed. Take IT in logistics service for example. If others generate some innovative ideas in the market, the vendors who cannot innovate in the first place but now have operational control of IT resources may then have to put the ideas into practice. The relative network becomes complex. Although such complications are not impossible to cope with, they again raise the cost for management, the costs for search innovation in particular. The complicated relative network in the market also limits the opportunities for users who understand the business to interact with specialists who understand the technology on a continuingly informal and formal basis.

Loss of control over the third-party logistics provider

A firm that outsources its logistics activities to a third-party logistics provider runs the risk of becoming dependent on that provider. By outsourcing logistics activities to the same third-party logistics provider for a long period of time, a firm may find itself in an increasingly vulnerable position and may even lose control of part of its logistics activities.

The loss of control of third-party logistics providers appears to be the most commonly cited reservation that inhibits firms from using third-party logistics (Bardi and Tracey, 1991; Bowman, 1995; Byrne, 1993; Cooke, 1994b; Lynch et al., 1994; Richardson, 1993a). All collaborative projects result in, to some extent, loss of control. In outsourcing arrangements, and the partial control of a project inevitably passes from the sponsor to the collaborator (Piachaud B.S. 2002). The extent to which the firm may effectively control an outsourced logistics business will greatly be determined by the information received and the early detection of problems. Since the information available to the logistics manager can be less comprehensive than it will, a lack of effective communication can ensue as a result if the logistics business was conducted in-house. This leads to problems of quality and delays, as well as to misunderstandings and even mistrust (Cavalla, D., 1996). Because of misunderstanding and mistrust, third-party logistics providers also have to build slack into their operations. Lack of visibility of a shipment and demand schedule may result in the creation of excess capacity and excess shipment expenditures. It may also lead to the use of an uneconomic mode for transportation.

Problems arising from evaluating and monitoring third-party logistics provider performance

In order to properly evaluate the functions of a third-party logistics provider, firms must develop clear guidelines for appraising the outcome of a third-party logistics provider. However, this is more often than not a factor that is frequently overlooked by companies when developing a partnership with a third-party logistics provider.

Monitoring logistics outsourcing is often a difficult and complex task. In order to ensure that the business carried out by the third-party logistics provider meets the required standards, and resources such as money, time and expertise are needed to establish an effective monitoring system.

Conflicts of company cultures

In logistics outsourcing arrangements, the targets of each party are often different; the factors that determine the commercial merit of the relationship are being considered from different perspectives, The management styles and degrees of bureaucracy within firms may also be different. Consideration of these factors is essential to ensure the viability of the collaborative venture and future success of the relationship (Piachaud B.S. 2002).

Difficulty of user's system integration

The American large manufacturers' survey made in 2004 by Lieb and Bentz shows that nearly one-third of the users indicating their use of third-party logistics has a negative impact on system integration. Why is it so? In many instances, the use of third-party logistics reduces direct contact between various functional groups within the manufacturing company and between that company and their vendors and customers. Under those circumstances, it is very important for the provider to facilitate system integration between the internal and external supply chain partners. In a great number of cases, it does not always happen. Increased attention must be given to effective communication both within client organization and along its external supply chain. A third-party logistic company which provides services to several members of a supply chain should improve the quality of information that flows among these organizations.

Summary

As we know, there is very few published research papers exactly aimed at outsourcing logistics risks. I explore potential risks in third-party logistics by summarizing researches on risks in outsourcing application of other industries. Moreover, there is no empirical study on this issue and no research attempting to quantify risk factors in logistics outsourcing. In my research, I will build a model to evaluate all the indicators which affect decision of using third-party logistics significantly including risk factors.

2.4 Hidden cost

Benefits can be eroded by costs that firms' managers cannot identify a priori. In this section, not only hidden cost will be described but the reason of why hidden costs exist will be presented. Drawing on a study of IT outsourcing by Bartholomew 2002, which examines hidden costs, the following observations about logistics outsourcing are made:

Vendor search and contracting

Many firms underestimate the costs associated with selecting a third-party logistics provider, and negotiating and drafting a contract. Companies incur such costs before spending the first dollar on the actual work. Vendor search and contracting cost will be paid between the original idea to outsource and the beginning of the outsourcing relationship period. It is always cheaper to keep vague about expectations and build the vendor's standard contract than to develop clear expectations and write them into a contract. It is cheaper to go with the convenient vendor, rather than research the vendor's suitability. But it is not cheap in the end.

Because many searching and contracting activities are the same regardless of the contract size, business planning larger contracts often spends on that category a lower percentage of their total outsourcing cost. For contracts below US$10 million, companies can expect to pay an average of 6% of the total sum as specified in the contract; for contracts higher than US$100 million, they pay an average of 0.25%. The cost can be measured in time and, to some degree, by required personnel. The average total duration of a US$500 million contract is 15 months, while the duration of a US$2.5-million contract is 18 months. The searching and contracting cost is higher for the US$500-million contract, but it is a smaller percentage of the total amount as specified in the contract. There is no direct correlation between the number of people and the actual cost. Everything depends on how much time the employees will devote to the outsourcing project.

Transition to the vendor

Most managers in the survey cannot analyze the cost for transition. The best they can do is to report the transitional time, a measurement offering only limited insight into what drives the transitional cost. The average transitional period is about a year. For 70% of the companies, the period is longer than 10 months. The characteristics of the outsourced activity greatly influence the transitional cost. The more idiosyncratic the activity is, the higher the cost is to pass to a vendor that must take time to learn the activity. Also, the more complex the outsourced activity is, the harder the transition is. Outsourcing activities that require transferring many people to the vendor also increase transitioning costs.

Managing the effort

Managing the effort probably requires the largest sum of hidden costs because it covers three areas: monitoring to ensure that vendors fulfill their contractual obligations, bargaining with vendors and negotiating on any needed contract changes. The cost of managing outsourcing is a small percentage of a large contract. The larger discrepancy is due to the fixed costs of some management activities. All the outsourcing efforts in the 50 companies studied will cost at least US$30,000 per year for management. Thus companies with smaller contracts devote a great percentage of a total outsourcing cost for management.

2.5 Logistics cost

Previous researches about logistics cost is mainly included in two major parts. One part sheds its light on strategic aspects of the logistics cost, and the other is focused on optimized cost-effective logistics decisions. In previous researches, there was a large amount focusing on the relationship between the logistics cost and a company's financial performance. As stressed by Gilmore (2002), logistics costs compromise a large amount of assets and directly affects the cash flow and the bottom line. Gilmore reported that for many companies, transportation costs could make up from 3 percent to 7 percent of the total sales, and this number could even be added up to millions of US dollars in an annual expense of medium-sized firms. Fagan (1991) mentioned that as the global sourcing became the main trend of business strategy, more and more companies were purchasing materials and services overseas in order to "obtain the right product at the right price in the right time". As a result, measuring and evaluating the logistics costs play a critical role for strategic benefits.

As mentioned above, currently the logistics cost becomes more and more important in the supply chain management field and draws more and more attention from scholars. There are a large body of literature focusing on the control of the logistics cost. The methods to analyze the logistics cost used by previous researchers can be classified into four major categories, such as recurrence-based, regression-based, activity-based, and optimization-based (Zeng, 2003). Fera (1998) identified and classified a relevant list of factors related to logistics for evaluating the feasibility of the international sourcing strategy for a company. The list including both the recurrence cost and the non-recurrence cost for global sourcing logistics management was presented for further analysis. A regression model was introduced by Zoroya (1998) to evaluate the logistics cost driving factors which affected the shipper's transportation fees. Three time-based factors were mentioned to identify what factors produced an impact on the price of transportation lane. Van Damme (1999) presented an accounting framework for logistics management to support logistics management decision. In his distribution cost model, the benefits of activity-based costing with regard to the allocation of costs and the control of process were combined with the benefits of cash flow-based accounting with regard to decision support.

There is a large amount of researches which used optimization-based method to measure the cost of a logistics supply chain system. Normally, such a cost is measured by the total logistics cost which is made up of transportation connected with the inventory cost and purchase decision-making. This approach attempts to optimize the total logistic cost. Originally, the logistics and transportation cost analysis came from the economic analysis related to the cost for perfect competition between firms which survive in the same market but producing in different places. For example, Buffa and Reynolds (1977) identified the "failure to consider explicit transport cost as a determinant of the inventory strategy" as a "major shortcoming" of inventory models. They took the "well established total cost model including holding cost, ordering cost and stock out cost" and added cost items for “in-transit holding, freight and purchase costs”. They concluded that the transportation mode choice decision and thus the purchase quantity decision were very “sensitive” to the transportation cost, “moderately sensitive” to transitional time variability and minimum full-vehicle road, and “virtually insensitive” to average the transitional time. Siliper (1979) introduced the total cost as a criterion to select whether air or sea is more economic freight. For comparison between the air and surface freight, the total logistics cost included value ex works, such as packing, inland transport/handing, freight, handling/inland transport, import duties, insurance, cost of capital and storage, value ex works per gross kg and time advantage for air transport “door-to-door”. In the field of freight estimation of logistics decisions, Swenseth and Godfrey (1996) summarized five methods of estimation, such as the constant function, the proportional function, the exponential function, the adjusted inverse function and the inverse function. These functions were directly compared in their study on data collected from a shipper in the Midwest and indicated that realistic estimates of shipping cost can be determined from a straightforward estimating function. Vidal and Goetschalckx (2000) modeled the effects of uncertainties in global logistics systems and developed a mathematical programming model in which the sensitivity of key cost drivers such as the exchange rate and the lead time on minimum total cost is evaluated based on the re-optimization of the system under different conditions. This model is able to incorporate significant parameter changes with no increase in the total system cost and demonstrates that the effect of uncertainties on the optimal design of a global logistic system is significant.

Chapter 3 Research Design and Data Collection

After making the above analysis, we hypothesize that there are many kinds of supplies that can enjoy the benefits from the third-party logistics companies which should go in for outsourcing, while at the same time, it is more appropriate for the other kinds to operate logistics functions by current oilfield-owned resources. In our research, we attempt by the following simulation to detect what kind of supply is more efficient for the third-party logistic company to take charge of their logistics functions, while which are not. The efficiency is measured by the cost of such kind of goods occurred in the logistics system. This research will be carried out according to the following steps:

(1) All the goods used for or produced in the oil production will be classified into different categories based on standards related to transportation and inventory functions in their logistics process;

(2) A mathematical model to evaluate the overall logistics cost of every kind of supplies, in which the cost of inventory and the cost of supply shortage will be measured related to the supplies' unit value and the penalty cost rate;

(3) Data will be collected from an oilfield in China to compute the overall cost of every type material if it is outsourced to a third party and operated by the oilfield itself, meanwhile, the mathematical model will be further revised and amended at the same time to simulate the real process of the oil industry as much as possible;

(4) Finally, comparing the two groups of data computed after the last step, conclusion will be drawn to describe which kind will be more efficient than operated by the current system in the logistics outsourcing of the oilfield production procedure.

3.1 Classification

Due to the extremely complicated process of oil production, a large quantity and dispersed kinds of goods and materials should be transported into the oilfield logistics system. There are thousands of kinds of supplies used in the oil production process, of which most are different with minor characteristics in oil producing point instead of different logistic view of point. For instance, thick seamless steel pipe and thin seamless steel pipe almost have the same logistic features with only difference in width. Therefore, we merge such kinds of goods and classify them based on three standards: value per unit, annual amount of purchase and whether it can only be used in the oil industry. The data comes from the real records of that oilfield supply purchase in 2005. For the standard of per unit value, the high-grade level is over RMB8,000 each unit (the highest is 20% unit value of the total items of goods), the medium level is between RMB8,000 and RMB3,000 and the low level for the value is below RMB3,000 per unit (the lowest is 20% unit value of the total items of goods), in which a unit will be calculated by ton for materials, a set will be computed by a piece of equipment and 10,000 meters will be counted for the cable and the pole. For the annual amount of purchase, if the amount of one kind of goods purchased in 2005 reaches 10,000 units in one period (the largest is 20% volume of the total items), the large one will be marked in this kind; if an amount is belows 5,000 units in one period (the lowest is 20% volume of total items), the low one will be given to such kind and the middle one will be amid the range. A unit will also be calculated by ton for materials, a set will be computed by one piece of equipment and 10,000 meters will be counted for the cable and the pole. For the professional transportation standard, “yes” will be marked in those kinds that need special transportation facilities and otherwise, “no” will be given. The classification will be listed as Table 3.1:

Table 3.1 Classification of Supplies in the Oil Producing Process

Product		Value	Volume	Speciality
Pipe	Bushing pipe	High	Large	Yes
	Oil tube	High	Large	No
	Seamless steel pipe	High	Large	No
	Seamless carbon steel pipe for transporting fluid	Middle	Large	No
	Drilling pole	High	Medium-sized	No
	Seamless alloy steel for transporting fluid	Middle	Small	No
	Oil pumping pole	Low	Large	No
	Jointing steel pipe	Middle	Large	No
	Helix pole (instrument)	Middle	Large	No
Fuel	Kerosene	Low	Large	Yes
	Gasoline	Middle	Large	Yes
	Coal	Low	Large	No
	Washed coal	Low	Large	No
	Kerosene oil	Middle	Low	Yes
Raw building materials	Middle-thick armor plate	Middle	Large	Yes
	Cement used in oil well	Low	Large	No
	Barite powder	Medium	Medium-sized	No
	Linetype material	Medium	Large	No

	Wire cable	High	Medium -sized	No
	Middle-scale raw steel material	Medium	Low	No
	Large-scale raw steel material	High	Low	Yes
Dangerous material	Explosive	High	Low	Yes

Chemicals & Additives	Polyacrylamide for the third-time oil producing	High	Large	Yes
	Chemicals used in drilling	Low	Large	Yes
	Chemicals used in oil-pumping	Low	Large	Yes
	Inorganic chemicals	Low	Large	Yes
	Organic chemicals	Low	Medium -sized	Yes
	Accessory ingredient for oil pumping	High	Small	Yes
	Salt	Low	Large	No
	Accessory ingredient for oil refining	High	Low	Yes
	Additive agents for common usage	High	Low	Yes
	Additive agents in fuel oil	High	Low	Yes
	Alkali	Low	Medium -sized	Yes
Electronic device & fittings	Facilities fittings in oil & gas pumping	Medium-sized	Large	No
	Borer fittings for petroleum & geology	Middle	Medium -sized	No
	Special meter for petroleum producing	Low	Large	No
	Oil extractor	High	Low	Yes
	Oil-well pump	High	Large	No
	Diamond tip of drill	High	Low	Yes
	Equipments for testing oil producing amount & repairing well	High	Low	Yes
	Low-voltage device	Low	Medium -sized	No
	Low-voltage device fittings	Low	Low	No
	Industrial pump fittings	Low	Medium -sized	No
	Equipment fittings for testing oil production amount & repairing well	Middle	Low	Yes
	Transformer	Middle	Medium -size	No
	Flow capacity meter	Low	Large	No
	High-voltage electronic device	High	Low	No

	Centrifuge pump	High	Low	No
	High-voltage & middle-voltage valve	Low	Large	No
	Hypopiesia cubicle switchboard	Low	Large	No
	High-voltage cubicle switchboard	Low	Medium -size	No
	Hydraulic pressure component	High	Low	Yes

3.2 Mathematical Model

Zeng (2003) classified the logistics cost into seven categories: transportation, inventory, holding, administration, customs charges, risk and damage and handling and packaging. These categories also present the logistics cost evaluation framework for the supply chain management as follows:

(1) Identify the objective, which is to examine the logistics cost associated with outside sourcing;

(2) Establish a set of possible modes and a combination of modes available for transporting materials and finished goods;

(3) Develop the minimum number of input parameters required to ascertain the cost;

(4) Re-classify the cost elements into three categories: weight-based, value-based and shipment frequency-based;

(5) Calculate the annual total logistics cost for moving materials.

In our model, it is assumed that a third-party logistic company is an independent outside company, which cannot use any oilfield-owned resources and cannot be original parts of the logistics department of the oilfield. The choice of whether to introduce the third-party logistics company will be measured by the cost of each kind of goods or materials in the logistics system of the oilfield, including the inventory cost, transportation cost, purchase cost and shortage cost.

The notations used in this model are shown as follows:

TC_j : expected total cost for the *j*th kind of goods in the logistics system of the oilfield, j=1,2,3…n.

$h_j\left(c_{oj}\right)$: unit holding cost of the *j*th kind of goods in the logistics system of the oilfield, which is highly related to the unit ordering cost of the item j=1,2,3…n.

s_{tj}: optimal order-up-to level of the *j*th kind of goods in the logistics system of oilfield at the end of period t, j=1,2,3…n.

x_{tj}: demand of the *j*th kind of goods during the period t, $x_{tj} \sim N(\mu, \sigma^2)$, j=1,2,3…n.

y_j : total demand of the *j*th kind of goods from period t+1 to period $t+l_j$, $Y_j = \sum_{i=1}^{l_j} x_{t+i}$, j=1,2,3…n.

l_j: leadtime of the *j*th kind of goods, j=1,2,3…n.

c_{oj}: unit ordering cost of the *j*th kind goods, j=1,2,3…n.

c_j: unit transportation cost of the *j*th kind of goods, j=1,2,3…n.

$p_j\left(c_{oj}\right)$: unit penalty cost of the *j*th kind goods when out-of-stock, which is highly related the unit ordering cost of the item, j=1,2,3…n.

Φ: standard normal distribution function

k: service level — the extent to which a supplying resource satisfies the customer requirements in terms of error rate, resource availability or accuracy in meeting requested dates.

f: item j's density function of demand probability distribution from period t+1 to period t+l

As presented above, the total logistics cost of the supply system in the oilfield industry is classified into four categories: purchasing cost, inventory cost, storage cost and transportation cost, as described in the following.

Purchasing cost: $c_{oj}E\left(x_{tj}\right)$

The purchasing cost for the jth type of goods during time period t is given as the unit ordering cost multiplied by the expected demand amount of the jth type of goods during the time. There is no significant difference in the purchase cost under the condition of either the third-party logistics company or the oilfield purchasing system, since the unit ordering cost and the expected demand are of constant values for the third party logistic and oilfield original logistics resources.

Inventory cost: $h_j\left(c_{oj}\right)\cdot\int_0^{s_{tj}}\left(s_{tj}-y_j\right)f\left(y_j\right)dy_j$

The integral is the expected quantity of overstock at the end of period $t+l_j+1$. The inventory holding cost for the jth type of good is the product of the expected quantity of overstock and the unit holding cost. The unit holding cost is related to the ordering cost as more expensive or valuable items often need much higher inventory facility and management cost. In other words, the unit holding cost is given as a function of the unit value of goods. If the third party company stocks one type of very highly valued goods, the company will invest extra funds to strengthen the safety system or spend more time and more human resources to protect these goods due to the company cannot use the existing resources of the inventory. All these measures will increase the holding cost charged by the third-party logistics company. By contrast, if the same goods are stocked by the oilfield, the oilfield logistics department can make use of at least part of the current facilities. Therefore, the inventory cost of the third-party logistics company is reasonably higher than that of the oilfield handled.

Shortage cost: $p_j\left(c_{0j}\right)\cdot\int_{s_{tj}}^{+\infty}\left(y_j-s_{tj}\right)f\left(y_j\right)dy_j$

The integral is the expected quantity of understock at the end of period $t+l_j+1$.

The inventory shortage cost is the product of the unit penalty cost and the expected quantity of understock. The penalty cost is also related to the unit ordering cost, which means the value of goods affecting the penalty cost. Generally, highly valued goods will not be stocked in a large quantity in the warehouse for the third-party logistic company doesn’t want to let so much funds lie idle on it. However, for safe production, the oilfield logistic management department will provide more spare parts or equipment in case of an emergency, which leads to the higher possibility for the third party company to stock such goods for the oilfield. Therefore, the 3PL unit penalty cost rate is much higher than the cost born by the oilfield itself on those high valued goods. Moreover, usually high valued materials are more important than other ordinary ones and play a more significant role in oil production. For example, when drilling a well, a drilling machine is the key equipment. If some spare parts are damaged in this process of drilling, they will cause a larger loss than the cost for stocking a pair of gloves. As a result, the cost for stocking higher valued goods is much higher than the price of those consuming things. In addition, urgent requirement for supplies happens every now and then. For the third-party company, due to the reason of economy, it is very hard to meet so many urgent requirements on time. Furthermore, if the scale is not so large and the third-party logistics company cannot enjoy the economy of scale, the cost will be higher than the cost of non-outsourcing logistics.

Transportation cost: $c_j E\left(x_{tj}\right)$

The transportation cost has a closed relationship with those special kinds of goods used only in oil production and those high valued goods. There are many goods needed in oil production and professional transportation, such as fuel, crude oil and extra-long steel products, etc. The third-party company should, first of all, purchase and build such professional transportation vehicles which can only be used in oilfields or only for the transportation of single kind of goods. As a result, it cannot enjoy the economy of scale which is one of the most distinct advantages for the third-party logistics companies. It is clear that the transportation cost in the 3PL case will be higher than the oilfield DIY case. In this model, the index of c_j in the third- party case must be higher than it is in the case of using oilfield internal resources. What is more, the cost for transporting some high valued goods or materials is reasonably higher for carrying 3PL than the cost born by the oilfield when using its own resources, such as the diamond drilling bit. Due to the high risk faced by third-party logistic companies to guarantee the security of those goods, the cost charged for transporting such goods by the third-party logistics company will be higher in order to balance the potential loss in case of accidents. To sum up, the transportation cost for the third-party logistics case will be higher than that of logistic functions done by the oilfield itself.

The total logistic cost on the *j*th type of good is give by the sum of above four cost categories, as the following.

$$TC_j = c_{oj}E\left(x_{tj}\right) + c_jE\left(x_{tj}\right) + h_j\left(c_{oj}\right)\cdot\int_0^{s_{tj}}\left(s_{tj} - y_j\right)f\left(y_j\right)dy_j$$
$$+ p_j\left(c_{oj}\right)\cdot\int_{s_{tj}}^{+\infty}\left(y_j - s_{tj}\right)f\left(y_j\right)dy_j$$

Where $y_j = \sum_{i=1}^{l_j} x_{(t+i)j}$, j=1,2,3…n.

$x_{tj}\sim N(\mu, \sigma^2)$,

$s_{tj} = \mu l_j + \Phi^{-1}(k)\sigma\sqrt{l_j}$,

$h_j\left(c_{oj}\right): \alpha_1 c_{oj} + \alpha_2$,

$p_j\left(c_{oj}\right): \beta_1 c_{oj} + \beta_2$.

3.3 Data requirement

In the logistics supply chain, the decisions-making can generally be classified into the strategic, tactical or operational decisions-making. The strategic decision-making is related to the company's long-term (2-5 years) goal which involves in most partners of the whole supply chain. The tactical decision-making is a mid-term (1 month to 1 year) goal while the operational one is a short-term one, which is related to daily performance. Tactical and operational decision-makings deal with issues in demand, procurement, production, warehouse and distribution respectively. Gunasekaran et al (2001) presented a framework for the measurement of the performance evaluation of a supply chain. They are also classified into financial and non-financial so that proper cost evaluation method can be employed in suitable situations in the supply chain. Especially, the selection of a method for measuring performance is based on company's operational goals. To sum up, different levels of decision-making require different types of data, in which a design scenario is very important because it is not reasonable for most of the time to model every detail of the whole logistic process.

Obviously, in our research, the decision-making is of strategic importance. The data we need in this study includes the following aspects of goods and materials of all categories we classified: the safe stock-level records, the inventory-level records, important data in the oil production process, value, degree of requirement for professional transportation, amount consumed in a period of time during real oil production, the risk-level shortage in the production process, transportation expense records and so on. All of the data should be collected from the real records about a typical oilfield which has a large number of points common in logistics among all the oilfields and can represent the general situation of logistics management in the oil industry of China. It is possible that there are many aspects of data related to the secrets of the oilfield performance especially because oil plays a pivotal role in growth of the national economy as a strategic energy. Authorization must be obtained in advance to use such data for the sole purpose of research after negotiating with persons in charge.

3.4 Data collection

Data are collected from a typical oilfield in China. To keep secret, the real name of that oilfield cannot be published in this thesis. Instead, we call it the S Oilfield.

To compute the total logistics cost by the third-party logistics company, we discussed with experienced managers of local third-party logistics companies on each parameter assignment. In the data collection process, we first explained every index of function to managers, then negotiated charges in every part of the logistics cost function with them for each items and discussed factors. After making interviews with three companies' managers, three groups of data were collected and a more reasonable one was assigned to the cost function to calculate the total logistic cost for every item of goods.

For the data used by the oilfield, we collected relevant records and transformed them into each part of the total logistic cost function. In the text book of logistics management, the inventory cost contains capital tied up in the inventory, variable storage costs, and obsolescence (Lambert et al, 1998, p.17). Quayle et al (1999) states that the cost of storage includes two major parts: The financial opportunity cost and the physical opportunity cost. The financial opportunity cost is made up of the cost of borrowing money and the other uses to which that money could be put; the physical opportunity cost is made up of the costs for store buildings and stockyards, the revenue cost of maintaining stocks in good conditions, light, heat, maintenance and the human resources for operating the stores. In the cost function of inventory $h_j\left(c_{oj}\right): \alpha_1 c_{oj} + \alpha_2$, α_1 indicates the finance tied up in the inventory related to the value of goods, and α_2 indicates other costs for the Inventory. For data collection, we checked the average interest rate and real records of the oilfield in last two years on warehousing, such as the operational cost, packaging and human resource costs for handling each item of goods in this study.

Lambert et al (1998) suggests that the factors influencing the transportation cost are classified into two groups: product-related factors and market-related factors. Factors in product-related are “density, stowage, easiness or difficulty in handling and liability”. The market-related factors include the “degree of intra-mode and inter-mode competition, location of the market, which determines the goods far away must be transported, the nature and extent of governmental regulations on transportation carriers, balance or imbalance of freight traffic in and out of a market, seasonality of product movement and whether the product is transported domestically or internationally". On the formation of such a definition, in this study, we add one more factor: the insurance for the risks in transportation, and specially the data provided by the third-party logistics company. The insurance of risks plays an important role in the transportation cost. In applying the above factors in petroleum production, the following records for every item are related: The weight and volume of goods, transportation tools, the handling cost, the value-weight ratio, gasoline price, distance of transportation in a given period of time, operational costs for transportation tools and the demand variance range, etc.

For ordering cost, after the data are collected, it is found that for every item, the ordering cost is a very small number compared with others. It is because the ordering cost is made up of the information transfer cost, the expense for phone or the Internet, and fax fees, etc. For both the oilfield and the third-party company, it is a very small part of the logistics cost. Therefore, this cost is generally neglected from the cost function in the computation and simulation process.

Chapter 4 Results and Discussion

Simulation analysis may need to quantify the benefits resulting from supply chain management in order to make the decision at the both strategic level (including redesigning a supply chain) and the operation level (including setting the values for policy control). Kleijnen and Smits (2003) distinguished four methods: A spreadsheet simulation, system dynamics, discret-event dynamic systems simulation and business games. They also presented that simulation models have the following three characteristics for the supply chain:

I. A quantitative , mathematical or computer model,

II. A dynamic model. For example, it has at least one equation with at least one variable that refers to at least two different points in time,

III. A model which cannot be solved by mathematical analysis, instead of the time path of the dependent variables (outputs) are computed-given the initial state of the simulated system, and is given the values of the exogenous variables (input).

Simulation can, to a large degree, overcome some of the difficulties. A well-designed simulator can explain the elementary features of the system. It will compress the time and space to trace the long-time results as long as controlled variables are manipulated. The results from the simulation will give managers a better understanding of the optimal decision.

The overall cost of each category of materials consists of the inventory cost or the penalty cost, the ordering cost and the transportation cost. Based on the above classification, the computerized simulation of every category of goods or materials under the both condition of doing the logistics business by oilfield themselves and outsourcing its logistics functions to a third-party logistics company will be conducted to give better understanding of the properties of models and provide the two groups of results.

Since these categories include several kinds of supplies, the total logistics cost for each kind of goods will be computed based on the model, and the average number will be used as the general result of such category. Programs will be developed for numerical experiments with a software package Excel 2003.

4.1 General reputation results

In order to present the total logistics cost for each item of goods, based on the logistics practice in petroleum production, we take one week as a period to calculate the total logistics cost for both the third-party logistics company and for the oilfield itself. The volume for each item of goods is an average one measured by week, and as a result, two types of logistics costs are the values in one week. We introduce a new indicator "Margin" to indicate the percentage of difference for the two groups of results. It is denoted as:

$$\text{Margin} = \frac{\text{Total logistics cost of 3PL - Total Logitstics Cost of DIY}}{\text{Total logistics cost of DIY}} \times 100\%$$

Table 4.1 Pipe Type Total Logistics Cost and Margin

Product	Total Logistics Cost		Margin
	DIY	3PL	
Bushing pipe	489,082	622,582	27.30%
Oil tube	299,966	349,750	16.60%
Seamless steel pipe	142,993	180,971	26.56%
Seamless carbon steel pipe for transporting fluid	128,163	173,506	10.49%
Drilling pole	209,591	145,454	35.38%
Oil pumping pole	119,573	132,114	-30.60%
Jointing steel pipe	72,424	82,803	14.33%
Helix pole (instrument)	53,002	57,476	8.44%

Table 4.2 Fuel Type Total Logistics Cost and Margin

Product	Total Logistics Cost		Margin
	DIY	3PL	
Kerosene	384,673	324,061	-15.76%
Gasoline	89,105	74,236	-16.69%
Coal	325,307	209,216	-35.69%
Washed coal	79,990	54,998	-31.24%

Table 4.3 Chemical & Additive Type Total Logistics Cost and Margin

Product	Total Logistics Cost		Margin
	DIY	3PL	
Polyacrylamide for the third-time oil producing	491,577	670,586	36.42%
Chemicals used in drilling	291,633	254,060	-12.88%
Chemicals used in oil-pumping	241,317	168,445	-30.20%
Inorganic chemicals	494,607	308,334	-37.66%
Organic chemicals	19,644	19,790	0.75%
Accessory ingredient for oil pumping	28,533	35,784	25.42%
Salt	58,453	43,412	-25.73%
Accessory ingredient for oil refining	4,401	6,347	44.20%
Additive agents for common usage	11,258	15,580	38.39%
Additive agents in fuel oil	4,837	6,311	30.48%
Alkali	15,579	15,173	-2.61%

Table 4.4 Raw Building Material Type Total Logistics Cost and Margin

Product	Total Logistics Cost		Margin
	DIY	3PL	
Middle-thick armor plate	70,060	67,874	-3.12%
Cement used in oil well	206,672	136,139	-34.13%
Barite powder	28,332	29,129	2.81%
Linetype material	25,884	25,285	-2.31%
Wire cable	26,481	31,519	19.03%
Middle-scale raw steel material	14,186	14,331	1.02%
Large-scale raw steel material	25,843	26,164	1.24%

Table 5 Electronic device & fittings Type Total Logistics Cost and Margin

Product	Total Logistics Cost		Margin
	DIY	3PL	
Facilities fittings in oil & gas pumping	141,241	156,909	11.09%
Borer fittings for petroleum & geology	138,421	147,146	6.30%
Special meter for petroleum producing	52,048	62,834	20.72%
Oil extractor	436,335	659,464	51.14%
Oil-well pump	22,486	25,490	13.36%
Diamond tip of drill	240,703	547,228	127.35%
Equipments for testing oil producing amount & repairing well	136,775	209,834	53.42%
Low-voltage device	31,772	32,104	1.05%
Low-voltage device fittings	107,172	98,330	-8.25%
Industrial pump fittings	38,288	46,259	20.82%
Equipment fittings for testing oil production amount & repairing well	30,961	38,351	23.87%
Transformer	44,333	37,668	-15.03%
Flow capacity meter	41,918	36,251	-13.52%
High-voltage electronic device	25,549	25,205	-1.35%
Centrifuge pump	26,159	31,743	21.35%
High-voltage & middle-voltage valve	212,014	167,382	-21.05%
High-voltage cubicle switchboard	57,423	51,970	-9.50%
Hydraulic pressure component	39,311	36,170	-7.99%

Table 6 Dangerous Products Total Logistics Cost and Margin

Product	Total Logistics Cost		Margin
	DIY	3PL	
Explosive	77,101	105,497	36.83%

We reputed the margin value to measure the degree of difference of the total logistics cost of the oilfield and the third-party logistics company. By making analysis of the marginal value, we classified the products into three major categories: products which are more suitable for handling by the oilfield if the margin is over 20%; products which are more efficient for outsourcing to a third-party service provider if the margin is lower than -20%; and others that need further discussions. However it is not enough to focus only on the marginal value, because the total logistics cost for some types of goods is very small and the differences of the two costs are not very significant. To classify the results with this method, the majority of the products will not be extremely efficient to be outsourced or handled by the oilfield. So it is not a wise decision to fully outsource the logistics activities of all of the products or handled by the oilfield itself. There are some kinds of products which are more economic to be outsourced while some others are not. To make decision on whether to introduce the third-party logistics company into the oil producing industry relies on the features of the specific products.

Based on the results of computation together with the characteristics of products, three main points can be summarized. The first point is about the value of products. It is found that the unit value of the supplies affects significantly the total logistics cost of the third-party logistics service provider. In Table 4.1, most high-valued types of goods come to the positive margin with the meaning that the third-party logistics company will charge more than the S Oilfield. Particularly for the types of goods with high value, in small amount and specially deeded, almost all of them will be charged 25% more than the total logistics cost margin. The reason to explain this fact is that the third-party logistics company has to pay more attention on such high-valued goods in the whole logistics process. The transportation parameter contains the factor of risk. The 3PL company must take more risks and so, the cost increases. For example, the third-party logistics company will consider the possibility of the loss on the route of transportation and then when the goods arrive, the third-party logistics provider has to guarantee the safety of goods in the inventory by increasing more safety facilities in the warehouse than the moderate and low valued goods. The penalty fees for possible loss and for the facility investment increase the total logistics cost for those high valued supplies. In addition, it is a general situation that higher valued goods and materials are more important than others in petroleum production. As a result, the shortage cost for the high-valued supplies will be higher than the others because the more serious loss caused by stocking.

The second main finding focuses on the volume. Most products which should be outsourced are in great demand, such as coal. The demand for coal in one review period almost tops 5,000 tons and the marginal result is less than -35%. Coal plays an essential role in the oil production process, For example, it is used to generate power. The economy of scale is related to the total logistics cost for the third-party logistics company. Not only in the petroleum industry, but also in other manufacturing industries, the third-party logistics companies save the logistics cost through the economy of scale. This allows the 3PL service providers to integrate the resources of logistics based on advanced IT systems. On the other hand, the 3PL company can optimally trace and plan the routes of transportation by hi-tech facilities, because an oilfield in China generally covers very broad areas. For the transportation of these goods in a large quantity, the 3PL company provides more professional and efficient logistics management than the oilfield itself. Therefore, the larger the quantity is, the lower the logistics cost will be collected by a 3PL company, particularly for those goods of low value, in large quantity and with no specialty as mentioned in this research.

Finally, the specialty of products also affects the gap between total logistics cost paid by the oilfield and collected by the third party company. In this research, specialty is an important factor affecting the decision-making on whether to introduce the 3PL company to operate the oil industry in China. As discussed before, there are more different features in the oil industry than other manufacturing industries in China. More types of material and goods are being used in the oil industry and therefore, some needs professional transportation facilities. Specialty for a 3PL company may imply low ability for integrating the logistics resources, which may raise the total logistics cost. For instance, both the bushing pipe and the oil tube are highly valued and needed in a large amount, but the bushing pipe has its specialty while the oil tube has no specialty. The marginal results come down from 27.30% of bushing pipe to 16.60% of oil tube. In the practice of the oil industry logistics performance, it is necessary to transport the bushing pipe with specially truck because each bushing pipe is much longer than an ordinary truck can carry. So in order to fulfill the transportation of those types of goods with specialty, a 3PL company will increase total logistics cost for the third-party logistics company.

Moreover, the patch size has some effect on the total logistics cost. If the amount of one patch is very large and the time is very limited, the third-party logistics company can handle the transportation for such items with more advantages. The high-voltage switchboard may describe the situation—that item is a type of goods with low value, in low volume and of non-specialty but with a large patch and few frequencies. Generally, the third-party logistics company has more advantages than its disadvantages when the item of goods has large volume to transport. By contrast, the demand for the switchboard is relatively lower than other goods, but it is need in the oil production process. One patch is usually much larger than other types. Though the total volume of the switchboard is not large, the 3PL company still can enjoy the large patch to reduce the logistics cost. As shown in the marginal result, the total logistics cost of the 3PL company is 9.5% lower than that of the S Oilfield.

To sum up, we can draw two conclusions from the general computation results: it is not a reasonable decision to outsource all the products' logistics functions; those products with low value, in large quantity and of non-specialty will enjoy the advantages provided by the third-party logistics company. In order to test the further effects of the parameters in the total logistics cost function, some simulations have been conducted and their results will be presented in following discussion.

4.2 Demand variance simulation results

Figure 4.1 Simulation of Standard Deviation of Pushing Pipe Demand

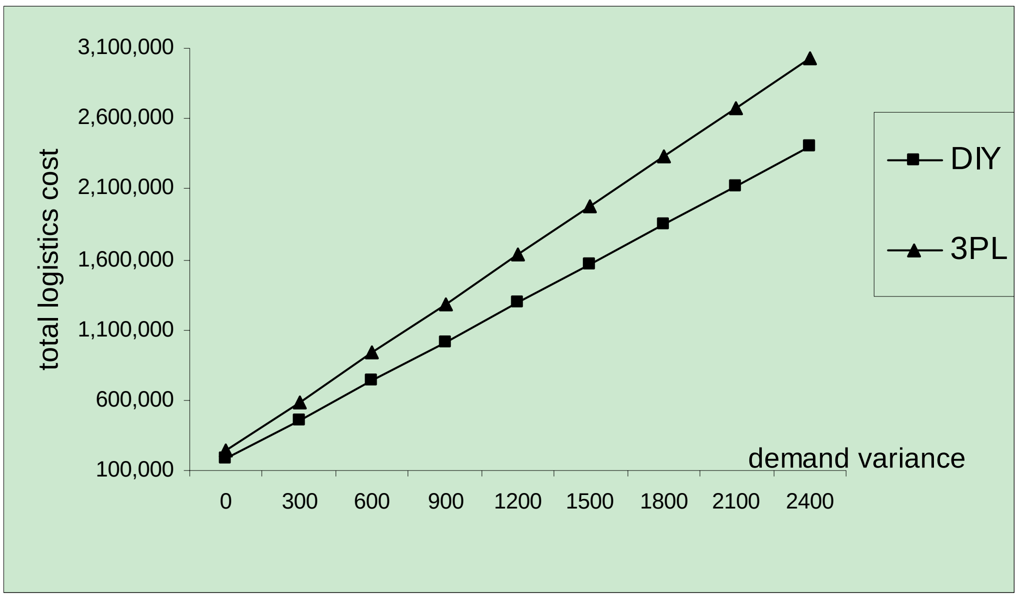
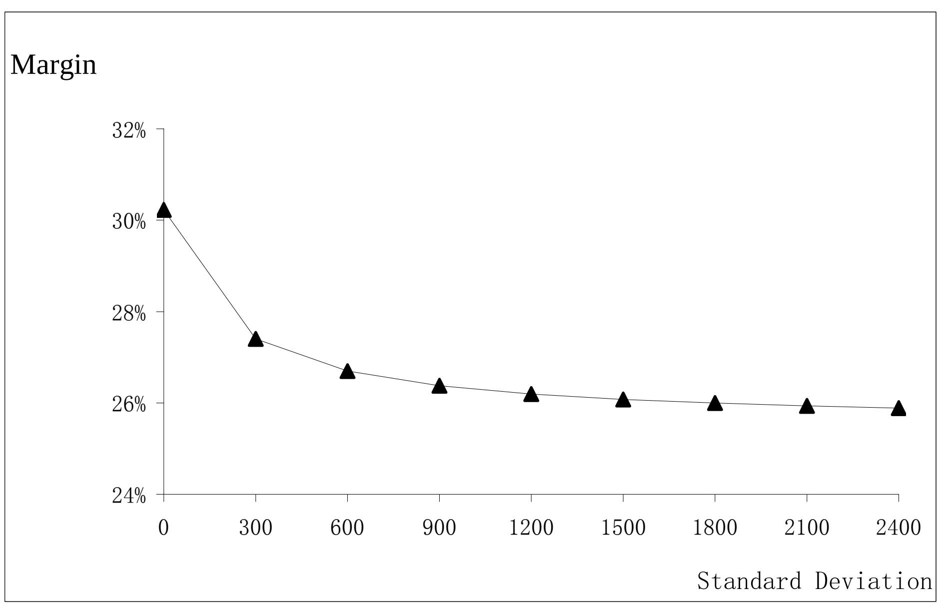


Figure 4.2 Margins under Simulation of Standard Deviation for Pushing Pipe



From Figure 4.1, with the increase of the pushing pipe standard deviation, the total logistics cost in one period increases accordingly, and the value difference between the two types of costs continues to grow. The increase of both total logistics costs follows a linear curve. When the standard deviation grows, the third-party company's total logistics costs increase more quickly than that of the oilfield. This finding indicates that the item with a high demand uncertainty is not cost-efficient to be outsourced. In practice, the third-party logistics company will charge a higher transportation fee because they must meet the urgent requirement with higher cost without the economy of scale.

As shown in Figure 4.2, the margins of the two type total logistics costs keep going down, although the value differences of the two groups of costs are clearly increasing as shown in Figure 4.1. It points out that if the standard deviation increases, the difference between the two groups of the total logistics costs may decrease and the increase of the total logistics cost in the oilfield is much quicker than the cost charged by the third party company. This result is to some degree out of expectation. In the practice of oil production, the increase of standard deviation means urgent and frequent uses of such products. As described in the first chapter, the oil industry has the characteristics of urgent and changeable demands. Generally, the changeable demand will make the third-party logistics company unable to enjoy the economy of scale — one of its most significant advantages. One of the possible reasons to explain this result is that the third-party logistics company can schedule logistics activities more efficiently than the oilfield itself because the third-party company possesses more professional techniques to make the plan for the transportation and other functions. As a result, the third-party company can provide more economic service than the oilfield.

It seems that the most significant decrease of the margin appears when the standard deviation changes from very small to about 600 in a review period, reducing from over 30% to less than 27%. Within such a stage, the total logistics cost is more sensitive to the standard deviation changing. When the standard deviation becomes higher than a very large number, the difference percentage of the two groups of total logistics costs also increases, but the degree is very limited. We can see from this phenomenon that when the standard deviation goes up from a given scale, the increase of the total logistics price for both conditions are growing with relatively the same degree, besides the values of the both costs increase much larger.

Although the margin keeps reducing when the standard deviation increases for those products are more suitable to be handled by the oilfield, the total logistics cost charged by the third-party company will not be higher than that paid by the oilfield itself if standard deviation goes up. By contrast, the increase of standard deviation for those products to be outsourced will change the decision on whether logistics functions should be outsourced or operated by the oilfield itself. The following figures will show such results:

Figure 4.3 Simulation of Demand Standard Deviation for Kerosene

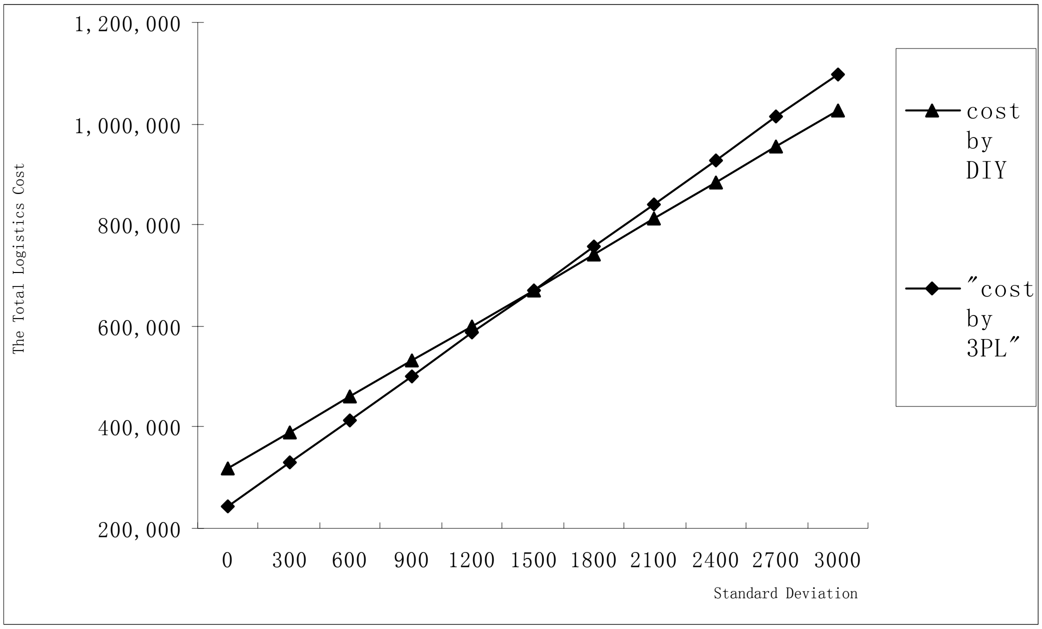
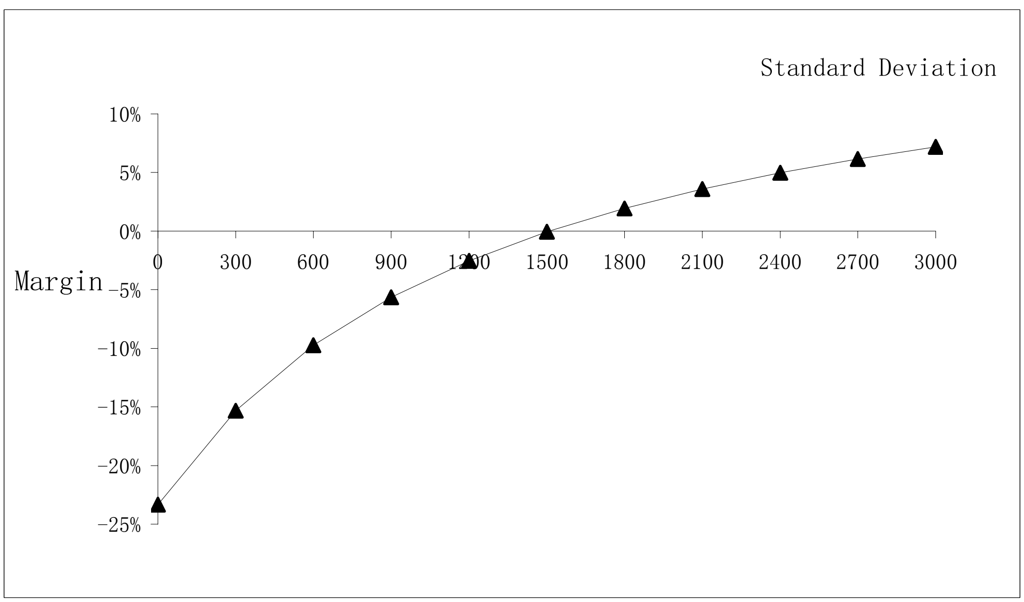


Figure 4.4 Margins under Simulation of Standard Deviation for Kerosene



For Kerosene, a product that should be outsourced to fulfill the logistics activities, the two curves have an intersection point at about standard deviation 1700. If the variance of demand for kerosene comes to about 1800, the total logistics cost charged by the third party company will reach almost the same as that paid by the oilfield. When the variance of demand was lower than such a number, both curves are going up but the values are more closed. The kerosene logistics activities are more economic to be handled by an outside company than by the oilfield itself, because the kerosene is relatively low-valued, in a large volume and stable in demand. The third-party logistics company can take the advantage of the economy of scale and is easy to schedule the transportation. When the standard deviation goes up to 1800 in one review period, the cost charge by the third-party logistics company was higher than that paid by the oilfield. At that stage, the third-party logistics provider cannot balance the increased cost caused by the increase of the demand variance using the benefits of scale. Therefore, the kerosene logistics function should be operated by the oilfield itself. From this result, we can conclude that it is probable to affect the decision-making on whether to be outsourced if the product frequently needs those urgent logistics activities because they are used at the first stage of the oil production process,.

Therefore, as for those goods which third-party logistics company has some but not significant vantage on logistics cost. Take kerosene for example. The margin of kerosene is -15.76%. If the demand standard deviation grows, the vantage will reduce accordingly. Before going up to a certain level, the vantage will totally be balanced and even offset the total logistics cost paid by oilfield. In oil production, there are many types of goods which are urgently needed or used to meet emergencies, and whose standard deviation is a big number. From the point of a third-party logistics cost, urgent demand needs to reschedule the transportation plan and arrange other related logistics functions separately. They cannot, therefore, enjoy the economy of scale. If such logistics activities for goods are outsourced to a third-party logistics service provider, the total logistics cost will be higher than that by DIY.

We can see from Figure 4.4 that the difference in the total logistics cost measured for the third party company and the oilfield is next to to zero before the variance of demand goes up to about 1500 and becomes larger after that. The change of margin for kerosene has many things in common with that of the pushing pipe. When the standard deviation changes to below 1500, the margin goes up very quickly; while after reaching 1500, it goes up much slowly, which indicates that the effect is relatively much more significant if the variable is smaller comparing than the average.

Figure 4.5 Simulation of Demand Variance for Cement

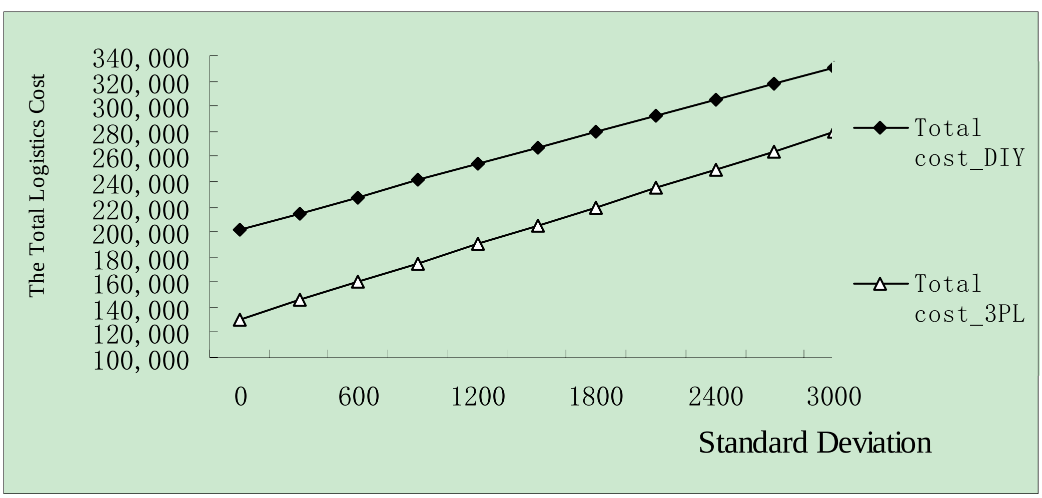
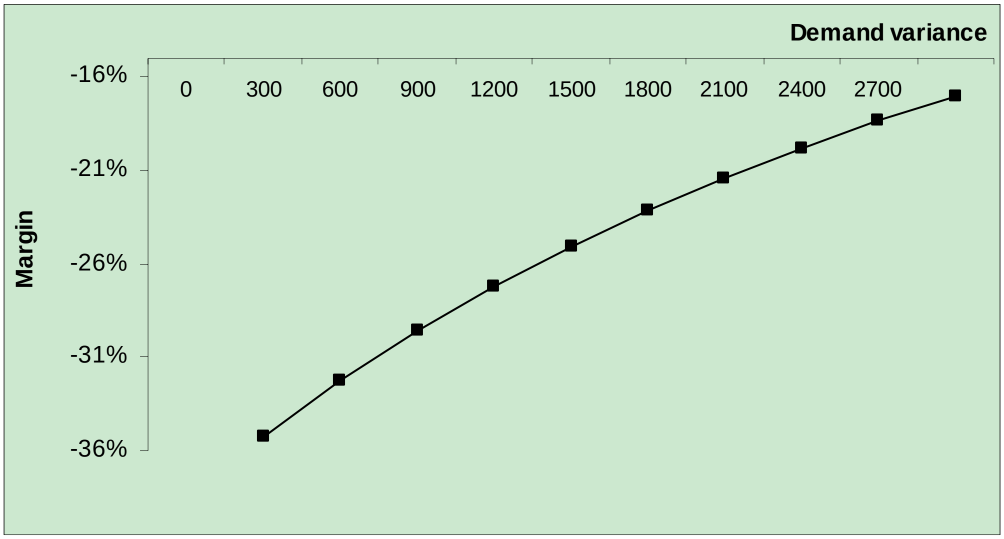


Figure 4.6 Margins under Simulation of Demand Variance for Cement



The 3PL company has more advantages in terms of the total logistics cost for the transportation of many types of goods than the cost paid by the oilfield. The change of demand deviation does not exert impacts on decision-making. With the increase of the demand variance, the costs offered by the third-party logistics company and the oilfield increase and the gap between the two costs became smaller. The decision on whether to be outsourced however will not change due to the increase of the demand variance. Take cement for example. When the standard deviation of demand goes up from 0 to 3000, the increase of the two costs followes a linear trend and the gap became narrower but it does not change the management decision. The cost offered by the third-party company continues to become lower than that offered by the oilfield, which means the margin will never become a positive number in modifying the demand standard deviation.

4.3 Leadtime simulation results

The leadtime is another important parameter affecting the total logistics cost function. To test whether the leadtime of a product has significant effect on the total logistics cost, two simulations on the leadtime has been completed for the pushing pipe and kerosene. The results are shown in the following figures:

Figure 4.5 Simulation of Leadtime for Pushing Pipe

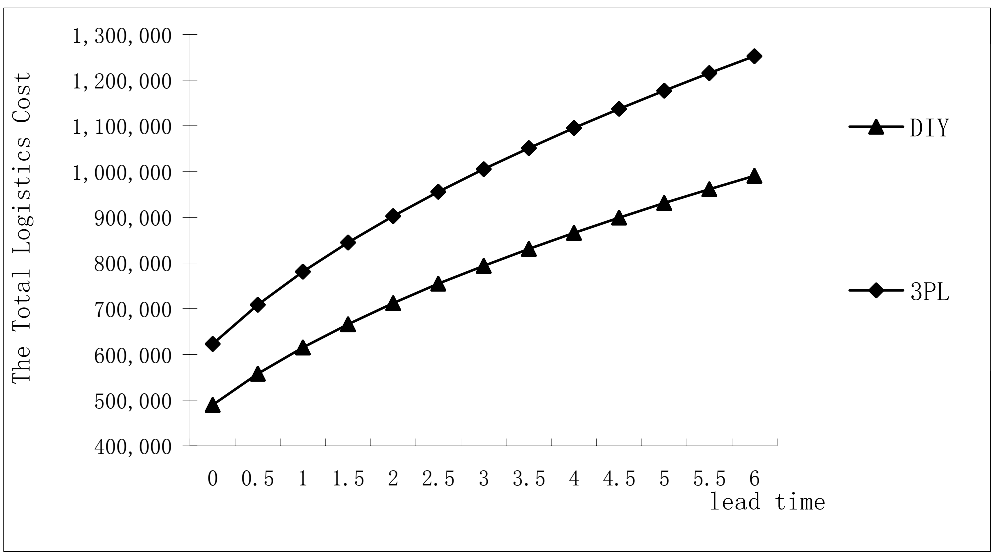
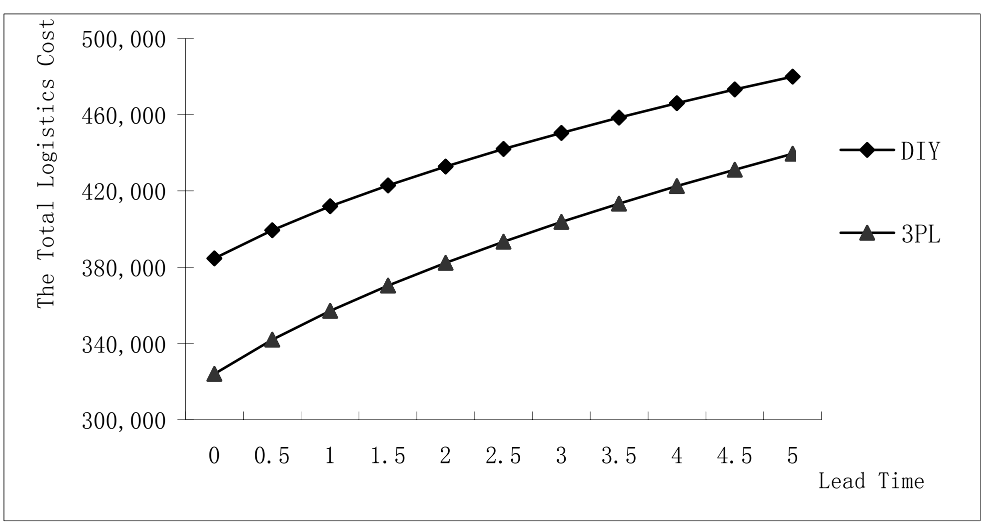


Figure 4.6 Simulation of lead time for Kerosene

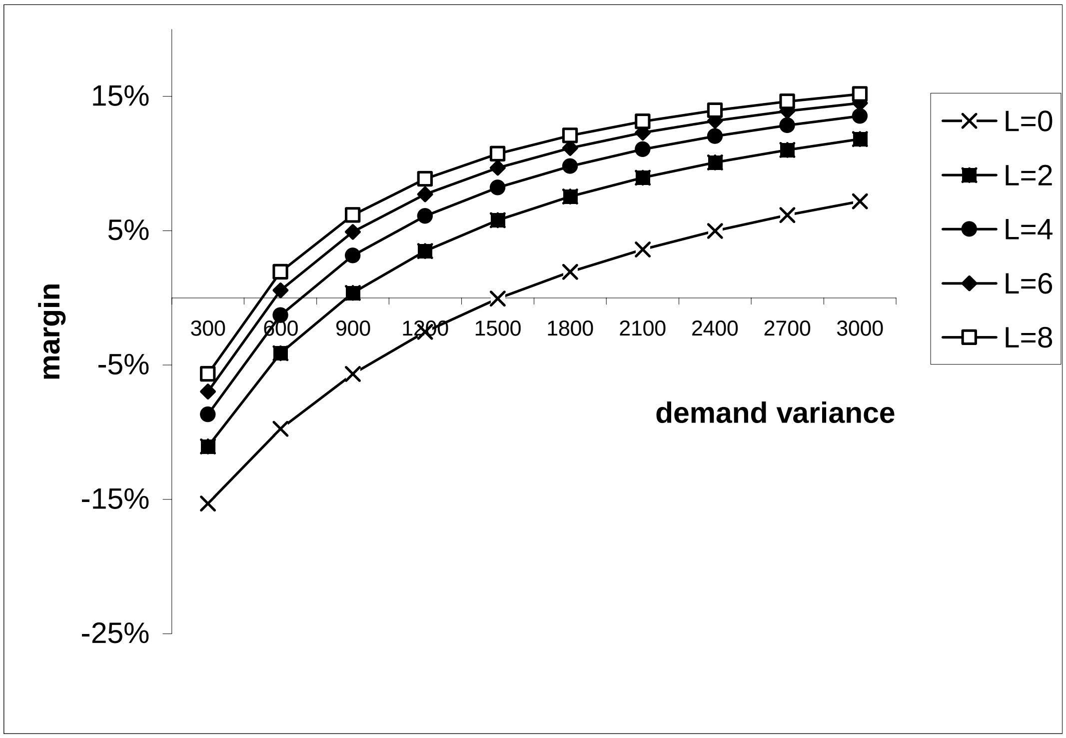


As expected, the leadtime for a product has a coefficient effect on the total logistics cost. Both Figure 4.5 and Figure 4.6 show that when the leadtime increases, both types of total logistics costs will go up accordingly and the difference of the two types of costs becomes wider, especially the one for kerosene. As shown in the above two figures, both the curves are convex, which means that when the leadtime increases, the total logistics costs grow more rapidly than the concave curves for the standard deviation simulation results. Another thing we can find from the figures that there are some kinds of products that are sensitive when the leadtime changes. The total logistics cost for transporting kerosene is more sensitive than that for the pushing pipe because the total logistics costs increased more rapidly than that for the pushing pipe. To sum up, the effect of the leadtime for total logistics costs are positive.

Based on the above simulations for different parameters, it is found that different parameters have diversified effects on the total logistics costs. It leads us to test the interaction between the two parameters that exercise an influence on the total logistics cost by choosing different levels of one parameter. The following content will present such simulations including the simulations of the leadtime and the demand variance, the leadtime and the service level and the service level and the demand variance. Same as the simulation before, we took kerosene for example in the following simulations.

4.3 Simulation of the leadtime (L) and the demand variance (sd)

Figure 4.7 Simulation of the Leadtime and Demand Variance



As for the trend of above five curves, the difference between the oilfield logistics cost and the third-party logistics cost increases more rapidly at the stage when the demand variance is from 0 to 600 in the review period. Each curve at this stage witnesses the biggest marginal increase, especially when the curves L=0, L=2 and L=4, and when the increases grow from below zero to above zero. At this stage, the decision on whether to outsource kerosene changes when the leadtime increases from 0 to 4. It implies that the interaction between demand variance and the leadtime at different levels will change the conclusion to outsource or not. When the leadtime in one review period is longer than 6 days, the increase of the demand deviation cannot make the margin to drop to below 0, the cost offered by the third party company continues to become higher than the cost paid by the oilfield. As the demand variance becomes larger, all the curves become flat in shape, which means the difference in the growth rate of the two costs keeps at a low level and the effect of the demand variance on the total logistics cost is weakened to some degree.

Based on the analysis of the vertical distance of the above five curves to measure the different degree of the effect of demand variance at different leadtime levels, the largest one lies in the curves L=0 and L=2, while the narrowest ones are those when curves L=6 and L=8. When the leadtime varies from 0 to 2, the gap between the two types of costs is increased significantly at the same demand variance value. With the leadtime become longer, their effects on the magnitude of growth of the gap between the two kinds of costs are becoming weaker when the demand deviation comes to one point. At the ending points of the curves when L=4, 6 and 8, the three curves almost come to the same marginal value. It shows that when both the leadtime and the demand variance are very large, the gap of the logistics cost between the oilfield and the third-party logistics company shows a relatively fixed value — the difference rate of the two type costs is relatively stable.

By applying those results to the practice of oil production logistics, several implications can be summarized. Given that two products share the same demand variance in one period, but if one needs a longer period of time for ordering and replenishing than the other, logistics is more likely to be handled by the oilfield. If one's leadtime is very long and the demand also changes by a big percentage, it is a more economic choice for the oilfield itself to manage the logistics functions.

4.4 Simulation of demand variance (sd) & service level (k)

Figure 4.8 Simulation of Demand Variance & Service Level-- Margin (1)

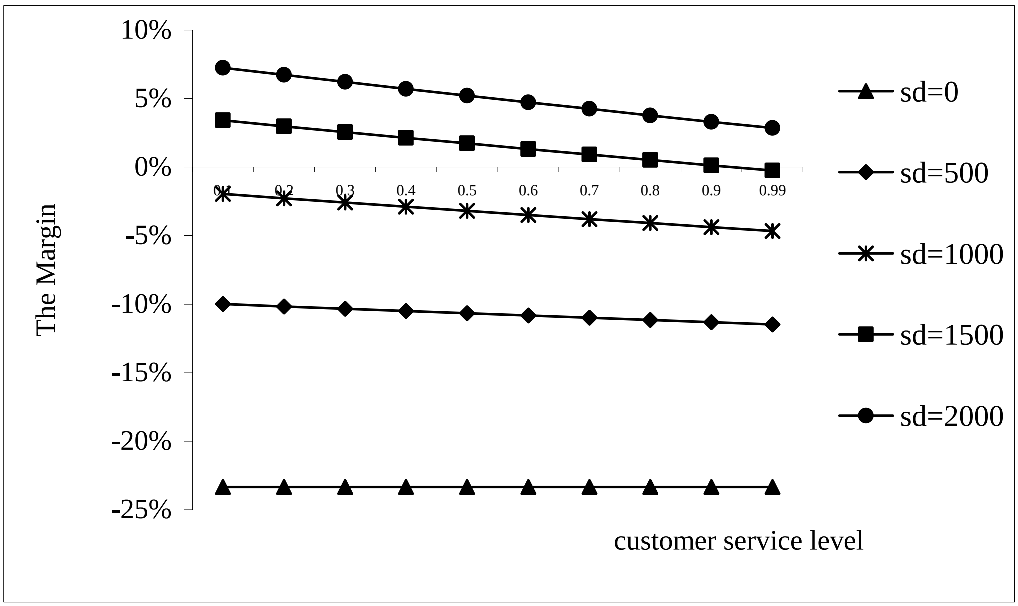


Figure 4.9 Simulation of Demand Variance & Service Level-- Margin (2)

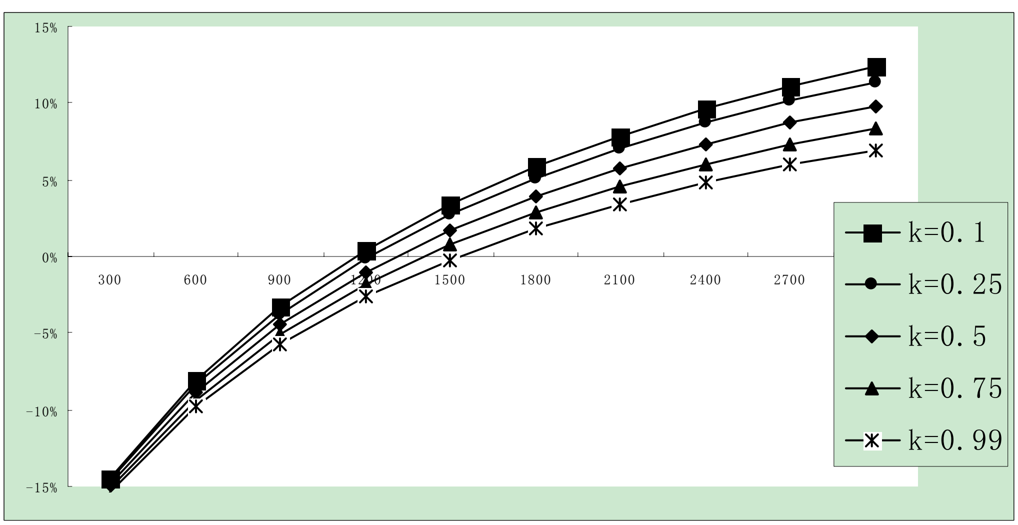
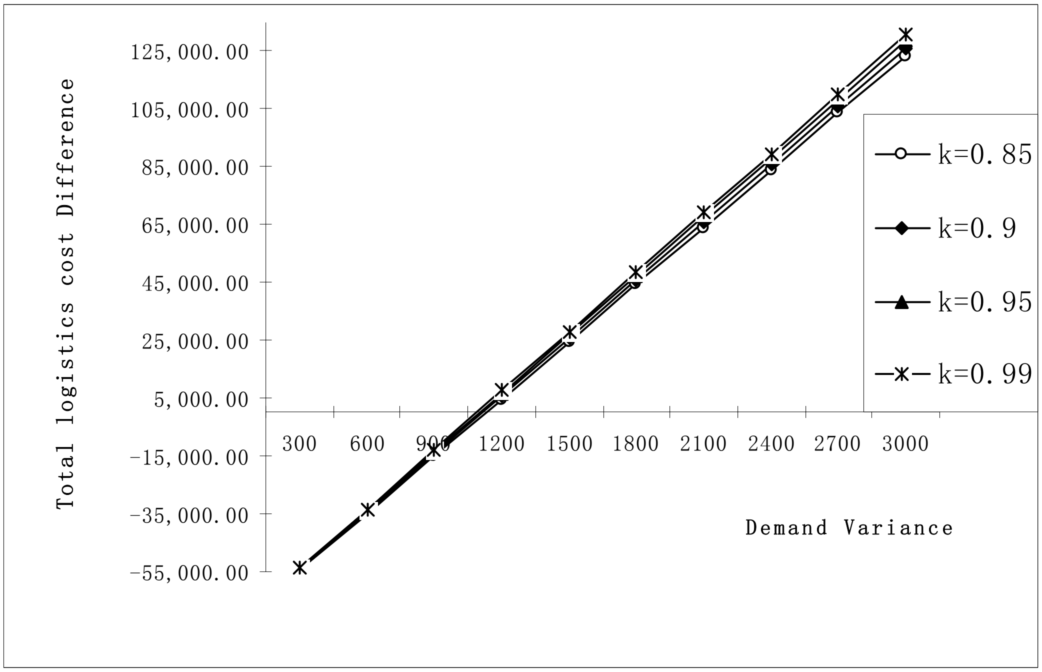


Figure 4.10 Simulation of Demand Variance & Service Level—Cost Difference



In simulations for this section, we also take kerosene for example to show the co-effect of the demand variance and the service level on the value difference between the total logistics costs offered by the third party company and the oilfield. In figure 4.10, the cost difference is defined as the total logistics cost value paid by the oilfield (DIY) minus that offered by the third-party logistics company (3PL) in a period of time. Unlike the margin, the index of the total logistics cost difference can present the absolute value gap between DIY and 3PL.

It can be seen from the Figure 4.8 that all the curves follow the same trend to decrease and their shapes are very close to a straight line, which means that the increase of the margin is takes the shape of a linear slope when the demand variance reaches a certain level and the customer service level changes from 0 to

0.99. If the demand change stays at a certain level, the speed of decrease of the margin will be the same when the service level increases from very small to almost one.

When the demand deviation increases, the slopes of the curves becomes less steep. That means if the standard deviation of the demand for kerosene increases, the marginal growth of the two total logistics costs reduces more quickly. This findings show us that the margin of one item with the demand variance staying at a very high level will decrease significantly when the service level increases faster than those of the low demand variation items.

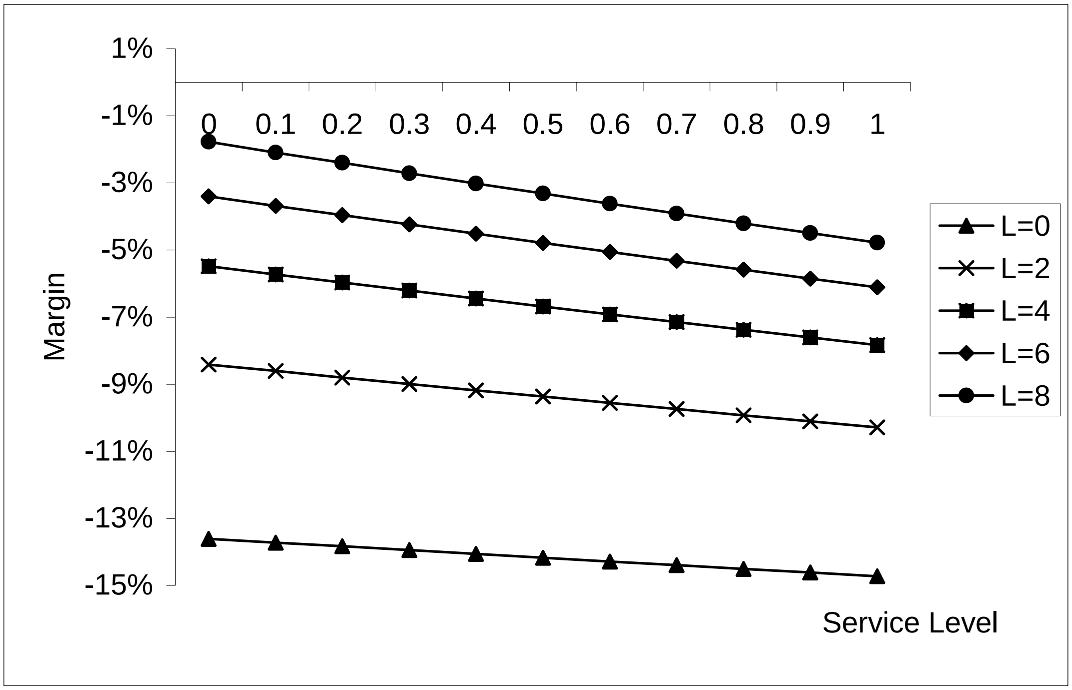
As shown in Figure 4.9., all the lines have the similar trend to decrease and have no cross-point, which means that at different service levels, the margins increases at a given speed if the demand standard deviation rises. When the service level goes next to one and when the demand variance comes up from very low to 3000 in a period of time, the margin of the two costs increases much slower than that when the service level is very low and the range of change is relatively narrow.

By making a comparison of Figure 4.8 and Figure 4.9, it can be seen that the increase of the demand variation exerts a positive impact on the margin but the service level has a negative impact. In practice, this finding shows that if one item needs a very high service level, managers will take the third-party logistics company into account. Certainly, one should also consider other factors in making decision. As discussed above, a high demand variance item shows an inclination that logistics will be handled by the oilfield's own resources. Nevertheless, the increased service level can reduce such an impact as shown in Figure 4.9.

With the increase of the demand standard deviation and the service level, the value difference in the total logistics costs between the third party company and the oilfield does not increase significantly when the service level rises from 0.85 to 0.99. In the petroleum production process, it is not probable for the service level to drop to below 0.8 or 1. As a result, to analyze the actual situation, we selectively simulate the value difference between the service levels when it equals from 0.85 to 0.99. Although the difference increases, all the four lines show that they are very close to each other. This phenomenon shows that the service level has a very limited impact on the value difference between the two types of logistics costs. By contrast, the demand deviation exerts a more significant effect on the increase of the total logistics cost. For kerosene, the difference of the total logistics cost between the third party company and the oilfield has increased from about RMB-55,000 to over RMB125, 000.

4.6 Simulation results of the service level (k) and the leadtime (L)

4.11 Simulation of the service level and the leadtime — Margin (1)



Figure

4.12 Simulation of the service level and the leadtime—Margin (2)

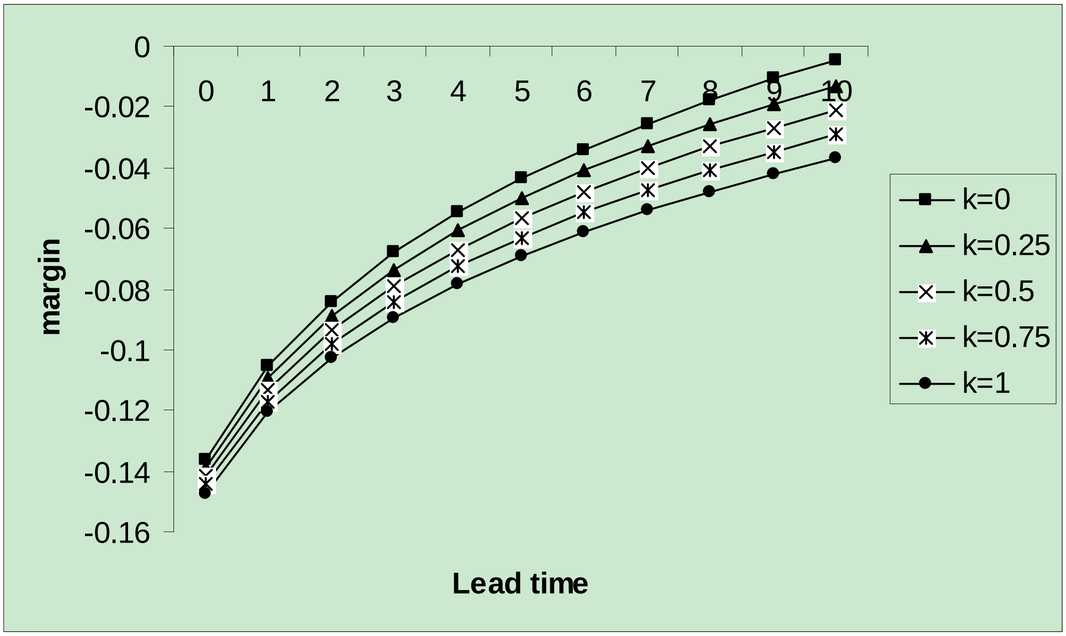
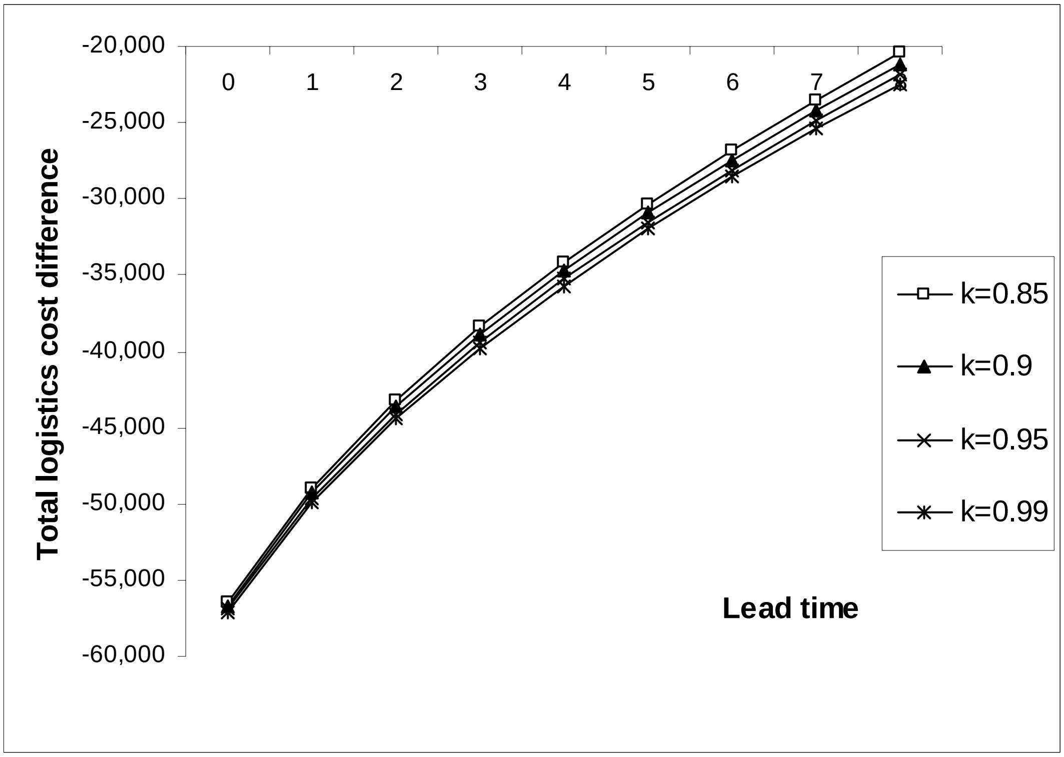


Figure 4.13 Simulation of the service level and the leadtime—Cost Difference



Almost the same as shown in Figure 4.8, all the five lines in Figure 4.11 show their tendency of straight ones, which means that the impacts from a certain leadtime at different service levels (k) follow a linear trend in a period of time. For both the oilfield and the third-party company, when the leadtime and the service level increase simultaneously, the margins of the two total logistics costs decrease accordingly. In Figure 4.11., the slopes are becoming fairly level when the leadtime increases. That means the margin reduces more quickly in a period of time when the service level grows from 0 to 1 and the leadtime becomes longer. As the findings in Figure 4.12 indicate that when the leadtime reaches a relatively high level, the change of the index margin becomes larger than that when the leadtime is very short.

As far as the value difference is concern, the effective service level on the difference of the cost value is shown in Figure 4.13. As shown in Figure 4.10, we take the service level from 0.85 to 0.99 for simulation under the actual production conditions instead of a mathematic simulation. At such a range and at the same leadtime point in a period of time, the gap in the cost values does not change significantly, because all the four lines are close to each other. The value of the line, when k=0.99, increases at the slowest speed of all of the four ones, which means when the service level reaches a very high level, the third-party logistics company has more advantages in the total logistics cost in changing the leadtime for one item.

Combined with the research results in Chapter 4.5 and Chapter 4.6, the increase of the service level may b ring a reduction to the advantages of the oilfield in the total logistics cost to handle kerosene's logistics activities, compared with that of the third party company. In other words, a high service level for an item of goods is more favored in making decision on whether to outsource the logistics function to the third-party logistics company. A possible explanation for such a finding is that the third-party logistics company is believed to provide the punctual and accurate service because the company faces extra risks in the logistics function. If the third-party logistics company cannot meet the service level they promised, it will be fined at a higher cost than the one it will get as specified in the contract. On the other hand, the third-party logistics company has approaches to balance the extra cost to meet the high service level because logistics is its professional business.

Chapter 5 Conclusions and Limitations

In this chapter, the following aspects will be presented: How the gap of research has been filled and to what extent the research has successfully been conducted. To achieve these objectives, five major parts in this chapter are arranged to deal with the conclusions and limitations, the restatement of the objectives in this study, a summary of the major findings, significance and implications of the present study, limitations and proposals for future research.

5.1 Conclusions

Ever since the petroleum industry was first set up, the logistics cost has become one of the issues neglected in the management field, because the oil output is the only concern in China's oilfields without taking the high cost and the low efficiency into consideration. With the professional advantages of the third-party logistics (3PL), recent outsourcing logistic activities to 3PL companies have become a trend in various industries the world over and significantly reduced their logistics costs. The oil industry in China has, therefore, been investigated and tested on the possibility and feasibility of outsourcing its supplying logistics functions to reduce its high logistics cost and achieving operational efficiency. However, concerning the special characteristics of the oil production logistics, such as a high value of products and production tools, large scale and high specialty, it may not be proper to leave all the oil production-related logistics activities to 3PL service providers. This study attempts to examine whether it is cost-efficient to outsource all logistics activities to a third-party logistics company from the economic point of view.

We explored the characteristics of the oilfield industry and logistics activities. Based on that, a theoretical model to classify items of goods is provided according to three standards: The value, volume and specialty. Next, we suggest an evaluation framework for analyzing the logistics service in an oilfield by measuring the total logistics cost and find the considered factors. Relevant operational data and parameters are collected from the S Oilfield in China for analysis. The results obtained suggest that there are types of goods suitable for the handling with the logistics outsourcing by the oilfield's own resources, especially those with high value, in low quantity and with specialty. Meanwhile, there are also some items of goods, such as the goods with low value, in a large quantity and with non-specialty, which are more cost-efficient with their logistics functions to be outsourced to a third-party company. The findings indicate that goods for urgent need in petroleum production and with a long leadtime to acquire are more inclined to be operated by the oilfield itself, while the third-party logistics company has more advantages to provide high service level logistics activities. It is not surprising because the S Oilfield and the third-party logistics service provider have their own advantages in offering a total logistics cost as summarized in literature review.

These findings are of practical significances for China's petroleum industry because, first of all, the logistics cost is a very big number in oilfield production. The data provide evidence that there are many items of goods for daily use, which total logistics cost in a 7-day period reaches tens of thousands of RMB. Take the pushing pipe for example, the total logistics cost in 7 days for the oilfield is RMB489, 081. The efficiency of logistics functions should not be neglected by oilfield management decision-makers. Secondly, it is hoped that the present research has made a contribution to the evaluation of the inbound logistics system in the oil industry of China based on its special characteristics of the industry. As every type of goods used in the oilfield has very different features, the method that the total logistics cost is measured by each item of goods, which has been proven to be one of the effective approaches to analyze the oil industry's logistics cost functions. Thirdly, contrary to previous managers' belief, the decision on outsourcing the inbound logistics functions of all items of goods is not an economical management strategy. Much more expenses will be saved on the logistics cost for many items of supplies in the oilfield if they are outsourced to a third party company. This implies that the logistics management in the oil industry in China may be more complex than expected. The supply of goods should be classified into different categories and then be operated through different measures based on their special features in the production process.

In the oil production practice, the research results can help reduce the logistics cost for the S Oilfield. It is because the choice of the S Oilfield or 3PL to perform the logistics functions for one item of goods depends on the comparison of the two types of total logistics costs. The value from the saved cost is a large number by adding all items together if every item can be conducted by the operation at a lower cost. On the other hand, the economic choice can improve the efficiency through displaying the advantages of two operations because the total logistics costs are measured by the service level. The effect of meeting the service level is also displayed in the cost function. Therefore, the results of this research can help improve the efficiency of the logistics function of the S Oilfield.

In this research, the S Oilfield is a typical one in China's oil Industry. The oilfields in China possess many characteristics in common such as they have the same historical backgrounds and the logistics management system. The results from the research on the S Oilfield can be spread to the whole oil industry in China. Among all types of goods in the supplying system of the oilfield industry, there are items suitable for outsourcing and many are more efficient to be handled by oilfields themselves. They should be treated with different methods for logistics operations.

In terms of methodology, the theoretical model to classify the items of goods and the evaluation functions of the total logistics cost to examine whether they are suitable for outsourcing can be utilized in other industries in China. The standard for classification can be changed accordingly. Therefore, the factors for other consideration are also different from this research, for example, adding or deleting some elements. The primary idea and methodology in this research can be applied to other industries by making some minor adjustment. We hope that this research can serve as an effective approach to analyze such problems both in the academic and practical fields.

5.2 Limitations and proposals for future research

5.2.1 Limitation

The present study has only explored the economic factors for the oil industry related to logistics management, not including other ones, such as the political qualifications and the qualifications of the human resources, as well as other man-made factors. In China, all the oilfield companies are entirely state-owned enterprises and characterized by the planned economy. Policies and employees will exert some impact on the management. Unfortunately, it is not possible to measure such factors in this study.

In the process of measuring the total logistics cost for an oilfield and a third-party company, it is an assumption that both are efficient to handle all the logistics functions. In actual operations, the oilfield is more likely to manage inefficiently. For a long time after an oilfield was set up, many spare parts for the logistics functions are lack of efficient operations. In order to compare the two groups of the total logistics costs, we consider the two are equally efficient. Nevertheless, the factor of inefficient management should be taken into account in the actual logistics management field.

Despite the efforts made, it remains that some data are incomplete and won't yield results as conclusive as might have occurred otherwise. Since logistics plays a very small part in the oilfield management, many relevant records are not available. Besides the data for measuring a third-party company's logistics cost, there are some data from the oilfield for discussion with experienced managers. Due to the limited number of operational records, caution is warranted in interpreting the results, especially those concerning the penalty cost.

In this research, we discussed items of goods which are obviously suitable for operations by the oilfield or by 3PL. There are a great number of "middle" items lying between the two extremes, such as those margins are between -10% and 10%. These types of goods need to be classified into more detailed categories and they are more sensitive to changes when altering the parameters' conditions. What proposal on such goods for outsourcing in the oil industry in China poses another limitation for this study.

5.2.2 Proposals for future research

More studies are recommended to determine whether there are other factors that may influence the logistics cost for China's petroleum industry, such as the qualifications of human resources. The total logistics cost function will further be improved and more comprehensive. Additional work should be done on the examination of further logistics features of such "middle" item of goods. A more effective method for classification and measurement should be focused on how to detect such "middle" goods logistics function. More implications about the logistics management will be suggested according to the above results.

5.2.3 Concluding remarks

To sum up, the present study sheds light on the logistics management of the petroleum industry in China, which is studied by few scholars. Contrary to the previous point of view, the logistics cost plays an important part in the management of China's petroleum industry, which has been ignored for a long time. Academically, this study provides a classification approach for supplying goods and a framework to evaluate the total logistics cost and suggests that it is not an economically efficient strategy to leave all the logistics functions to a third-party logistics company since many types of goods have a lower cost if handled by the oilfield itself than by the third party company. From the practical perspective, it is indicated that the logistics management of the oil industry needs complicated and classified management measures. The conclusions obtained from this research provide a foundation for the analysis of the logistics outsourcing problem for other industries.

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