

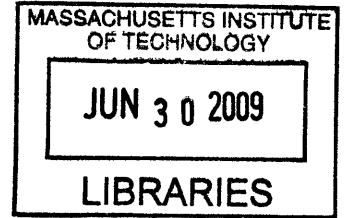
Measuring Performance of Transportation Carriers

by

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Submitted to the Engineering Systems Division in Partial Fulfillment of the Requirements for the Degree of

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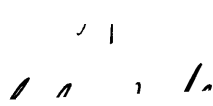
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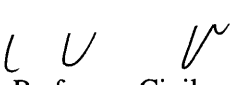
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Abstract

ChemiCo, a specialty chemical manufacturer for the auto and architectural market is seeking new business opportunities in the Chinese architectural market. Although ChemiCo entered the Chinese automotive market in 2006 with its newly built plant in China, it is still trying to understand the dynamics created by the fierce competition from many small local players in the Chinese market.

The objective of this research is to help ChemiCo understand the complex Chinese transportation market specifically and provide guidance in carrier selection. The proposed approach will offer ChemiCo an objective means to procure transportation services for the architectural market and deliver products to customers across China from its existing facilities (plants and warehouses).

We employ qualitative research methods to analyze the current Chinese transportation market. Based on this assessment, we evaluate various transportation options available to ChemiCo, keeping in mind their current and future level of supply complexities. We also investigate ChemiCo's existing carriers in the Chinese trucking market. An Analytical Hierarchy Process (AHP) is used to evaluate the key measurements of carrier performances for various customer segments and make recommendations.

The thesis proposes a comprehensive set of performance measurement criteria to select transportation carriers and presents a carrier selection process for ChemiCo. This process is designed to meet ChemiCo's specific decision goals and allows it to assess and compare the performance of various carriers in a dynamic fashion.

Thesis Supervisor: Dr. Mahender Singh
Title: Research Director, SC2020 & MEHD

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1 Introduction

China has become the world's third largest economy, and as a result an increasing number of multinational companies are seeking business opportunities in China. This research was sponsored by ChemiCo (actual name of the company is disguised to hide its true identity) which started establishing a significant position in the Chinese market in 2006. ChemiCo sells petroleum based products and set up its first plant in Suzhou, China to target the automotive and architectural markets. Serving nearly 50% of sector in the US and European markets, ChemiCo plans to carry over its success from its western market into the booming architectural market in China. The business opportunity in the Chinese architecture market is very attractive considering the total construction in China grew from 120 million in 2000 to 418 million in 2006 with an annual growth rate of 20.7% (Appendix 1). Meanwhile, market for ChemiCo's products in China has been projected to grow at 45% rate given 10% annual increase in new construction buildings in all the cities and towns of China.

With a potential huge market and low barriers to entry, many small and medium local players have been very successful in terms of the competitive cost structure in the market. Facing fierce competition from local Chinese players, ChemiCo is looking for a competitive service strategy to gain share in this potentially big market.

The entire competitive service strategy to equip ChemiCo with optimal cost structure and service level to supply the Chinese architectural market is too broad of a scope for this thesis. Considering the poorly developed transportation infrastructure, the capacity shortage of most transportation modes and the fragmented transportation market in China, a better understanding of the Chinese transportation market, along with setting

up a competitive transportation strategy for carrier selection, will be most effective in serving ChemiCo's needs of becoming more competitive in the booming Chinese market.

Therefore, the research question taken up in this thesis is as follows:

How should ChemiCo select and manage its carriers given the complexities of the Chinese transportation environment?

Furthermore, this research aims to help ChemiCo better understand the challenges and future opportunities to conduct intermodal freight movement within China and set up a performance measurement framework for transportation carrier selection to supply the potential Chinese architecture market.

1.1 ChemiCo Background

ChemiCo is a large manufacturer of specialty chemical products. ABC, ChemiCo's brand is used in the auto and architectural markets. ChemiCo is anticipating exceptionally strong growth in Asia, especially China. In order to meet the huge demand of ABC in Asia, ChemiCo is expanding its asset base to the Asia-Pacific region and rapidly introducing innovative products.

ChemiCo set up a factory in Suzhou, China in 2006, a significant symbol of its commitment to the 45% growth opportunity in the Chinese market. So far, ChemiCo's Suzhou factory has only produced for the automotive market, and the location of the plant provides ready access to the burgeoning Shanghai automotive industry. In anticipation of production of architectural products for the Chinese market, ChemiCo needs to find transportation carriers to further improve its ability to distribute ABC

products directly from the current Suzhou plant and warehouses in Shanghai and Guangzhou to its architecture customers that are potentially spread all over China.

1.2 Thesis Overview

This thesis provides ChemiCo with a performance measurement framework for transportation carrier selection to supply the Chinese architecture market from ChemiCo's Suzhou manufacturing plant and its warehouses in Shanghai and Guangzhou. At present, carrier selection is limited to trucking companies. In the future, as China's infrastructure and regulation develop, rail, air, and barge transportation will be available for shipping ChemiCo's products.

We begin with the analysis of the Chinese transportation market in Chapter 2. In an effort to better understand and assess Chinese transportation challenges and future opportunities, the review of the Chinese transportation market in this chapter focuses on assessing different transportation modes in China and evaluating the multi-mode opportunities and challenges for ChemiCo's operation at the current stage and in the future.

Even though ChemiCo would like to consider opportunities for multi-modal freight shipment, currently, trucking is the only transporting option available in China. Accordingly, relevant literature on carrier performance is reviewed in Chapter 3. This chapter presents insights from the literature about criteria for measuring transportation carriers' performances in the past.

The AHP (Analytical Hierarchy Process) methodology in conducting a qualitative study and setting up the performance measurement framework for trucking carrier

selection in this paper is discussed in Chapter 4. The AHP methodology is applied to design a questionnaire, which is used to evaluate the performance of current trucking carriers. In Chapter 5, each of the variable criteria for the defined customer segments from the questionnaire feedback is rated and evaluated. Moreover, the service gap, the differences in perceptions of carrier performance criteria between ChemiCo's customers and ChemiCo staff is analyzed and recommendations are made accordingly. Conclusions and future research directions are presented in chapter 6.

2 Chinese Transportation Market

Mode selection and carrier selection is performed separately according to the review of the relevant literature in the carrier selection domain. However, these two decisions in today's business world are often made simultaneously because of the growing competition among different modes. Due to the specific transportation market ChemiCo is operating in, choices of transportation mode to ChemiCo in China are very limited at the current stage. Therefore, carrier selection in this thesis will only be focused on the specific transportation mode that is feasible to ChemiCo in China. Indeed, with the increase of complexity in the future Chinese transportation market, assessing all mode choices available in this market by a systematic approach will equip ChemiCo with even more opportunities to succeed when the market is mature.

2.1 Review of the Chinese Transportation Market

During the last 30 years after the founding of the People's Republic of China in 1949, the Chinese economy was mostly centrally planned and largely controlled on the basis of traditional socialist principles. Beginning in 1978, the central government launched economic reform, which achieved has transformed the Chinese markets. Over the past 25 years, China's GDP has grown at an average of more than 8% per year, with a 10% annual growth rate from 2002 to 2007. This growth is expected to continue at very high rates into the near future.

One key characteristic of this economic resurgence is that much of China's economic production and growth takes place in the coastal provinces. Specifically, 93% of China's exports originate in these coastal provinces. Almost 40% of the exports

originate in the Pearl River Delta region alone (the region including Hong Kong, Shenzhen, and Guangzhou), the first region opened to foreign economic development. The Yangtze River region (Shanghai) was the second region to experience substantial economic growth. Over the past 10 years, the government has attempted to spur economic growth in the northeast and northern coastal zones, and most recently it has adopted a national investment and economic policy to support economic progress in the western inland provinces. The "Go West" policy has important implications for trade and logistics because goods manufactured in the western provinces will have to make their way to the ports on the coast, possibly increasing logistics costs.

Currently, road transportation constitutes over 70% of the whole Chinese domestic transportation. The cost of domestic transportation in China is much higher than that in the developed countries and logistics costs represent about 18.9% of the total cost of product manufacturing and delivery (United States is around 10%). Compared with the US and many developed countries, this discrepancy can be explained by the poorly developed infrastructure and the different structure of the economy. Services, which generate little freight movement, are only 32% of China's GDP, compared to 81% in the United States and 68% in Japan. Additionally, the average value of products made in China is well below the corresponding values in the United States and Japan. Therefore, it is not surprising that China's logistics costs account for a larger part of the delivered price of manufactured goods.

2.2 Comparison of Major Chinese Transportation Modes

Transportation modes are an essential component of logistics systems since they are the means of moving products. This section will focus on assessing the four main modes of transporting products in China. Each mode has its own requirements and features, and is capable of serving the specific demands of freight movement.

2.2.1 Highways (Truckload)

Historically, China has underinvested in its highway system. Compared to developed countries' road network system, the Chinese road network is sparse with respect to its geographic area and population. As a result, an impressive amount of investments made in the area of nation's road network over the last five years. The result is the National Trunk Highway System (NTHS), a 35,000 kilometers network composed of 12 major highways (five north-south corridors: Beijing-Fuzhou, Beijing-Zhuhai, Chongqing-Zhanjiang, Erlianhaote-Hekou, and Tongjiang-Sanya; and seven eastwest corridors: Dandong-Lhasa, Hengyang-Kunming, Lianyungang-Huoerguosi, Qingdao-Yinchuan, Shanghai-Chengdu, Shanghai-Ruili, and Suifenhe-Manzhouli), at an estimated cost of \$150 billion. NTHS connects all provincial capitals and cities with populations exceeding 500,000 inhabitants (100 major cities), and represents the increased government attention given to the highway system's development across the nation. In addition, expressway extensions into the western provinces are aimed at increasing economic opportunity in the western inland of China.

The government plans to continuously expand the national expressway system, and it is expected that by year 2010 the expressway system will be 65,000 kilometers

long and by year 2025 it will be 85,000 kilometers long. Heavy government investment and the improving infrastructure have made road transportation the most popular choice for the inland cargo distribution in China and facilitated the increasing use of trucks. However the overload and overweight trucks and the toll fee system still remain as huge challenges for the highway trucking transportation sector.

With the increasing economic activities and the absence of effective load regulations have made matters worse as the overload and overweight trucks are now rapidly multiplying on the primary highway routes. Given that the trucking industry consists primarily of numerous one- to three-truck operators, the trucking industry is highly competitive with too many small players. In order to cut down the cost and survive in the market, many trucking operators load their trucks as much as possible in order to lower the unit cost and maximize the revenue. Even though the overload and overweight trucks are now engaged in the highway freight enforcement program initiated by the central government and the municipal government, the overweight and overload trucks are still common in the Chinese road transportation market.

Another big challenge to the road transportation in China is the toll charge, which constitutes a huge part of the total operating cost to the trucking operators. According to the survey conducted by the Ministry of Transportation and Communications of China, the toll charge represent 22%-38% of the total transportation cost for the trucking operators and the toll charges for long-haul trucking operators amount to be twice as high as the fuel cost. In order to make profit, some small trucking operators either overload their trucks to reduce the unit transportation cost or charge special fee on the long-haul transportation service. Since the toll rates are agreed between the municipal government

and the local company that built each highway segment before starting the highway building project, huge variance can be found on the toll charges among different cities or provinces. Considering the different pay back period agreed between the municipal government and the local builders, it is not easy for the central government to align the toll charges across the country.

2.2.2 Rail

The railway infrastructure in China has received relatively low levels of investment compared with Chinese road and port infrastructure. Traditionally, China placed priority on passenger rail traffic over freight on the many single-track rail lines across the country, and investment interests in all but a few coastal regions are limited. With rail network shared with passenger rail services, unreliable freight movement due to the poorly developed infrastructure and the lack of dockside rail access at ports, cargo movement on the rail network in China is only about 2.2% of the national rail freight tonnage and 1.5% of the total volume moved across the country.

Realizing the importance of rail transportation in nation-wide trade and the constraint posed by current infrastructure, the Chinese municipal government has implemented a 5-year plan. A 10 million Twenty-Foot Equivalent Unit (TEU) target via rail has been established as part of the plan. Eighteen newly-built intermodal yards are part of the strategy to attract more container traffic to rail transport. Several of these yards are already in operation and others are under construction. New freight-only track is being constructed in major origin-destination corridors and investments are being made by the Chinese government on rolling stock.

An aggressive plan to create an 84,973-km main rail network by 2010 and a 100,000-km network by 2025 is in place. Rail tracks are planned to double to alleviate freight train conflicts and a double-stack container transportation route is being developed. At the same time, the plan to enhance rail access to ports, to target rail investment in the west region and to construct five major hubs will hugely boost the national rail transportation.

But, unlike many of the major road projects, rail operation in China is monopolized by the central government and the investment opportunities to private investors are rare.

2.2.3 Inland Water (Barge)

Large navigable rivers, especially in central and southern China, have linked many Chinese major inland cities. Meanwhile China's geography and the location of Chinese population are exceptionally favorable to inland water transportation, which creates a huge potential for setting up an inland water transportation network. China's inland waterway system at present is dominated by the Yangtze River and the Pearl River. These two major navigated waterways link 38% of the whole country.

To ease the pressure of demand for new roads and the improved railways, the government has increased investment in waterways to deepen navigation channels and upgrade navigational aids since 2003. The total length of navigable inland waterways in China was up to 123, 400 km in 2006. The Chinese Ministry of Communications (MOC) launched the 11th Five-Year Development Plan (FYP) for Road and Water Transportation in 2006, which includes construction of 639 coastal deep-water berths

providing capacity of 2.1 billion ton and 340 inland berths providing capacity of 64 million ton. Appendix 2 illustrates the development plans for water transportation during 11th FYP period (2006-2010).

Even though the Pearl River and the Yangtze River have served as the main commercial arteries for China's nation wide trade, canal and low bridges are still problematic for inland water transportation and limited water depth on the rivers' upper sections prevents safe year-round access by vessels with capacity of more than 100 tons. Some terminals only have limited barge access due to the capacity constraints, and in some cases barges must have a minimum of six containers to berth pier-side.

The nation-wide trade can not occur without port capacity to handle the ever-increasing flow of containers coming from the mainland factories. China has sixteen major shipping ports with a capacity of over 50 million tons per year. By 2010, eight of the top 15 container ports in the world will be in China, with Shanghai expected to be the largest container port (source: US department of Transportation). Yang Shan Port, the newly-built port in Shanghai, in particular plays a significant role in spurring both the local Chinese economy and the global market. The mainland entry to the port bridge has become a highly desirable location for logistics and warehousing centers. However, even though many large ports have been developed to cater to the container vessel, few berths are available for barges along the river or at the mainland port itself. In addition, there are many concerns currently regarding the seaworthiness of the newly-built YangShan Port to serve barge fleet in the deep water.

2.2.4 Air

In 2004, the turnover of airfreight in China reached 7.18 billion ton-km, and the volume of freight traffic 2.767 million tons. In 2007, cargo and mail throughput were 8.611 million tons, up by 14.3%. Apart from that, the number of airports with cargo and mail throughput over 10,000 reached 43 in 2007, increased by 4 as compared with 2006. The data indicates that China's airports have strong operation capability. It is estimated that cargo throughput of China's mainland airports will grow to 11.8 million tons by 2010 with average annual growth rate of 14%.

Air cargo carriers operations area still focus on the three key regions represented by hub airports of Shanghai, Beijing and Guangzhou. The hubs in the Yangtze River Delta (Shanghai), Bo Hai Bay (Beijing), and Pearl River Delta (Guangzhou) regions have achieved annual growth rates of approximately 12-13% for air express and approximately 9-11% for general freight through 2008. It is expected that China will continue its development on these three major air cargo hubs given their commercial and economic importance. Even though no additional major hubs are planned for the short-term to accommodate the national cargo transport, the geographic distribution of manufacturing and economic development including the government's efforts toward will facilitate more hubs in other Chinese cities.

2.3 Current Transportation Mode for ChemiCo's Product in China

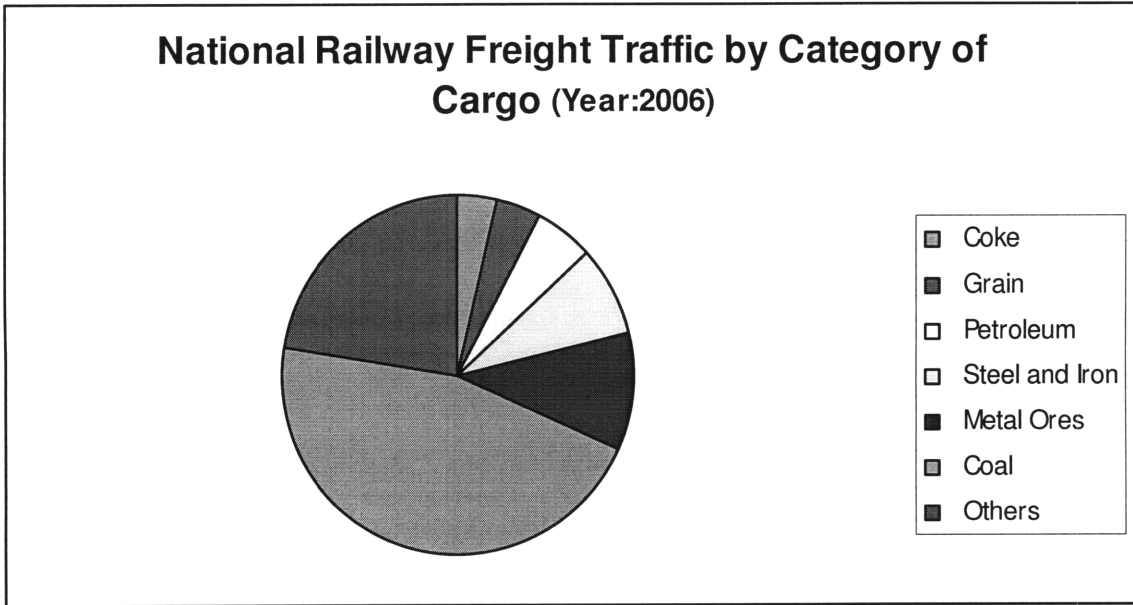
If the two criteria for transportation mode selection are rate and lead-time, trucking delivery enjoys a clear cost advantage whereas air transport offers the shortest lead-time. Table 1 presents the rate and lead-time difference between each transportation

mode operating between city A and city B. However, if we further investigate the existing transportation modes in the overall Chinese market, it is easy to see that the available mode choices are fairly limited due to the geographical coverage of ChemiCo customers and the ABC product itself.

Table 1: Rate and Lead Time Comparison between Transportation Modes

From	To	Distance (KM)	Truck		Air		Rail	
			Rate	Lead Time (hrs)	Rate	Lead Time (hrs)	Rate	Lead Time (hrs)
Shanghai	Beijing	1450	0.46/kg	72	2.3/kg	3	0.8/kg	12
Guangzhou	Beijing	2288	0.85/kg	96	2.3/kg	3	1.5/kg	38

ChemiCo’s product ABC (the focus of this study) is a very standard product and certain series of the product requires reefer containers or reefer carriages to carry it. Rail transportation in China is still quite limited to bulk cargos (see Figure 1) because of the poorly developed infrastructure and rail transport facility. Since special equipments such as reefer containers or reefer carriages are required to carry the certain segments of the ABC product, the current rail facility can’t easily provide the refrigeration protection necessary along the transportation route. Also, it is not easy for the rail transport system to meet the on-time delivery service requirement set by ChemiCo.



Source: National Bureau of Statistics of China

Figure 1: National Railway Freight Traffic by Category of Cargo

Furthermore, ChemiCo’s customers in the Chinese architecture market are scattered all over the country, and customers in the big cities with direct access to rail transport represent only 67% of the total customer base. As a result, trucking has to be accompanied by rail to supply the other 33% of the customers. Stiff competition from the trucking firms and the lack of reliability and flexibility of rail transport itself makes rail transport uncompetitive.

ChemiCo’s scattered customers in the architecture market also create a challenge for the air transportation across China. Beijing, Shanghai, and Guangzhou, which account for 23.5% of ChemiCo’s total customer volume, are the only three primary mainland hubs in China that can serve both national and international cargo transportation. Many of the other airports in the medium and small cities still face big challenges for air cargo delivery due to the scarce landing strips and fairly limited overall infrastructure. All these airports have to undergo expansions to accommodate the broadening geographic

expansion of manufacturing in China. However, as infrastructure expansion continues, all these constraints have forced the operating costs to rise, which poses another challenge to the air cargo distribution of products made by the Chinese manufactures with factories that are usually set up in the remote areas of the country.

Additionally, with costs seven to ten times higher than the surface transport, air shipment is still more favorable to the time-sensitive and high-value commodities which require the premium service featured by air transport. Considering ChemiCo's ABC products, which are distributed in exceptionally large orders, air shipment may not be an economical solution to consider.

If we look into barge transportation on the navigated waters as an option for distributing the ChemiCo's products, we have to struggle with the current inland water network coverage. Even though 38% of the ChemiCo customers are located along the Yangtze River, only a fraction of the navigable capacity of the Yangtze River can be used at the moment for barge transport. While the river stretches from Shanghai to Chongqing, most inland transport occurs between Nanjing and Shanghai. Additionally, the overall cargo handling capability in terms of port mechanization and service level has been falling behind. The average capacity of barges along the Yangtze and the Pearl River is only 229 tons, compared with the 1000 tons average level of inland transport capacity in many developed countries. The saving on the economy of scale (per unit rate) is not evident due to the barge capacity shortage.

In conclusion, China has not progressed to the point of systematically managing its transportation infrastructure and is still in the "build" mode. Considering the infrastructure constraints posed by the rail, air and barge modes, we conclude that

trucking, being faster than rail and less expensive than air, is a favorable proposition for ChemiCo at the current stage for supplying its customers across the country.

2.4 Multi-mode Transportation Opportunities and Challenges

Competition between different modes has tended to create a segmented and disconnected transportation system in China. However, many of today's supply chains elsewhere use multi-mode transportation model by weighting the relative advantages in price, time, reliability, frequency and flexibility of different transportation modes through a systematic comparison and finding combinations that are often cheaper than a single modal solution. Even though trucking remains the most practical transportation mode for ChemiCo in China at the current stage, we should watch for the evolution of different modes of transportation in the Chinese market, with sights on a future application of a multi-mode transportation system for ChemiCo.

The variables that may generate opportunities for the future Chinese multi-mode transportation market are elaborated by analyzing the following four components.

- **Infrastructure**

Infrastructure investment will be dedicated to growing the Chinese transportation market during the next several years. The 2.6 trillion USD spending by the Chinese government in 2008 on the waterways improvement and the 9.05% annual investment increase in inland waterways in the next five years will hugely facilitate the growth of the inland water transportation. With a low cost solution to inland distribution where navigable waterways penetrate the interior markets with less impact on the environment than road transportation, barge transportation will become more appealing in the future.

At this point, the Chinese government is in the process of adopting barge design and energy standards along with subsidies for their adoption to improve consistency and efficiency in barge operations. This practice could rapidly foster barge transportation, making it a significant component of China's intermodal transportation system.

- **Regulation**

The promotion of the more economical heavy-duty truck segment, with new over-load policies and a new road toll system launched by the Chinese government will become the largest incentive for the development of highway transportation development in the near future. A deduction in road tolls of about 20% will be offered to trucks with registered total weight above 15 tons and to trucks with registered total weight between 10 and 15 tons.

The Five-Year Plan (2006-2010) initiated by the Chinese Ministry of Commerce concentrates on central China development, including the development of 639 coastal deep-water berths with a capacity of 2.1 billion tons and 340 inland berths with a capacity of 64 million tons. A waterway network comprising the mainstreams of the Yangtze River and the Xijiang River, the Beijing-Hangzhou Grand Canal, the world-class waterways networks of the Yangtze River Delta and Pearl River Delta, and another 18 major tributaries of rivers will be developed (see Table 2). The growth and investment opportunities in river ports, particularly in the Yangtze River port, will be so important that ports should become more integrated for connecting the coasts with the inland parts of China. The great potential and international competitiveness in China's waterway transportation industry will increase dramatically in the future.

Table 2: The Layout of Inland Waterways

From East to West	Yangtze River and Xijiang River
From North to South	Beijing-Hangzhou Grand Canal
Two networks	The high-class waterways networks of the Yangtze River Delta and Pearl River Delta
Eighteen Lines	18 major tributaries of rivers: Minjiang River, Jialingjiang River, Wujiang River, Xiangjiang River, Yuanshui River, Hanjiang River, Hanjiang Canal, Ganjiang River, Xinjiang River, Heyu Route, Huai River, Shayinghe River, Youjiang River, Beipanjiang - Hongshuihe, Liujiang - Qianjiang, Heilongjiang River, Songhuajiang River and Minjiang River

Source: China's Ministry of Commerce (MOC)

- **Industry Structure**

With the increased popularity of Just-In-Time (JIT) practices in the supply chains of manufacturers, many companies have worked harder to reduce inventory levels and lower the overall production costs. Manufacturing firms that have established Just-In-Time policies in conjunction with their suppliers are progressively adopting scheduled shipments to ensure the timely departure and arrival of the cargos. JIT programs have had a positive impact on manufacturing and service processes, a success that has also altered the transportation industry. More shipment of cargos and larger centralized manufacturing and warehousing operations make trucking a well-suited mode for companies involved with JIT. The flexibility and frequency of truck delivery over the other modes meet most shippers' expectations for a faster, smaller and more reliable transport mode catering to the JIT practice.

- **Long and Short Distance**

In practice, truck transport is usually used for short distances (defined as not exceeding 400 km); with railway transport is used for average distances and maritime transport for long distances (above 400 km). Long-haul transportation makes trains more

efficient than trucks on a ton-mile basis. Given the “Go West” campaign, launched by the Chinese government by investing huge sums into the western region over the next decade to develop it into a magnet for both domestic and overseas investors, it is fair to predict the use of rail for the long-haul transportation market. Many multinational companies, such as Intel, have recently constructed their manufacturing facilities in China’s western Sichuan province, in view of which the Chinese government has shifted investment focus to the inland transportation market. The government is planning to build 62 rail lines in the next ten years, making the speed of China’s rail transportation development the fastest in the world.

2.5 Overview of the Current Chinese Trucking Market

Trucking is the predominant means for moving goods within China, especially in the river delta manufacturing regions. With the country lifting restrictions on foreign involvement, many U.S. trucking and logistics companies have jumped in, including YRC Worldwide (formerly Yellow Roadway Corp.) and Minnesota-based CH Robinson Worldwide Inc. Logistics company Schneider Nationals Inc. is seeking permits to operate in China with the goal of hauling and managing freight in one of the world's fastest-growing economies. With its partnership with China International Marine Containers Co., which manufactures truck trailers and ocean containers, Schneider would become a source for trailers down the road with a Chinese operating license. China is expected to be the next great long-haul truckload market in the world.

Even though the Chinese trucking market is opening to the world operators, the “hard infrastructure” challenges in terms of road improvement and oversize trucking

scale system development, and the “soft infrastructure” challenges regarding the tax rules and local protectionism, still hinder the flow of goods on the road network across China.

- **Fragmented Market with Millions of Independent Players**

The Chinese trucking market is extremely fragmented, intensely price competitive and not organized on a national basis. Barriers to entry are very low so that most Chinese trucking companies on average have only one truck and one or two employees. Large trucking operators typically have less than 200 trucks in this fragmented market. The top 100 trucking companies in China represent less than 2% of the whole market share.

Long-distance trucking service in China is offered by large trucking service providers, among which the largest provider at the current stage boasts nearly 3 million trucks and a registered fleet of 3,000 trucks specializing in long-distance service. In contrast, short-distance trucking services are normally provided by the local operators who offer relatively inexpensive cost but more competitive services. The separation between the short and long distance trucking operators is partially due to the restriction set by local and city authorities to protect local trucking businesses. In some big cities such as Shanghai and Beijing, freight trucks with out-of-city plates are not permitted to operate in the city within certain times of day.

- **Fluctuating Price with Three Type of Players**

There are three types of players in the Chinese trucking value chain. The “specialized line” type encompasses companies that provide LTL (Less-Than-Truckload) services for one or two particular routes, such as the route service between Beijing and Shanghai. The “load matching” type comprises brokers who act as the go between for trucks owners and customers or “truck owners” and “specialized line”. Finally, the “truck

owners” type, who buy 2-3 trucks and hire 5-6 drivers, are seeking loads from load matching brokers.

There are about 100,000 “specialized line” companies, 1 million “load matching” brokers and 3 million “truck owners”. This kind of fragmented structure creates a complex challenge for shippers, making it almost impossible to find reliable carrier and the listed current market price. To deliver even one ton of cargo from city A to city B, shippers may end up searching over 500 similar carriers who may quote various prices. Facing the fragmented carrier market, most multinational corporations are reluctant to deal directly with millions of “specialized lines”, brokers and truck owners. These companies would rather outsource the trucking service to 3PL (Third-party Logistics Provider) that specialize in operating or managing road transportation for big clients.

Even if most big shippers sign a fixed trucking contract with 3PLs, the real trucking market price in China changes dramatically each day. Regional and seasonal difference may lead to over 200% price fluctuation within only one month. For example, during the Chinese New Year period, one-week cargo volume may account for 10% of the whole year’s cargo volume, which directly results in extreme fluctuation of the market price.

3 Literature Review

Transportation carriers' performance is becoming an important factor that influences the effectiveness of the whole logistics function of a company. Accordingly, the importance of carrier selection criteria has become more commonly recognized, with increasing emphasis on setting up a comprehensive measurement system for a carrier's performance. In the past forty years, there has been a transformation in analysis of carrier selection: research that was once conducted separately is now being analyzed simultaneously along with the analysis of mode selection.

3.1 Review of Carrier Performance Attributes

Identifying carrier attributes has motivated a great deal of research using quantitative and qualitative approaches. In the past decades, different researchers have identified about thirty criteria for carrier selection in the western countries, some of which have been chosen for this analysis of carriers' performance in the Chinese market.

Early studies of transport selection criteria, such as Cook (1967), found that transportation cost was the most important criterion when selecting a carrier. Soon afterwards, Bayliss and Edwards (1970), on the basis of sample studies of consignments in 500 transport intensive industries, proposed that indirect costs, such as carrier frequency and flexibility, were more crucial than direct transport costs.

Bardi (1973), after comparing the importance of the carrier service performance before and after the passage of the Motor Carrier Act of 1980, found out that carrier service performance ranked highest among all other selection criteria for America's domestic shippers.

As deregulation took place in the United States in early 1990's, the transportation industry became more competitive. Many firms began to understand the importance of the carrier selection process for them to survive in the new environment. Over time, additional carrier performance criteria have been identified, with increasing emphasis beyond simply reducing overall transit time and lowering transport costs for cargo delivery in the container.

McGinnis (1990), after reviewing the carrier attribute literature during that period of time, found that transportation choice was largely influenced by such factors as freight rates, reliability, transit time, loss and damage, claims processing, tracking and tracing. The conclusion is that shippers in the United States generally valued service more highly overall than cost in the freight transportation choice process before and after deregulation.

Whyte (1992) proposed thirteen criteria for measuring carrier performance, among which reliability of on time pick up and delivery, computer link between shipper and carrier, and the carrier's personal knowledge of the shippers' needs were the most frequent measurements being analyzed. Murphy and Dalenberg (1991) gave more weight to the importance of flexible rates and the abilities to track and trace shipments on top of the criteria analyzed by Whyte (1992).

3.2 Review of Carrier's and Shipper's Perspectives

Though the carrier selection has become a topic of interest in the transportation literature, the question of which characteristics are used in the actual selection process and which criteria receive more objective evaluation has remained unanswered. The different perspectives held by carrier and shipper on the performance measurement leads

to a gap between the offered and expected service level. This provides great insight into how to align the performance measurement of transportation carriers.

Evans and Southard (1974) carried out the first studies on relationships with shippers, which were further elaborated by various researchers such as Murphy, Daley and Dalenberg (1991). These, like Evans and Southard, suggested that shippers will ignore intermediaries such as forwarders as they place a higher emphasis on price, while carriers hold a different view.

Also focused on the relationship between carriers and shippers, Foster and Strasser (1990) suggested that carriers do not have a solid understanding of how shippers actually select a carrier or modes of transportation. Additionally, carriers view the criteria as independent factors that will be treated independently.

Several authors investigated the degree to which carriers hold the same view as shippers in terms of carrier selection attributes. Abshire and Premeaux (1991) addressed this research question with a survey that queried managers in both the carrier and the shipper communities on the relative importance of variables used to select carriers. The result of the research showed that carriers do not really understand which selection criteria tend to influence a shipper's choice of carriers. It indicated that perceptual differences existed for 19 of the 35 variables that were examined, which may lead to the situation that carriers may not pay attention to the more important selection variables. These differences would definitely put a carrier at a competitive disadvantage, which could directly result in a decrease of the market share. On the other hand, carriers that do understand the shipper's perception of importance would secure the market share for sustainable advantage and become a valued member of a company's distribution channel.

3.3 Summary

The research conducted so far on carrier performance criteria and different perspectives on carrier performance from shippers' and carriers' points of view has been mainly focused on the US and European markets, where the national transportation infrastructure, government regulation on the transportation market, and legal contracts between carriers and shippers have been well established, defined and regulated.

The aim of this research is to add to the existing literature on carrier selection by developing a framework that extends to the local transportation market in China. The performance measurements adapted by companies in assessing various transportation carriers will be narrowed down to some of the key measurements to analyze the transportation carrier performance for ChemiCo in the Chinese architecture market. Additionally, the framework seeks to provide a level of carrier performance evaluation by taking into account different ChemiCo's customer segments.

4 Research Approach

Since the Chinese trucking market is very fragmented and the price and service levels vary significantly, it is very difficult for a shipper to find the right supplier. Most carrier selection research done by western researchers is focused on the standardized carrier market where cargo movement is influenced mainly by the perception that the correct carrier choice will reduce the total transportation cost of the consignment. This choice is particularly important when the market is regulated, in which case the performances of carriers are not hard to differentiate. For this reason, finding a carrier in a fragmented trucking market like that in China requires different comparison criteria.

The objective of this section is to present a pair-wise comparison matrix to select the carriers for ChemiCo's trucking delivery. Consequently, a review of some of the relevant carrier performance criteria is made and a comparison matrix based on the AHP methodology is presented during this selection process.

4.1 Review of Methodology

Based on mathematics and psychology, Saaty (1985) developed the Analytic Hierarchy Process (AHP) model, which provides a comprehensive and rational framework for structuring a problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.

Liberatore, Nydick and Sloane (1999) used the AHP model to design a hierarchical structure and weigh the trade-offs between decision criteria and alternatives to facilitate improved clinical and management decisions. Wang et al (2003) presented

the AHP model as a new framework for knowledge-based decision support systems for government vendor selection and bidding. Jablonsky and Fiala (2003) selected the AHP model for productivity comparison of Central European countries accessing the EU.

Compared to other techniques, the AHP model provides a way for decision makers to use concrete data about the elements or their judgment about each element's relative meaning and importance to perform the evaluations in a hierarchy. The AHP model converts these evaluations into numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, allowing diverse and often hard to measure elements to be compared to one another in a rational and consistent way. Since multiple carrier selection criteria are defined to measure the importance of carrier performance, the AHP model makes it possible to take several factors into consideration simultaneously, and make numerical tradeoffs to arrive at a synthesis or conclusion.

AHP is best suited for situations where structuring, measurement, and synthesis are required, and it reflects the major components (decision criteria) of the problems and their interconnections (comparisons of these components). AHP methodology significantly differs from other alternatives, as Karlsson (1998) comments: "Even though constructing an AHP model requires eliciting extensive data from a group of respondents, and is thus time consuming in this respect, it is fairly insensitive to judgmental errors."

4.2 Application of AHP in Carrier Selection

AHP provides a comprehensive and rational framework for structuring a problem, for representing and quantifying its criteria, for relating those criteria to overall goals, and

for evaluating alternative solutions. The application of the AHP model in this thesis is to set up a decision-making approach through structuring multiple criteria into a pair-wise comparison matrix, assessing the relative importance of these criteria and determining an overall ranking of the criteria.

The three-steps involved in the decision analysis are outlined below, namely a) structuring multiple criteria, b) assessing the relative importance of these criteria, and c) determining an overall ranking of the criteria. These main steps are also incorporated into a questionnaire design. The questionnaire, in the format of a spreadsheet, can be easily translated by a conversion of qualitative measurements of suppliers' performance into the quantitative terms.

Step (1): Structuring Multiple Criteria

The growing importance of customer service tends to add to the already rising transport cost (Cooper, 1990). Cost and service have thus become the main aspects of the carrier selection process. Freight charge and rate change (the rate changes are initiated by carriers on a frequent basis such as rate change due to the fluctuating fuel prices or seasonal capacity constraints) are two important criteria to assess a carrier's performance from the cost perspective.

Cost will not be a criterion in this thesis, however, because ChemiCo, as opposed to its customers, is paying for the trucking cost. Even though the transportation cost will be reflected in the price that ChemiCo charges its customers, the performance criteria they use to approach customers does not include cost. So, for the sake of understanding the relative priority given by ChemiCo's customers to an assortment of non-cost variables, we will ignore cost. Therefore, the emphasis on carrier performance criteria in this

research has shifted from cost side to service side, and our findings should be seen in the light of this decision.

The variable service criteria defined to measure carrier performance are evaluated through discussion with ChemiCo's customer service and sales staff, by taking ChemiCo's current trucking practice and service contract into consideration. Combined with the insights gained from the previous literature review on carrier's performance criteria and the interviews conducted with ChemiCo's sales and customer service staff in China, we came up with ten variable criteria to evaluate carriers' performance. These are:

1. Reliability of on Time Delivery
2. Flexibility of Delivery in Non-working Hours
3. Flexibility of Receiving Time
4. Flexibility in Delivery Quantity
5. Flexibility in Last Minute Changes
6. Cargo Handling Capability (e.g. physical facilities and equipment provided for loading or unloading products and the trucking capacity)
7. Quality of Drivers (e.g. carrier's qualifications; ability to handle special products)
8. Loss/Damage (fraction of shipments that are lost or damaged)
9. Carrier's Response to Emergency Situation
10. Shipment Tracking and Tracing Ability

Step (2): Assess the Relative Importance of Criteria

Modeling the carrier performance evaluation by structuring the ten criteria listed above is followed by the prioritization process and ranking, which is the numerical

representation of the relationship among the criteria. A judgment or comparison is to be made on a scale rating during this prioritization process.

The comparison is made using a questionnaire, which is designed as a square matrix to facilitate comparison and ranking by respondents. The spreadsheet in Table 4 represents the sample pair-wise comparison matrix, in which ten criteria are set out in the horizontal and vertical lines for pair-by-pair comparison.

The judgment and comparison will be the input from a group of ChemiCo customers who are segmented into two groups based on transporting distances and cargo volumes. The rating scale of absolute numbers (1-9) is used to assign numerical values to judgments made by ChemiCo customers when comparing two elements, with the smaller number used to reflect lower importance and the bigger one for more important variable. Detailed explanation of the numerical score, which is used to transfer the qualitative criteria into quantitative data for comparison, is provided in Table 3. The rating scale expected to be put into the grey highlighted area of the questionnaire in Table 4. Table 5 shows a sample filled matrix by a ChemiCo customer.

Table 3: Scale for Comparisons in Questionnaire

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two elements contribute equally to the objective
3	Moderate Importance	Experience and judgment slightly favor one element (in Column) over another (in Row)
5	Strong Importance	Experience and judgment strongly favor one element (in Column) over another (in Row)
7	Very Strong Importance	One element (in Column) is avored very strongly over another (in Row); its dominance is demonstrated in practice
9	Extreme Importance	The evidence favoring one element (in Column) over another (in Row) is of the highest possible order of affirmation
Intensities of 2, 4, 6, and 8 can be used to express intermediate values when comparing one element (in Column) over another (in Row).		
Please use the reciprocal of the above numbers to indicate the less importance when comparing one element (in Column) with another (in Row)		

Source: Saaty, *A scaling method for priorities in hierarchical structures*

Table 4: Sample Questionnaire to ChemiCo Customer

Question: Which carrier performance criterion is more important?

Company Name:

	Reliability of on Time Delivery	Flexibility of Delivery in Non-working Hours	Flexibility of Receiving Time	Flexibility in Delivery Quantity	Flexibility in Last Minute Changes	Cargo Handling Capability	Quality of Drivers	Loss/Damage	Carrier's Response to Emergency Situation	Shipment Tracking and Tracing Ability
Reliability of on Time Delivery	1									
Flexibility of Delivery in Non-working Hours		1								
Flexibility of Receiving Time			1							
Flexibility in Delivery Quantity				1						
Flexibility in Last Minute Changes					1					
Cargo Handling Capability						1				
Quality of Drivers							1			
Loss/Damage								1		
Carrier's Response to Emergency Situation									1	
Shipment Tracking and Tracing Ability										1

Please specify the factors you consider important that are not mentioned in the above chart.	
Factor 1	
Factor 2	
Factor 3	

Table 5: Sample Questionnaire Filled by One ChemiCo Customer

Question: Which carrier performance criterion is more important?

Company Name: XYZ

	Reliability of on Time Delivery	Flexibility of Delivery in Non-working Hours	Flexibility of Receiving Time	Flexibility in Delivery Quantity	Flexibility in Last Minute Changes	Cargo Handling Capability	Quality of Drivers	Loss/Damage	Carrier's Response to Emergency Situation	Shipment Tracking and Tracing Ability
Reliability of on Time Delivery	1	9	9	5	9	5	9	1/5	9	9
Flexibility of Delivery in Non-working Hours		1	1/3	7	7	3	7	5	7	7
Flexibility of Receiving Time			1	1	1	5	1	7	7	1
Flexibility in Delivery Quantity				1	3	1	1	7	7	1
Flexibility in Last Minute Changes					1	1/7	1/7	1	3	1/7
Cargo Handling Capability						1	3	7	7	1
Quality of Drivers							1	7	7	1
Loss/Damage								1	1	1/7
Carrier's Response to Emergency Situation									1	1/7
Shipment Tracking and Tracing Ability										1

Please specify the factors you consider important that are not mentioned in the above chart.	
Factor 1	
Factor 2	
Factor 3	

Step (3): Determining an Overall Ranking of the Criteria

After the matrix is developed and all pair-wise comparisons are obtained, eigenvectors or the relative weights (the degree of relative importance amongst the elements) are calculated by synthesizing the variable criteria. The most important criterion is identified after ranking the relative weights. The overall ranking of all criteria is obtained after mathematically normalizing all the weights in each questionnaire feedback. The overall priorities for the variable criteria are established through this synthesizing process.

In order to approach ChemiCo customers in China who are more comfortable communicating in Chinese, questionnaires are designed in both English and Chinese with response guide (Appendix 3) for explanation. ChemiCo's sales and customer service people in China proofread the questionnaire and guides before it was sent out. ChemiCo's sales and customer service people, who are the key contacts for their customers, were well informed on the questionnaire structure and response guide.

5 Data Analysis and Findings

To investigate ChemiCo customers' perceptions of the importance of carrier performance, responding customers are all expected to perform a pair-wise comparison with a spreadsheet method on the 9-point rating scale. In this section, we will review the results of the questionnaire along with the analysis of the findings. A scale rating on the importance of carrier performance criteria will be proposed to ChemiCo to guide them during the carrier selection process.

5.1 Data Analysis of Variable Criteria

The matrix shown below refers to the use of APH methodology in questionnaire design.

$$A = \begin{pmatrix} 1 & a^{12} & \dots & a^{1m} \\ 1/a^{12} & 1 & \dots & a^{2m} \\ \dots & \dots & 1 & \dots \\ 1/a^{1m} & 1/a^{2m} & \dots & 1 \end{pmatrix}$$

A^{ij} : the relative importance of attribute "i" (on column) versus attribute "j" (on row); (i, j = 1, ..., m)

A^{ij} is an integer, which is equal to the relative importance of pair-wise comparison, if attribute "i" is more important than attribute "j". Otherwise, it will be a fraction, which is an inverse of the relative importance. ChemiCo's customers record their judgment into the upper triangle matrix (highlighted in grey of Table 4 in Chapter 4) as they perform pre-identified pair-wise comparison.

Entries in the lower triangle of the matrix are computed by taking the inverse of the input in the upper triangle of the matrix. For example, if the performance criterion of “Reliability of on Time Delivery” is strongly favored over the criterion of “Flexibility of Delivery in Non-working Hours” by respondents, say the input is 5 in the first row of the second column in Table 4. Accordingly, the reciprocal of the number, 1/5, is stored in the second row of the first column, which measures the importance of “Flexibility of Delivery in Non-working Hours” to “Reliability of on Time Delivery”.

As to the data in the main diagonal, “1” indicates the equal degree of relative importance when each criterion is compared with itself.

Next, the proportion of each criterion in the sum of each criterion’s scales of numbers is calculated and the weights are computed by averaging all the proportions of each parameter. Averaging the weights from all responding customers’ questionnaires, the final result represents the overall weight of each carrier performance’s criteria. To articulate the values in Table 4, three steps are followed.

- Sum up all the entry in the same matrix column;

$$W^i = \sum A^{ij} \text{ (i, j= 1... m)}$$

- Normalized matrix: divide each entry by the sum of the same matrix column;

$$A = \begin{pmatrix} 1 & a^{12} / W^1 & \dots & a^{1m} / W^1 \\ 1 / (a^{12} \cdot W^1) & 1 & \dots & a^{2m} / W^1 \\ \dots & \dots & 1 & \dots \\ 1 / (a^{1m} \cdot W^1) & 1 / (a^{2m} \cdot W^1) & \dots & 1 \end{pmatrix}$$

- Relative importance of attribute: find average of each normalized matrix row.

Seventeen valid questionnaire feedbacks were received out of a total of 30 questionnaires that were sent out to the customers for a 57% response rate. Table 6 specifies the overall rating of carrier performance criteria after following the above three steps. It represents ChemiCo customers' perspectives on the importance of each carrier performance criterion.

Table 6: ChemiCo Customers' Perspective on Carrier Performance Importance

<u>Carrier Performance Parameters</u>	<u>Weight</u>	<u>Standard Deviation</u>
Quality of Drivers	0.292	0.056
Cargo Handling Capability	0.183	0.037
Shipment Tracking and Tracing Ability	0.105	0.017
Carrier's Response to Emergency Situation	0.102	0.039
Reliability of on Time Delivery	0.071	0.058
Flexibility of Delivery in Non-working Hours	0.057	0.054
Flexibility in Delivery Quantity	0.057	0.039
Flexibility in Last Minute Changes	0.061	0.013
Flexibility of Receiving Time	0.040	0.02
Loss/Damage	0.031	0.009

Figure 2 conveys the output of Table 6 as the chart comparison.

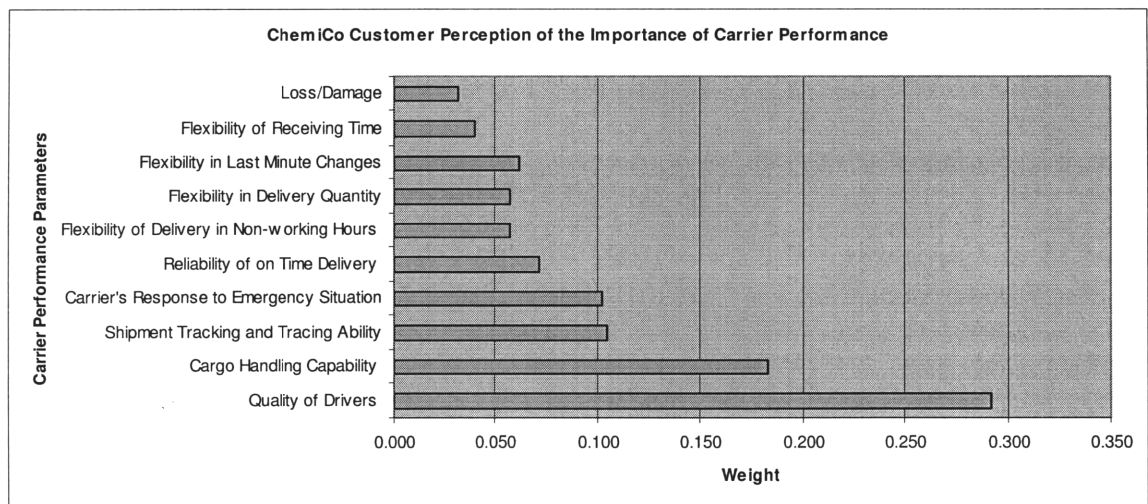


Figure 2: Importance of Carrier Performance (ChemiCo Customers)

5.2 Results and Findings

A simple comparison of the ten variable criteria on the importance of carrier performance demonstrates that “Loss and Damage” and “Flexibility of Receiving Time” are perceived as fairly low, since the mean score on a one-point scale is only 0.031 (with the standard deviation of 0.009) versus 0.292 for the highest ranked factor. Criteria of “Quality of Drivers” and “Cargo Handling Ability” are ranked the highest among all the criteria, with corresponding scores of 0.292 (with the standard deviation of 0.056) and 0.183 (with the standard deviation of 0.037) out of 1.00.

Next, we divided the questionnaire feedback from 17 ChemiCo responding customers into different customer categories based on the customer information given by the ChemiCo sales team. The findings are targeted to prioritize the carrier performance criteria for ChemiCo in supplying different customer segments.

Based on the customers’ data list shared by ChemiCo’s sales team in China, ChemiCo customers can be segmented into two categories characterized by transportation distances and cargo volumes. Long distance and short distance customers are identified by transportation distance beyond and within 400 kilometers from the loading place, ChemiCo’s Suzhou plant or warehouse in Shanghai and Guangzhou, to the unloading place, ChemiCo customers’ factory or warehouses in China. High and low annual cargo volume customers are divided based on the certain top or bottom percentage of the whole 2007 ChemiCo cargo volume.

- **Long or Short Transporting Distance Customers**

According to the Ministry of Transportation and Communications, short distance for highway road transportation in China is limited to 150 kilometers, and long distance

is defined as distance beyond 400 kilometers. Any distance between these two is called medium distance transportation. Table 7 breaks up the overall rating on carrier performance criteria made by ChemiCo customers into two rating comparisons made by customers with long transporting distance (beyond 400 kilometers from ChemiCo plant or warehouses to customers' factory or warehouse) and customers with short transporting distance (within 150 kilometers from point to point).

Table 7: Carrier Performance Evaluation by Distance-Variou Customers

<u>Carrier Performance Parameters</u>	<u>Long Distance</u>	<u>Short Distance</u>
Reliability of on Time Delivery	0.029	0.082
Flexibility of Delivery in Non-working Hours	0.032	0.063
Flexibility of Receiving Time	0.030	0.042
Flexibility in Delivery Quantity	0.055	0.057
Flexibility in Last Minute Changes	0.064	0.061
Cargo Handling Capability	0.198	0.179
Quality of Drivers	0.331	0.283
Loss/Damage	0.030	0.032
Carrier's Response to Emergency Situation	0.125	0.097
Shipment Tracking and Tracing Ability	0.106	0.104

Figure 3 interprets the output of Table 7 as the chart comparison.

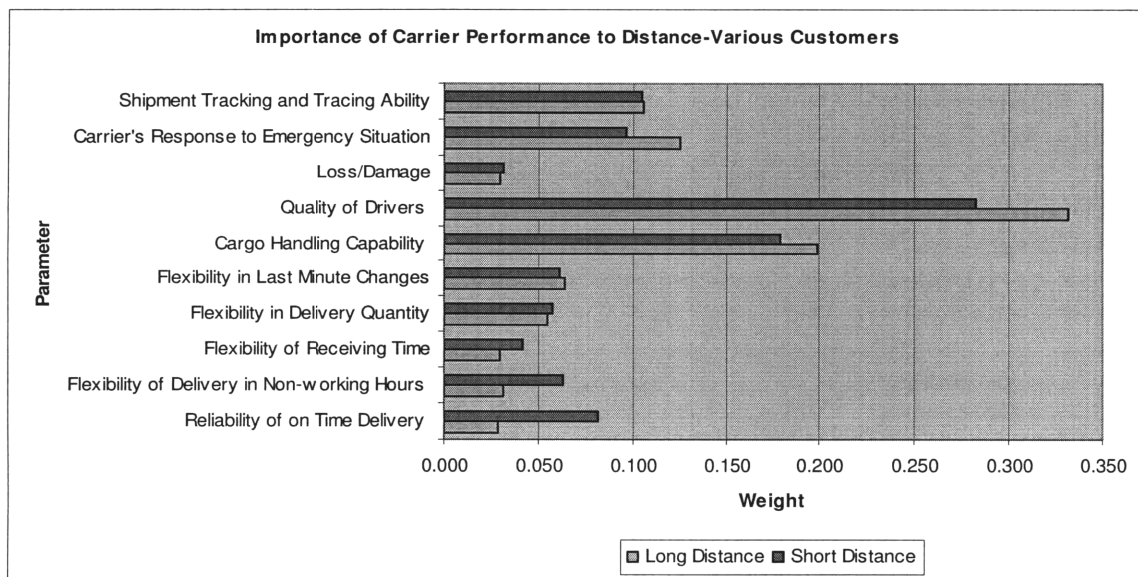


Figure 3: Importance of Carrier Performance by Distance

By eyeballing Figure 3, it is clear that “Quality of Drivers” and “Cargo Handling Ability” are the tow most important criteria; “Loss/Damage” receives the lowest significance. Compared with the evaluation provided by all ChemiCo customers (shown in Figure 2), all customers give highest score to the criteria of “Quality of Drivers” and “Cargo Handling Ability” regardless of the distance. This shows that transportation distance has no direct impact on the most critical criteria selected by customers for carrier performance measurement. ChemiCo’s short distance customers, however, rate the importance of “Flexibility of Delivery in Non-working Hours” and “Reliability of On-time Delivery” higher than the long distance customers for obvious reasons.

- **High or Low Cargo Volume Customers**

Table 8 classifies the overall carrier performance rating criteria of ChemiCo customers based on cargo volume - high cargo volume and low cargo volume. High and low volume of cargo is defined based on the 20% benchmark of the cargo volume in 2007. Specifically, in 2007, the average volume for ABC product was 53,000 units per customer; the average for top 20% of the total cargo was 97,000 units per customer and the average for bottom 20% of the total cargo was 15,000 units per customer.

Table 8: Carrier Performance Evaluation by Volume-Variou Customers

<u>Carrier Performance Parameters</u>	<u>High Volume</u>	<u>Low Volume</u>
Reliability of on Time Delivery	0.029	0.045
Flexibility of Delivery in Non-working Hours	0.032	0.052
Flexibility of Receiving Time	0.030	0.046
Flexibility in Delivery Quantity	0.055	0.058
Flexibility in Last Minute Changes	0.065	0.066
Cargo Handling Capability	0.197	0.189
Quality of Drivers	0.336	0.293
Loss/Damage	0.030	0.037
Carrier's Response to Emergency Situation	0.120	0.101
Shipment Tracking and Tracing Ability	0.104	0.113

Figure 4 shows the results in Table 8 as a chart.

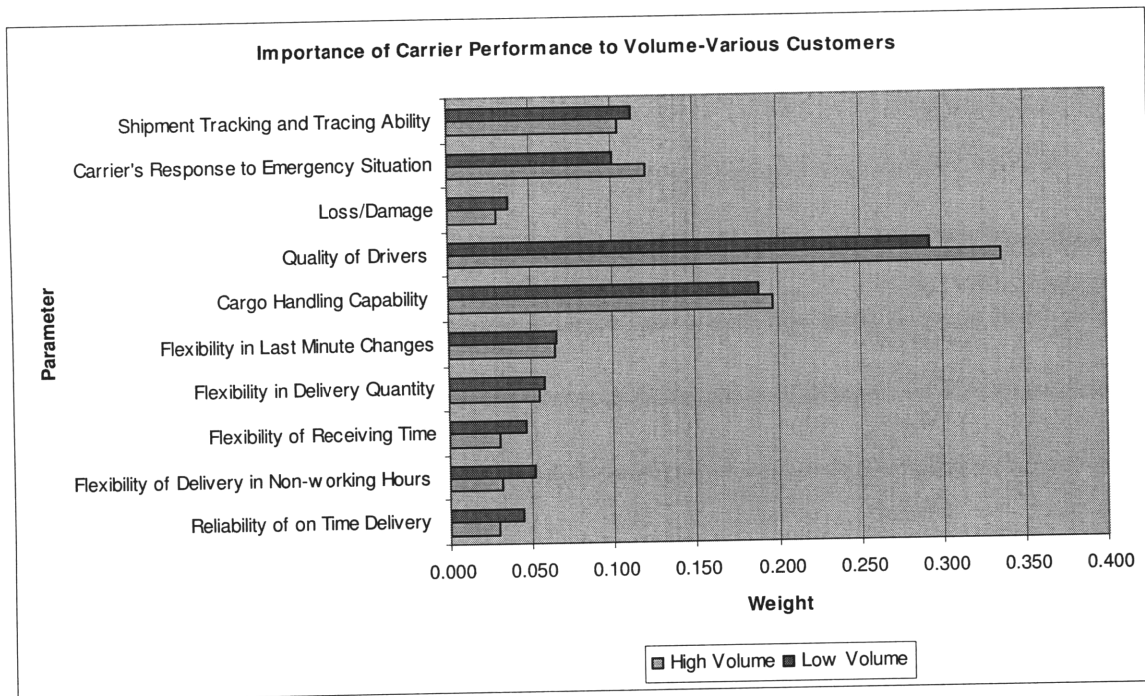


Figure 4: Importance of Carrier Performance by Volume

Data in Figure 4 shows that the two criteria of “Quality of Drivers” and “Cargo Handling Ability” have the highest weight among all the criteria. “Loss/Damage” gets the lowest significance. The importance of “Quality of Drivers” and “Cargo Handling Ability” out-weighs other eight criteria. The rating of these two criteria, even though placed a little bit higher by ChemiCo high volume customers, is still consistent with the overall ranking by all ChemiCo customers in Figure 2. The outcome makes it apparent that cargo volume has no direct influence on the most critical criteria concerning by customers on carrier performance measurement. Ratings on the other eight criteria are quite close and the gap is minor that customers’ judgments are very consistent regardless of cargo volume.

5.3 Service Gap Analysis

Since most Chinese trucking carriers maintain a narrow focus on keeping transportation costs down, carriers have more incentive to compete on price, rather than overall quality and added value that a full-service transportation provider can offer. Given the relatively large number of trucking operators and the intense competition for freight movement in the market, most shippers are tired of comparing and measuring carrier performance in terms of service variables.

However, the question is whether the carrier chosen by the shipper can really meet the service requirement of its customer? This is even more important when transportation service is a crucial part of the business proposition of the shipper to its customers. This takes on another dimension in cases where the importance of the carrier performance perceived by the service provider (ChemiCo in our case) is different from that perceived by the service receiver (ChemiCo's customers in China, in our case). And the discrepancy between these two may result in an inefficient selection of carrier. We call this service gap.

In order to uncover the service gap discrepancy between the carrier performance as perceived by ChemiCo and by its Chinese customers, the same questionnaire (Table 4) was distributed within ChemiCo's sales and customer service team in China.

Seven valid questionnaire feedbacks were collected from a total of ten questionnaires that were sent out to ChemiCo sales and customer service staff in China for a 70% response rate. Table 9 shows the result of the survey completed by ChemiCo's Chinese staff.

Table 9: ChemiCo's Perspective on Carrier Performance Importance

<u>Carrier Performance Parameters</u>	<u>Weight</u>	<u>Standard Deviation</u>
Reliability of on Time Delivery	0.178	0.048
Flexibility of Delivery in Non-working Hours	0.126	0.064
Loss/Damage	0.120	0.061
Flexibility in Delivery Quantity	0.103	0.024
Flexibility in Last Minute Changes	0.100	0.038
Shipment Tracking and Tracing Ability	0.088	0.053
Flexibility of Receiving Time	0.087	0.034
Carrier's Response to Emergency Situation	0.076	0.022
Cargo Handling Capability	0.064	0.027
Quality of Drivers	0.058	0.016

Figure 5 displays two different perspectives on the importance of carrier performance held by ChemiCo and its customers after doing the same calculation on the questionnaire feedback.

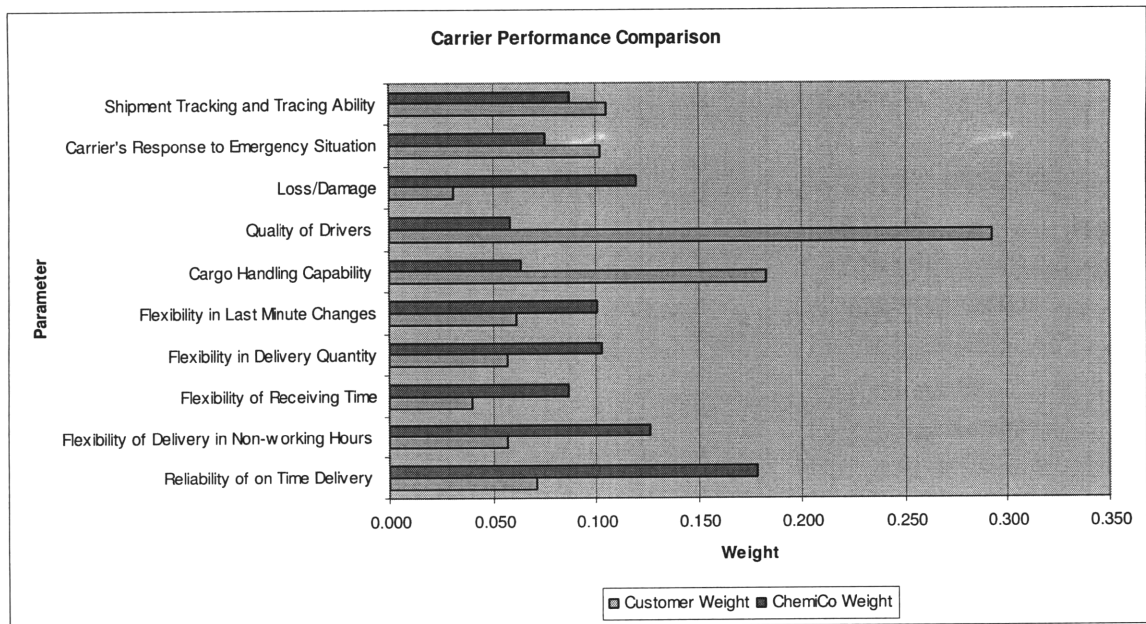


Figure 5: Comparison of Carrier Performance Perceptions

Concerning the relative importance of the ten carrier performance criteria, ChemiCo ranked “Reliability of on Time Delivery” (0.178 out of 1.00 with the standard deviation of 0.048) and “Flexibility of Delivery in Hours” (0.126 out of 1.00 with the standard deviation of 0.064) as the two most important criteria, while ChemiCo customers chose “Quality of Driver” (0.292 out of 1.00 with the standard deviation of 0.056) and “Cargo Handling Capability” (0.183 out of 1.00 with the standard deviation of 0.037) as the highest two on the list. Meanwhile, “Quality of Driver” and “Cargo Handling Capability” also received the largest discrepancy in emphasis placed by ChemiCo and its customers.

5.4 Analysis of the Findings

Table 10 summarizes the results of carrier performance preference of ChemiCo customers in the Chinese architecture market.

Table 10: Summary of Carrier Performance Preference

<u>Carrier Performance Parameters</u>	<u>Large Volume</u>	<u>Small Volume</u>	<u>Long Distance</u>	<u>Short Distance</u>	<u>Overall</u>
Quality of Drivers	1	1	1	1	1
Cargo Handling Capability	2	2	2	2	2
Carrier's Response to Emergency Situation	3	4	3	4	4
Shipment Tracking and Tracing Ability	4	3	4	3	3
Flexibility in Last Minute Changes	5	5	5	7	5
Flexibility in Delivery Quantity	6	6	6	8	7
Flexibility of Delivery in Non-working Hours	7	7	7	6	6
Flexibility of Receiving Time	8	8	8	9	9
Loss/Damage	10	10	10	10	10
Reliability of on Time Delivery	9	9	9	5	8

(1: most important, 10: least important)

To a large extent, the bottom line indicators of trucking carriers' performance are operating cost and service. Since ChemiCo instead of its customers pays for the trucking freight charge, this thesis targeted to prioritize carriers' performance criteria from the customers' perspective (cost is assumed to be the constant indicator in the calculation.)

It is typical to find service level discussions include travel time, reliability, and flexibility as its core component. However, the ratings on the importance of "Flexibility" and "Reliability" of carriers by customers tell quite a different story as these are ranked very low in our findings. A possible reason is that trucking in general excels relative to the other modes in terms of flexibility, reliability, and availability, explaining also why trucking in China is shippers' preferred mode.

The summary of carrier performance preference indicates that ChemiCo's customer base (customers who responded), no matter their category, place greater importance on the criteria of "Quality of Driver" (carrier's professionalism and ability to handle special products), "Cargo Handling Capability" (physical facilities and equipment provided for loading or unloading products and the trucking capacity), "Carrier's Response to Emergency Situation" and "Shipment Tracking and Tracing Ability". Note that these variables were identified by respondents as the most important from the list of the performance criteria that do not include cost; therefore, we are not making any claims regarding the relative importance of cost to these other variables from this analysis.

Meanwhile, the findings do suggest that ChemiCo's customers are relatively unconcerned with criteria such as "Loss and Damage" as long as carriers take responsibility of cargo delivery and loss and damage are usually covered within an acceptable and reasonable range of volume agreed in the service contract.

- **Critical Carrier Performance Criteria**

The fierce competition forces a lot of trucking carriers only to compete on price by lowering internal operating cost through cost cutting measures such as truck drivers' salary. As a result, truck drivers' turnover rate is relatively high and training is hardly being conducted in these companies. These factors directly lead to the low quality of truck drivers in China. On top of that, the huge surplus of truck drivers in the market creates even more brutal competition. Referring to "The Blue Papers of China Truck Driver Living Status" issued by the Chinese Organization for Motor Vehicle Manufacturers, 80% of Chinese truck drivers dedicate more than 80% of their time for work and about 41.4% of heavy truck drivers drive more than 9 hours per trip. Apparently, the low competency of Chinese truck drivers is more or less owing to the fragmented and inefficient market system.

"Cargo handling capability", in terms of providing physical facilities and equipment to load and unload cargos and offering enough capacity for delivering ChemiCo's ABC product, is rated as the second highest important criterion by ChemiCo customers. One reason behind placing so much importance on this criterion is the weak enforcement of the standard vehicle configuration and the limited integration of technology into trucking operations. Apart from that, there are certain problems which need to be solved in the Chinese heavy-duty vehicle market. Since most of ChemiCo's products are heavyweight cargos, greater focus is placed on the heavy-duty trucks.

Even though the Chinese heavy-duty truck market is growing rapidly thanks to the Chinese massive urbanization and ongoing construction of roads and high-speed railways, the market is still facing a dual challenge in terms of technology and cost. Due

to the lack of chassis for the special heavy-duty trucks in the Chinese market, the truck makers just convert the chassis from common trucks to the heavy-duty trucks, resulting in inconsistent quality. Most truck makers are adopting simple equipments and processes for production, and copying each other instead of making investment in innovative products that can differentiate them in the market.

The current heavy-duty trucks in China account only for 40% of the whole truck market, much lower compared to 70% in many developed countries. The gap between the demand and supply of the heavy-duty truck is growing, which will become the fastest growing segment and offers the most attractive business opportunity to truck makers. With the continuous promotion of more economical heavy-duty truck segment, new over load policy, and of the new road toll system by the Chinese government in recent years, trucking carriers with the capability of adopting heavy-duty trucks should be given more attention by ChemiCo during the carrier selection process.

- **Implications of the Service Gap**

ChemiCo's Perspective: The gap analysis on the carrier performance measurement revealed that *the ChemiCo customers' perception of the carrier performance was substantially different from that of the ChemiCo staff* – not only in regard to what they perceive, but also in the types of services they require. To narrow the current service gap, ChemiCo needs to come up with a new process for carrier selection by considering the customers perceptions on the most important carrier performance criteria. The process requires complete definition of each service requirement, characterization of the customer value proposition for each service, and a systematic approach to set up a carrier database. There are two key recommendations for ChemiCo:

- 1) Craft alternate carrier selection criteria or negotiate with carriers on the service level they need to adopt and improve. Evaluation of these alternatives (in terms of value creation, risk, and competency requirements) reveals a clear course of action: *the physical facilities and equipment to load and unload cargos and the capacity of the vehicles should be improved with a handful of critical personnel-related services*, the latter in conjunction with more occupational and professional trainings and more systematic management.
- 2) Set clear expectation regarding the service that it requires from the trucking operators. Such expectation i.e., experience and professionalism of the carriers, should become an integral part of setting up the relationship with a carrier and forming a strong partnership that can help ChemiCo delight its customer base. For instance, carriers' capability in decreasing the time to deliver cargo to end customers may result in inventory savings to ChemiCo customers. Carriers' capability in providing a larger size shipment relieves the operational workload at the customers' warehouse.

Carrier's Perspective: Carriers should compare and contrast ChemiCo's expectations on service with their own value proposition. This process will allow them to work more effectively with their customers such as ChemiCo and cut costs while elevating service level and building efficiency. There are two key recommendations for the carriers:

- 1) The demand on vehicle handling capability and driver's qualifications should catch the attention of the Chinese trucking firms, which see a chance to escape from their current "no-profit zone" by providing new and differentiated services.

2) The service requirement on the cargo handling capability, such as the vehicle capacity, should promote the use of the heavy-duty truck. More presence of heavy-duty trucks in the Chinese road transportation market is just a matter of time. Trucking operators have faced a competitive trucking market, and those who can succeed would do well to choose companies that best fit their individual competencies. For instance, a carrier who boasts strong cargo handling capability would prefer the shippers who can offer sufficient volume to justify the efficient use of the carrier's freight equipment.

The difficulties and fragmentation in the Chinese trucking transportation market create the opportunities for companies who can identify the market gaps and develop partnerships through mutual understanding of goals, needs, and challenges.

6. Conclusions

Chinese cargo transportation sector has experienced major growth and expansion since China's entry into WTO. Airports, roads and railway construction have provided a much needed massive boost to cargo transportation in China. However, logistics costs in China still account for nearly a fourth of the country's Gross Domestic Product (GDP). By contrast, logistics costs in the US represent only around 10% of the country's GDP. The fragmentation and capacity shortages in logistics in China create opportunities for companies with more advanced systems, efficient operational practice and know-how to streamline the process and succeed as the market leader.

With regard to policymaking, the current experience shows that the Chinese Transportation Ministry is working hard to bring new policy changes in the transportation sector to ensure that reliable and efficient national transport services are offered in an increasingly competitive transport market. The government spending on the infrastructure improvement has already reduced the cost of logistics in and between many large industrial clusters, such as the Pearl River Delta, the Ningbo-Shanghai-Suzhou area, and the Beijing-Tianjin corridor. Additionally, investments in the construction of transportation infrastructure with respect to transport networks, such as railways, highways, and waterways, represent a significant promise of a thriving multi-model transportation system in the future.

We found that the scale of transportation infrastructure in China at the present time, in comparison with many other countries is not advanced enough in providing flexible choices on transportation modes to companies like ChemiCo. However, continuous assessment of emerging opportunities and challenges in the market will

prepare companies to take advantage of new options as the market matures. The Chinese transportation market analysis and mode comparison can help ChemiCo gain a better understanding of the possible transportation modes to be considered at the current stage or in the future when entering into a new market.

We collected and analyzed data to gain a better understanding of the carrier performance criteria for ChemiCo in the trucking carrier selection process. We evaluated and compared the service gap existing at the current stage. We summarized the results to promote a better understanding of where to focus in terms of efforts to narrow the gaps and suggest how to approach a fragmented transportation market like China by setting up a performance measurement framework for its carriers. Even though carrier selection process in this research is focused mainly on trucking, which is the only feasible mode for ChemiCo in China at the currently, the methodology for carrier selection process can be applied to other modes as well.

Due to the limited scope of this research there are potential areas for future research to expand and focus on. The current research used primarily the carrier performance criteria in trucking sector to measure the carrier service preference, and thus focused on one transportation mode and ignored other alternative modes that will be available in the future. Further research is needed to combine different mode options to capture the underlying dynamics of carrier selection criteria. The same findings can be generalized to all areas of performance in various modes. Similarly, the criteria of cost can also be brought into play to study its importance and impact vis-à-vis non-cost criteria for deeper understanding of financial versus non-financial aspects of competition.

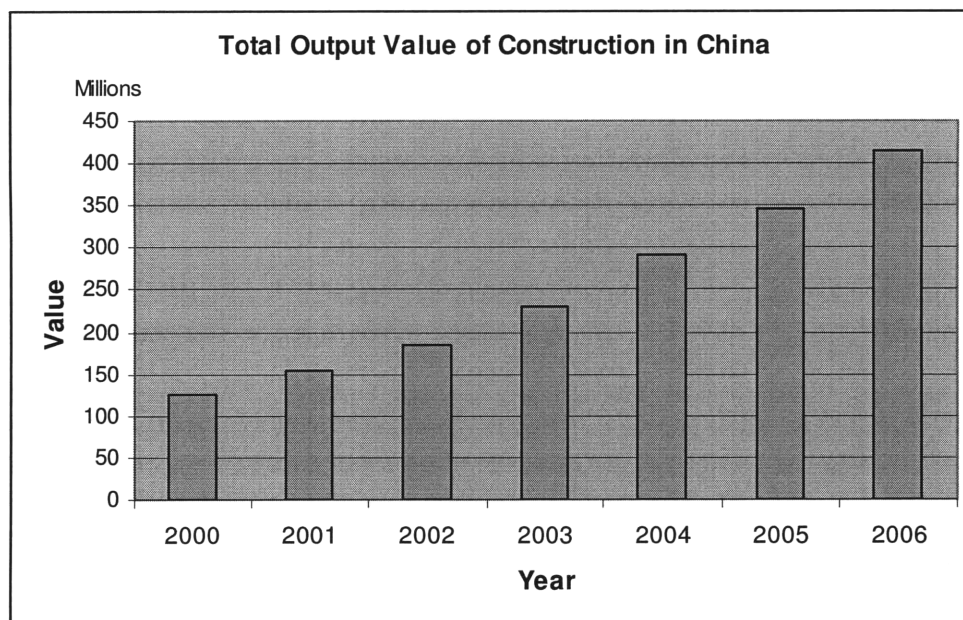
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Appendix

Appendix 1: Total Output Value of Construction in China



Source: China Statistical Yearbook 2007

**Appendix 2:
The Development Goals for Water Transportation
during 11th FYP period (2006-2010)**

Indicator	Unit	Increase during 11th FYP
I. Coastal Port		
Deep-water berth	unit	639
Capacity	0.1 billion ton	21
II. Inland Waterway		
Class III or above Waterway	km	2000
Class IV Waterway	km	1800
Berth	unit	340
Throughput	10 000 ton	6400

Source: The Chinese Ministry of Communications (MOC)

Appendix 3: Questionnaire Instruction to ChemiCo Customers

Instruction

1. Instruction

The questionnaires (for ChemiCo Customers) are designed on AHP methodology and used for MIT-ChemiCo thesis “Measuring Performance of Transportation Carriers”.

The model is designed to find the most critical elements for carrier selection in certain decision target. The result of the questionnaires will be analyzed and tested on AHP methodology and expected to assist ChemiCo in setting up the most critical performance measurement in carrier selection.

Ten “**Variable Elements**” are defined as:

- Reliability of on Time Delivery
- Flexibility of Delivery in Non-working Hours
- Flexibility of Receiving Time
- Flexibility in Delivery Quantity
- Flexibility in Last Minute Changes
- Cargo Handling Capability (physical facilities and equipment provided for loading or unloading products and the trucking capacity)
- Quality of Drivers (e.g. carrier’s professions; ability to handle special products)
- Loss/Damage
- Carrier’s Response to Emergency Situation
- Shipment Tracking and Tracing Ability

2. Response Guidance

Responder of this questionnaire should evaluate the above Ten variable elements, comparing them to one another in pairs. In making comparisons, the decision makers can use concrete data about the elements or they can use their judgment about the elements’ relative meaning and importance. Rate “1-9” are used when comparing the importance of two variable elements in each decision target.

Decision Steps:

- Rate “1-9” (based on the instruction of “fundamental scale for comparison”) according to the importance you judged when comparing variable element in “Column A” with variable element in “Row 1”. Fill in all the tables highlighted in “GREY”.

The Fundamental Scale for Comparisons		
Intensity of Importance	Definition	Explanation
1	Equal Importance	Two Elements contribute <i>equally</i> to the objective
3	Moderate Importance	Experience and judgment <i>slightly favor</i> one element (<u>in Column A</u>) over another (<u>in Row 1</u>)
5	Strong Importance	Experience and judgment <i>strongly favor</i> one element (<u>in Column A</u>) over another (<u>in Row 1</u>)
7	Very Strong Importance	One element (<u>in Column A</u>) is <i>avored very strongly</i> over another (<u>in Row 1</u>); its dominance is demonstrated in practice
9	Extreme Importance	The evidence favoring one element (<u>in Column A</u>) over another (<u>in Row 1</u>) is of the <i>highest possible order of affirmation</i>
Intensities of 2,4,6, and 8 can be used to express intermediate values when comparing one element (<u>in Column A</u>) over another (<u>in Row 1</u>).		
Please use the reciprocal of the above numbers to indicate decrease of the importance when compared the element (<u>in Column A</u>) with another (<u>in Row 2</u>)		