Evaluation of Supplier Location Using the Comparison Between the Transportation Cost and the Opportunity Cost

by

Ms. Tanaporn Jitpisoot

A Final Report of the Six Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment
Of the Requirements for the Degree of Master of Science
in Supply Chain Management
Assumption University

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Academic Year	September 2007

ABAC School of Management, Assumption University has approved this final report of the six-credit course, SCM 2202 Graduate Project, submitted in partial fulfillment of the requirements for the degree of Master of Science in Supply Chain Management.

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ABSTRACT

Globalization has created a borderless organization in which the location of a firm's production and facility is of great importance. Firms are now looking at securing cost, quality, technological and other competitive advantages as a strategy to pursue in a globally competitive environment. Customers also expect a wide variety of products with just-in-time delivery. Location decisions involve firms seeking to locate, relocate or expand their operation. Choosing the location of a plant is a complex task involving a variety of factors, including low cost of land and operation, skilled but relatively cheap labor, closeness to raw materials, early access to potential markets, and favorable trade regulations.

This study begins by investigating some potential factors that can influence plant location decisions. For example, an automotive supplier may set up a plant in other regions to take advantage of lower labor cost, lower transportation cost, government incentive, economics of scale, and time-based performance. The aim of this study is to examine how the transportation cost and the cost of sacrificing economics of scale can influence where the automotive supplier chooses to locate and expand the plant. Then, a set of factors is examined and analyzed using data from Ford (Thailand).

Finally, the results from these factors analyses indicate that poorly placed plants can result in excessive cost in long term operational performance. This result can serve as a guideline to other automotive suppliers in seeking competitive position advantage from their environment. As the results show, location decision is a strategically important managerial challenge that significantly impacts the long-term performance of global firms, and in particular, the long-term operational performance of global supply chains

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CHAPTER I
INTRODUCTION

1.1 Introduction to the Study

In today's fast paced economic climate, many firms increasingly realize that globalization has made the world smaller and more competitive. A change in one place impacts another quickly. Also, customers seek products that can respond well to their specific needs. As such, firms are now looking at securing cost, quality, technological and other competitive advantages as a strategy to pursue in a globally competitive environment. One currently popular competitive advantage for firms is to promote and provide value to its customers by performing its supply chain activities more efficiently than its competitors. As a result, one area of increasing focus is on logistics management and economics of scale of a firm's set of supply chain operations.

Logistics management can be viewed as the detailed process of planning, implementing and controlling the efficient, cost-effective flow and storage of materials and products, and related information within a supply chain to satisfy demand (Christopher, 1993). Effective logistics management provides a major source of competitive advantage if it can control cost and enhance service differentiation. This unique role will help firms become both cost and value leaders. Thus, good logistics management is increasingly recognized as the key enabler, which allows a company to gain and maintain its competitive advantage and ensure maximum customer satisfaction.

Economics of scale characterizes a production process in which an increase in the scale of the firm causes a decrease in the long run average cost per unit. When more units of a commodity or service can be produced on a larger scale, yet with (on average) less input costs, then economies of scale are said to be achieved. Alternatively, this means that as firms grow and production units increase, firms will have a better chance to decrease its costs.

When a firm must make a location decision for a new facility, it must think about the future orders to be received from potential customers. Namely, it must choose the location so as to minimize the future cost of shipments to its customer. At the same time, locating near a customer means it can receive more orders and hence can enjoy the economies of scale in production. However, when there are multiple customers, the supplier must consider the balance between the shipment cost and the economy of scale it can enjoy. If it chooses a location that is close to one customer but far from the others, it will lose the potential orders from the other customers and thus lose the opportunity to enjoy economy of scale in production.

This study will examine the transportation cost, which usually represents the most important single element in the logistics cost, and the cost of sacrificing scale economy which is most important to evaluate when placing a plant near a customer's plants. These two factors generally apply to the location decisions of automotive supplier which play an important role in enabling an effective and efficient supply chain.

Background of the Thailand Automotive Industry

Thailand has become the world's second largest market for 1-ton pick-up trucks after the USA, and the biggest automobile production base in Southeast Asia. The rapid growth in the Thai automotive industry can be partly ascribed to the government's policies toward this sector. While other countries like China or Malaysia, for example, set up national car programs to develop their local industries, the Thai government pursued a different strategy, attracting global vehicle assemblers and auto-parts manufacturers to the country. Nevertheless, the Thai government enacted several measures to support local manufacturers. For example, in 1978, the government limited the number of models and series of vehicles to enable auto-parts firms and vehicle manufacturers to attain economies of scale. Another crucial factors in encouraging the industry's growth were protectionist policies such as local content requirements (LCRs) and high import tariff rates.

Local content requirements and high tariff rates helped develop the Thai automotive industry mainly in two ways. First, the policies led to the widespread use of subcontracting, which benefited the local auto-parts industry. Second, production and management know-how and technologies were transferred to local firms as a result of multinational firms' attempts to upgrade the quality of local suppliers and to conform to local content requirements (Busser, 1999; Yamashita, 2004).

The structure of the auto-parts suppliers in the industry was also affected by government policies. The improvement in the quality of labor and production resulting from technology transfer played an important part in expanding the number of original equipment manufacturers (OEMs). According to Doner (1991), the number of OEMs in Thailand producing sophisticated auto-parts increased dramatically from less than 30 during the period 1962-1975 to 150 firms by the mid-1980s. It is assumed that the surge in the number of OEMs was brought about by the advances in OEMs' technological capabilities and the expansion in the demand for OEM parts more generally as the Thai automobile industry grew. Production, sales and exports trends for Thailand's automotive industry as well as the timing of important policy measures are shown in Appendix A.

Furthermore, Government policies not only influenced the structure of the auto-parts industry, but also the location choices of automobile assemblers and parts suppliers. The spatial concentration of the Thai automotive industry in Central and Eastern Thailand, for example, has been shaped by government initiatives such as the establishment of industrial estates and the Board of Investment (BOW s incentive systems. According to a study of 709 first-tier suppliers by the Thai Automotive Institute (TAI) (2002), first-tier suppliers are most heavily concentrated in Bangkok, which accounts for 33 percent of the total. SamutPrakan, ChonBuri and Rayong Provinces have the second, third, and fourth highest concentration of suppliers, accounting for 22 percent, 7 percent, and 6 percent, respectively. Although there are no reliable studies of second and lower-tier suppliers, TAI (2002) reckons that second and lower-tier suppliers were also largely concentrated in Bangkok and SamutPrakan Provinces. The location distribution of assembly plants and first-tier auto-parts suppliers is shown in Appendix B and C.

Reasons for this concentration in Central Thailand are the well-established infrastructures and incentives created by the government. These led the first wave of Japanese assemblers in the 1960s to establish their assembly plants in the first industrial estates in Bangkok and SamutPrakan. Attracted by the positive externalities of locating near their customers and other component firms, auto-parts firms followed suit in establishing their plants in Central Thailand to gain access to a larger market and to minimize transportation and communication costs.

The second influx of parts makers into Thailand followed in the latter half of the 1980s as a result of the appreciation of the yen and expectations of further growth in demand (Maruhashi, 1995; Lecler, 2002). In the 1990s, however, assemblers mainly invested in Eastern Thailand. For example, Toyota and Isuzu established new factories in Chachoengsao Province while Mitsubishi set up in ChonBuri Province, Eastern Thailand, to capture a share of the expected growth in domestic demand and respond to the anticipated arrival of Ford, General Motors (GM) and BMW. Moreover, Western assemblers, entering at the end of the 1990s, also established factories in Rayong Province, Eastern Thailand. These assemblers were subsequently followed by parts manufacturers, both Japanese and non-Japanese, that also set up in Eastern Thailand.

These developments mean that a new center of auto production has emerged in Eastern Thailand – a fact that may be partly explained by government incentives aimed at narrowing regional income gaps. Using surveys, Lecler (2002) found that the geographical change was mainly the result of the negative effects of overinvestment in the Bangkok area and its vicinity, such as traffic congestion, high labor costs and land scarcity. The expansion to Eastern Thailand helps investors avoid the high costs that would otherwise be incurred if they established a new network in Bangkok. It also provides them with several advantages, such as the proximity to port or highway facilities, relatively close vicinity to their head offices in the Bangkok area, cheaper wages and land rents than in the Bangkok area, and substantial incentives from the BOI (www.boi.go.th).

Background of the Ford Company

In 1960 Ford Thailand was first established in Thailand. At that time, the Thai Motor Industry Company was formed as a joint venture between Anglo-Thai Motors and Ford U.K. and this company rapidly began assembly operations. Later in 1973 the joint venture was incorporated as a wholly owned subsidiary, Ford Thailand. However, the company decided to cease operations in 1976. With typical determination, Ford re-entered the Thai market in 1995 with the formation of the Auto Alliance Co., Ltd. located in Rayong province.

Ford Company adopted Just-in-Time manufacturing in an attempt to reshape its manufacturing environment. JIT requires that a company have a few reliable suppliers and is believed to enhance productivity and build a leaner manufacturing system which minimizes inventories (Helo,2004) which, in turn, reduces risk and helps minimize the cost of manufacturing (Curry and Kenney, 1999; Rahman, 2004). Ford, which manufactures a sport utility and pick-up truck, typically require first tier (major component) suppliers to locate their facility within a two hours drive of the Ford manufacturing facility. Accordingly, first tier suppliers which assemble made-to-stock components into made-to-order JIT components frequently establish assembly facilities within a few minutes drive in order to reduce the impact of component availability problems.

The local part manufacturers supply approximately 80 percent of all the parts used for the Ford assembly of pick-up trucks, and approximately 55 percent for the sport utility vehicles. In recent years, the number of parts manufacturers for non-Japanese assemblers has increased considerably as a result of Auto Alliance (Ford), and General Motors establishment in the Thai automotive industry. Thailand locally produced or assembled parts include engines, suspension control and springs, axles, hubs, propeller shafts, brakes, clutches, steering systems, body parts, electronic parts, air conditioning, tires, wheels, internal and external trim components, and glass.

Currently, Ford has more than 1,000 Thailand suppliers. The major auto components come from 160 Thai suppliers including Engine&P/T, Electrical, Exterior, Exterior/Plastic, Stamping, A/C system, Chassis, Rubber Part, Interior, and Fastener and most of them are in different locations, as shown in Table 1.1. Based on 160 auto components for the Ford Company, Engine&P/T constitutes the biggest volume component to the Ford Company. Also supplied are Chassis, Stamping, Exterior, Rubber Part, Interior, Electrical, Exterior/plastic, A/C system, and Fastener. The ranking of these components is shown in Figure 1.1:

Figure 1.1: Auto Components of Ford Company

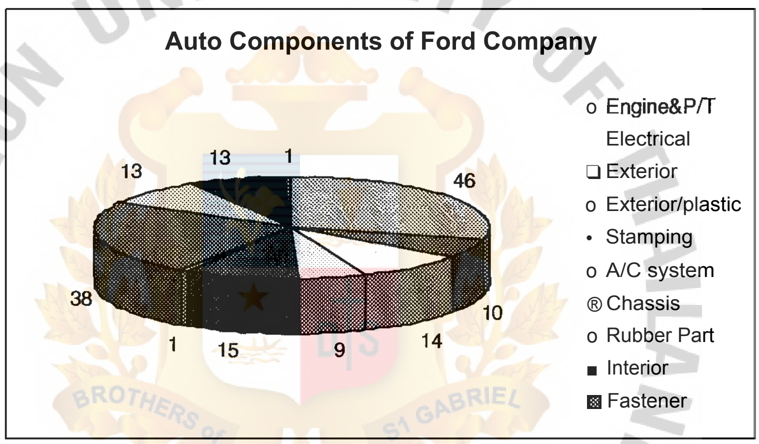


Table 1.2 shows the top ten annual sales in 2006 of automotive suppliers. Dana Spicer (Thailand) is shown as the biggest auto component supplier in Thailand. The annual sales to Ford are approximately 2,765 million Baht.

Table 1.2: Top Ten Annual Sales in 2006 of Automotive Suppliers to Ford Company

No.	Supplier Name	**Location of Supplier**	**Auto Component**	**Total**
1	MAZDA MOTOR CORPORATION	Japan	Engine/PT	8,287,675,005.11
2	FORD MOTOR COMPANY PHILLIPPINE	Phillippine		2,949,735,050.64
3	DANA SPICER (THAILAND)	Rayong	Chasis	2,765,564,304.93
4	BOSCH AUTOMOTIVE (THAILAND)	Rayong	Chasis	1,778,913,902.41
5	HALLA CLIMATE CONTROL (THAILAND)	Rayong	A/C system	1,595,902,950.59
6	THAI SUMMIT PKK	Chonburi	Stamping	1,298,600,745.90
8	GENERAL SEATING (THAILAND)	Rayong	Interior	1,027,868,992.12
9	VISTEON (THAILAND)	Rayong	Interior	967,968,611.13
10	THAI SUMMIT EASTERN SEABOARD	Samutprakarn	Stamping	751,727,699.54

However, the production capacity of Toyota company tends to be higher in the past 5 years (see Figure 1.2). It is possible that Toyota company will have more demand for auto components. In this study, in order to achieve higher demand, market share, sales volume, and other opportunities, the researcher will mainly focus on Dana Spicer to evaluate a new opportunity location

Figure 1.2: Car Assemblers in Thailand, ranked by Production Capacity in 2005

	Toyota otor Thailand Co. Ltd	350.800	27.62
2	Isuzu Operations (Thailand) Co..Ltd.	200,000	15.75
	Mitsubishi Motors (Thailand) Co.,Ltd.	170,200	13.40
4	Auto Alliance (Thailand) Co.,Ltd.	135,000	10.63
	Honda Automobile (Thailand) Co td.	120.800	9.45
	General Motors (Thailand) Co.,Ltd.	115,000	9.05
	Siam Nissan Automobile Co.,Ltd.	102.000	8.83
8	H no Motors Dale (Thailand) Ltd.	28,800	
9	Thonburi Automotive. Assembly Co.,Ltd.	16,300	1.28
10	Y.M.C Assembly Co.,Ltd.	12,000	0.94
11	BMW Manufacturing (Thailand) Co.,Ltd.	1	0.79
12	Thai Swedish Assembly Co.,Ltd.	10.000	8.79
13	Bangchan General Assembly Co.,Ltd.	0	0.00
	Total	1,270,100	100110

Source : Office of industrial Economics, Ministry of Industry_
Remark : excluding Motorcycles

1.2 Statement of the Problem

Making a location decision for the production of products is a key aspect of strategic and logistical decision-making for manufacturing firms. The optimum location may offer competitive advantage and may contribute to the success of the efficiency of supply chain management. Presently, most of the car manufacturers adopt the Just in Time concept to the success of the supply chain. Following the JIT concept, the statement of problem can be divided into three steps for location decision of the automotive supplier:

1. How can automotive suppliers sharply deliver the required components to the manufacturer within the production timeframe? Since the core of the JIT concept emphasizes the reduction of inventory cost, the way to solve this problem is to locate the automotive supplier plant near the car manufacturer. Furthermore, not only will the delivery time be reduced but also the transportation cost will be minimized.
2. Besides the transportation factor, how can the economy of scale and the opportunity cost of achieving the economy of scale be taken into account when making the location decision?
3. When there are competing factors, how can a balance be achieved among all the factors that can influence the new facility location?

1.3 Objectives of the Study

According to stated problem of the study, the researcher maps two major factors: the transportation cost and the cost of sacrificing scale economy, which are influences to evaluate the potential location for the automotive supplier. To accomplish the primary objective, the specific sub-objectives of the study are as follows:

1 To examine how the transportation cost relates to the decision to locate the automotive supplier plant.

2 To examine the cost of sacrificing scale economy: this refers to the cost of components remaining in the warehouse due to no demand from another car manufacturer.

3 To evaluate the transportation cost and the gap of cost of sacrificing scale economy when decision-making to locate or relocate the automotive supplier plant.

4 To recommend the potential location for an automotive supplier.

1.4 Scope of the Study

The scope of the study will focus on Dana Spicer which represents the biggest automotive supplier of Ford company. Figure 1.2 shows that Toyota has the largest production capacity in Thailand, as well as having trends towards expanding the business in both domestic and export markets. It is possible that Toyota will have more orders for the automotive suppliers in the near future. In order to achieve an economy of scale and lower transportation cost, the researcher is considering developing the theoretical framework of the research of Tomoo Marukawa (2006) for the evaluation of whichever location is the best for Dana Spicer. This study will concentrate on a location between Ford and Toyota companies. Ford is located at Rayong province and Toyota is located at Samutprakarn province (see Appendix **B).** Additionally, in order to give the reader a better view or a more comprehensive understanding, some figures or numbers are simulated in the location analysis.

1.5 Limitations of the Study

Due to the time limitation, the limitations were identified and recognized while conducting the study, as follows:

1. To seek the proper location of an automotive supplier, the study will mainly focus on Dana Spicer.
2. The primary focus of the study is on Ford and Toyota companies.

3. Dana Spicer mainly supplies axle components to Ford company. The axle components are grouped as chassis components (see Table 1.1).
4. Dana Spicer does not only supply axle components but also supplies some auto components to other automotive companies.
5. The demand from car manufacturers and transportation rates have been assumed to be responsible for a structured analysis.
6. This study will develop the research of Tomoo Marukawa (2006) for evaluating the proper location, wherever it is the best. Some factors will not be identified in making a location decision, such as cost of land, taxes, insurance, equipment, building, labor, production, utilities, etc..

1.6 Significance of the Study

Understanding suppliers is a part of integrated supply chain management. Most firms identify new suppliers who have the potential for excellent performance and then approach these suppliers with the objective of securing cost and developing closer relationships. In the supplier's perspective, to enable an effective and efficient supply chain, establishing or relocating the plant near to the customer's plant will obviously concentrate many aspects, in terms of total cost of the supply chain, transportation cost, government incentive, economics of scale, access to markets, and other related factors. This study will show how the transportation cost and the cost of sacrificing scale economy are important factors in deciding the proper location for an automotive supplier. Not only will the study show the data analysis for both factors, but also the study will present the results through as a recommended alternative to the automotive supplier.

1.7 Definition of Terms

Toyota Production System (TPS) is the philosophy which organizes manufacturing and logistics at Toyota. It includes the interaction with suppliers and customers. And it is built on two main principles: "Just-in-Time" production and “Jidoka”.

Just-In-Time (JIT) is an inventory strategy implemented to improve the return on investment of a business **by reducing in-process** inventory and its associated costs.

Jidoka is providing **machines and operators with** the ability to detect when an abnormal condition has occurred **and immediately stop work.** This enables operations to build-in quality at each process and **to separate men and machines** for more efficient work. Jidoka is sometimes called autonomation, **meaning "automation** with human intelligence".

Scale Economy characterizes **a production process** in which an increase in the scale of the firm causes a decrease in the long-run **average cost** of each unit.

Cost of sacrificing scale economy is the cost of **components** remaining in the warehouse due to no more demand from the car manufacturer.

Supply Chain is a network that describes the flow of materials from suppliers through facilities that transform them into useful products and, finally, to distribution centers that deliver those products to customers.

Supply Chain Management (SCM) is an integrated approach to procuring, producing, and delivering products and services to customers; it includes the management of materials, as well as associated information and the flow of funds.

Logistics is the discipline of managing the flow of materials and transportation activities to ensure adequate customer service at reasonable cost.

Location decisions are of great significance to a firm since they represent the basic strategy for accessing customer markets, and will have a considerable impact on revenue, cost, and level of service. These decisions should be determined by an optimization routine that considers production costs, taxes, duties and duty drawback, tariffs, local content, distribution costs, production limitations, etc..

CHAPTER II
LITERATURE REVIEW

The selected literature is reviewed in this chapter. First, the Auto Industry in Thailand is discussed. Transportation is explained as an aspect of logistics management. Then, key location factors are addressed using various researchers. Finally, the criteria of supplier selection are addressed for the study.

2.1 TheAuto Industry in Thailand

Industry Overview

- Auto Production: Annual global auto production, as published in June 2002, was broken down by region to 16.46 million units in Western Europe, 15.66 million units in North America and 16.02 million units in Asia and Oceania. In other words, Asia and Oceania accounted for approximately 30% of the global output (See Appendix **D).** This means that approximately three out of ten customers of auto parts manufacturers who sell to automakers are located in Asia and Oceania. Out of 16.02 million units produced in the region, Japan turned out some 10 million, followed by 2.3 million by China and 1.14 million by ASEAN-4, among which Thailand contributed a little less than 500 thousand units. In the analysis of time series data over the past five years between 1997 and 2001, Thailand has now recovered an annual output level of half a million units which it achieved prior to the Asian currency crisis, and is expected to turn out one million units a year by 2006. The positioning of Thailand in a supply chain is shown in Appendix E.

- Expansion by Japanese Companies: Industrial agglomeration in the Thai auto industry has largely been attributable to investment accumulation by Japanese companies. Expansion activities in automotive-related areas by Japanese companies including Toyota Motor Co. and Nissan Motor Co. started in the early 1960s, and many companies have since followed during the subsequent forty-odd years in response to the promotional and protective policies of the Thai government (see Appendix F). The number of Japanese auto-related companies expanding into Thailand peaked twice, in the late 1980s and mid

1990s, bringing the total number of manufacturing bases of Japanese auto parts companies in the country to the largest among Asian nations outside Japan. In terms of product types, engine components (including gaskets) and electrical parts (including condensers) comprised the majority up to the late 1980s, whereas high-precision plastic components and molds took over in the mid 1990s. Against the backdrop of the need to increase local content and expand incentive policies to promote investment by small enterprises, there are future plans for Japanese manufacturers of high quality, sophisticated products (including turbochargers and cylinder heads) to expand into Thailand, which should help further broaden the supplier base supporting the auto industry there.

- Recent Change: One of the most notable changes that have been taking place in the auto manufacturing industry in Thailand is its export growth (see Appendix G). Since the Asian currency crisis in 1997, shrinkage of the domestic market and improved export competitiveness due to the depreciation of the Thai baht, combined with the desire to maintain a high capacity utilization rate on the part of auto manufacturers, have made Thailand play an increasing role as an export base to the rest of the world as well as serving its domestic market. Close to 40% of the current auto production of Thailand is exported, and companies are expanding production in a recent move to consolidate capacity, both in Asia and for one-ton pickups worldwide. Thailand is also becoming an export center for auto component manufacturers. Thai auto parts exports have more than tripled in value over the past five years, as seen in Appendix **H** which breaks down their component exports by destination. It also shows that more than half of the exports are for industrialized countries including Europe and the U.S. Exported items include sophisticated, high value-added products such as engines and OE components. These facts indicate that Thailand is playing the role of an export center for sophisticated, high value-added components for specific models to be assembled in developed countries.

- Expansion by Western Auto Manufacturers: In recent years, Western auto companies have been actively expanding into Thailand. They plan to further boost their capacity in the country in order to respond to expected demand increase in the ASEAN region as a result of AFTA coming into effect, as well as to increase their market shares which have long remained at low levels. This move has been causing intensification of competition with their Japanese counterparts, who had entered the market earlier. The recent activities of Western automakers represent their belated strategic development in East Asia, whose geographical distance historically kept them away. Many of them chose to build a production base in Thailand because: 1) after the introduction of AFTA, they intended to consolidate production to Thailand and make it the base for exporting to other ASEAN countries; 2) expansion of many component manufacturers had already resulted in certain levels of industry agglomeration; and 3) Thailand is one of the largest markets for one-ton pickup trucks[16] in the world, which makes the country an ideal manufacturing location for domestic and export markets. Appendix I summarizes the production/ marketing plans of auto manufacturers in Thailand in 2002 or later. It indicates that exports of finished cars and principal components from the country are intended for European countries, Japan and ASEAN and Oceania nations. Appendix J summarizes the time frame of the Establishment of Thailand as an Export Base. And, Appendix K summarizes unit production of Western auto manufacturers in Thailand.

- Expansion by Western Auto Parts Manufacturers: In tandem with Western automakers' expansion of their Asian bases, leading Western auto parts manufacturers have entered Thailand and have been expanding their local operations (see Appendix L). The objectives of Western auto parts manufacturers' expansion into Thailand are: 1) to coordinate with Western automakers' expansion; and 2) to increase business with Japanese auto makers. The former objective has become especially active since the 1998 establishment of Auto Alliance Thailand, a joint venture between Ford and Mazda. For the latter objective, Western parts suppliers aim to gain shares in an untapped market serving Japanese auto companies. Since Japanese auto manufacturers have already established high shares in markets around Asia, a Thai location will be very convenient to supply them and hence expand market share in an efficient manner. Against this background, we need to focus on market share expansion by Western auto parts manufacturers.

Furthermore, Western auto parts companies have the following two advantages over their Japanese counterparts. 1) Western companies enjoy a high degree of management freedom, owning a majority stake in local subsidiaries and controlling them from day one, as they entered the Thai market after the easing of restrictions on foreign ownership (see Appendix M). On the other hand, some Japanese affiliates, which are structured in accordance with the old joint venture rule, still face difficulty in winning control of their local operations. 2) Western companies were able to envision deregulation, including the easing of local content requirements and tariff reductions, as a result of AFTA coming into effect. This, in turn, has enabled them to concentrate their ASEAN investment in Thailand from the outset, positioning it as the export base in the region and achieving higher investment efficiency. Japanese companies, in contrast, need to strategically review their bases scattered around the region.

- Market shares of Western Auto Manufacturers: Now, let us turn to the business environment of the Thai auto industry, which those Western suppliers aim to serve. Component manufacturers in Thailand are more susceptible to influences from industry reorganization. This can be explained by looking at the breakdown of Thai auto production between Western and Japanese auto makers. Appendix N shows manufacturer shares of Thai auto production. Apparently, the combined market share of the Western manufacturers, GM and Ford, only stands at around 20%, or 100,000 units. When it comes to purchasing policies, some other automakers such as Isuzu, Mazda and Mitsubishi are under the influence of their Western partners, who have equity participation in them. Therefore, even though Japanese manufacturers have seemingly high market shares, it can be said that practically 70% of Thai Auto production is under the control or influence of Western automakers as far as their procurement policy is concerned. When Western automakers decide to launch their cars in the region, the Thai factories of Isuzu, Mazda and Mitsubishi are expected to operate as manufacturing centers for supplying the cars. Against this backdrop, Japanese auto parts manufacturers may lose orders to their Western competitors, who are well versed in the procurement policy of Western auto makers. Some Japanese parts manufacturers stated their concerns, saying, "There is no problem to speak of now, but we feel uneasy about what is going to happen at the next model change." At the time of a model change, there is no guarantee that auto companies will continue to buy from the same supplier based on the record of previous component deliveries. In other words, Western parts companies have in front of them a better opportunity to increase their market shares (Takeshi, Toshiko, Yohei, Youichiro, Kaoru, 2002).

2.2 Logistics Management

The definition of logistics from CLM (now the Council of Supply Chain Management Professionals – CSCMP), in 2003 is: "that part of supply chain management that plans, implements and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements" (www.cscmp.org). Moreover, logistics is a collection of functional activities (transportation, inventory control, etc.), which are repeated many times throughout the channel through which raw materials are converted into finished products and consumer value is added (Ballou, 2004). Logistics management can be viewed as the detailed process of planning, implementing and controlling the efficient, cost-effective flow and storage of materials and products, and related information within a supply chain to satisfy demand (Christopher, 1993).

Logistics processes form the critical loops of supply chains and oversee the flows of materials, information and cash, which are the essential elements of fulfilling customers' orders. As greater distances, currencies and cultures separate markets, suppliers and manufacturers, logistics plays a more critical role in the success of the supply chains. As a result, total logistics cost has become one of the most important economic indicators of supply chain efficiency. Gilmore (2002) explicitly points out that there is a growing recognition of the role that transportation and logistics excellence plays in achieving a world-class supply chain and that transportation costs represent a substantial component of overall supply chain and corporate spend for many companies. The costs associated with logistics activities normally consist of the following components: transportation, warehousing, order processing/customer service, administration, and inventory holding (Lambert et al., 1998, Saccomano, 1999). Not surprisingly, total logistics costs often represent a large portion of total supply chain costs, especially when the supply chain is extended to the global market. The total cost model by Lambert 1998 and Aronsson 2003, presents six major logistics cost categories that are driven by a number of key logistics activities required to facilitate the flow of a product from the point of consumption. The total cost of logistics includes place/customer service levels, order and information costs, lot quantity costs, transportation costs, warehousing costs, and inventory carrying costs.

2.3 Transportation

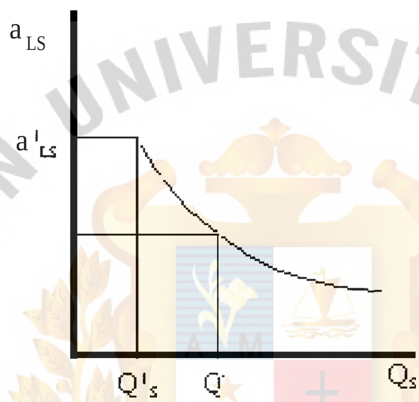
Transportation is one of the most important factors in a logistics system. Transportation costs will occur from delivery. It also creates time utility since it determines how fast and how consistently products can move from one point to another (Lambert and Stock, 2001). The transportation costs will also vary considerably with the modes of transportation chosen including air, truck, rail, water, and pipe. Also, rates are based primarily on three factors: distance, shipment size, and competition.

Distance represents the distance between districts in which the assembly plant and the supplier are located. Distance is measured in kilometers based on information from the Department of Highways, Thailand. In the case of Ford and Mazda, whose assembly plants are located in Rayong Province, and some suppliers whose plants are located in more than one district, the distance will be calculated.

2.4 The Economics of Scale

Economics of scale in production means that production at a larger scale (more output) can be achieved at a lower cost (i.e. with economies or savings). A simple way to formalize this is to assume that the unit-labor requirement in production of goods is a function of the level of output produced In Figure 2.1, we present a graph of the unit-labor requirement in steel production as a function of the scale (level of output) of production. At production level Q^1_s, the unit-labor requirement is given by a_{LS}. If production were to rise to Q_s, then the unit-labor requirement would fall to a_{LS}. This means that at the higher level of output, it requires less labor (i.e. fewer resources or cost) per unit of output than it required at the smaller scale.

Figure 2.1: The Relationship between Production and Labor



Another way to characterize economies of scale is with a decreasing average cost curve. Average costs, AC, are calculated as the total costs to produce output Q, TC(Q), divided by total output. Thus AC(Q) = TC(Q)/Q. When average costs decline as output increases it means that it becomes cheaper to produce the average unit as the scale of production rises, hence economies of scale.

Economies of scale are most likely to be found in industries with large fixed costs in production. Fixed costs are those costs that must be incurred even if production were to drop to zero. For example fixed costs arise when large amounts of capital equipment must be put into place even if only one unit is to be produced and if the costs of this equipment must still be paid even with zero output. In this case the larger the output, the more the costs of this equipment can be spread out among more units of the good. Large fixed costs and hence economies of scale are prevalent in highly capital intensive industries such as chemicals, petroleum, steel, automobiles etc. (Steve Suranovic, 2006).

Wider markets can result in lower production costs. With the greater volume provided in these markets, more intense utilization can be made of production facilities and specialization of labor usually follows. In addition, inexpensive transportation also permits decoupling of market and production sites. This provides a degree of freedom in selecting production sites so that production can be located where there is geographic advantage.

As an observation, auto parts manufactured in such places as Taiwan, Indonesia, South Korea, and Mexico are used in assembly operations in United States and are sold in the U.S. marketplace. Low labor costs and high-quality production are the attractions to manufacturers in these foreign locations. However, without inexpensive and reliable transportation, the cost of placing parts throughout the U.S. would be too high to compete with domestic production (Ballou, 2004).

If a reduced number of suppliers receive larger purchase volume contracts, economies of scale should result in lower production costs. Supply base optimization provides the opportunity to achieve lower product costs by awarding larger volumes to fewer suppliers (Robert, 2005).

However, uncertainties in supply, process and demand are recognized to have a major impact on the manufacturing function (Wilding, 1998). We agree with Davis (1993), who believes that the real problem in managing and controlling complex networks is "the uncertainty that plagues them". Uncertainty propagates throughout the network and leads to inefficient processing and non-value adding activities. This uncertainty is expressed in questions such as: What will my customers order, how many products should we have in stock, and will the supplier deliver the requested goods on time and according to the demanded specification? 'The more uncertainty related to a process, the more waste there will be in the process" (Persson, 1995). The presence of uncertainty stimulates the decision maker to create safety stock buffers in time, capacity or inventory to prevent a bad chain performance. These buffers will restrict operational performance and suspend competitive advantage (Jack and Adrie, 2002).

2.5 Facility Location Decision

Locating a facility is an importance decision affecting the cost of managing the supply chain. A supply chain is a network of facilities, and the location of production facilities, warehouses, distribution centers, and suppliers determines the efficient flow of goods to and from these facilities (Joel and Keah-Choon, 2005). Supply chain management entails not only the movement of goods but also decisions about (1) where to produce, what to produce, and how much to produce at each site; (2) what quantity of goods to hold in inventory at each stage of the process; (3) how to share information among parties in the process; and finally, (4) where to locate plants and distribution centers (Sandra and Teres, 2006).

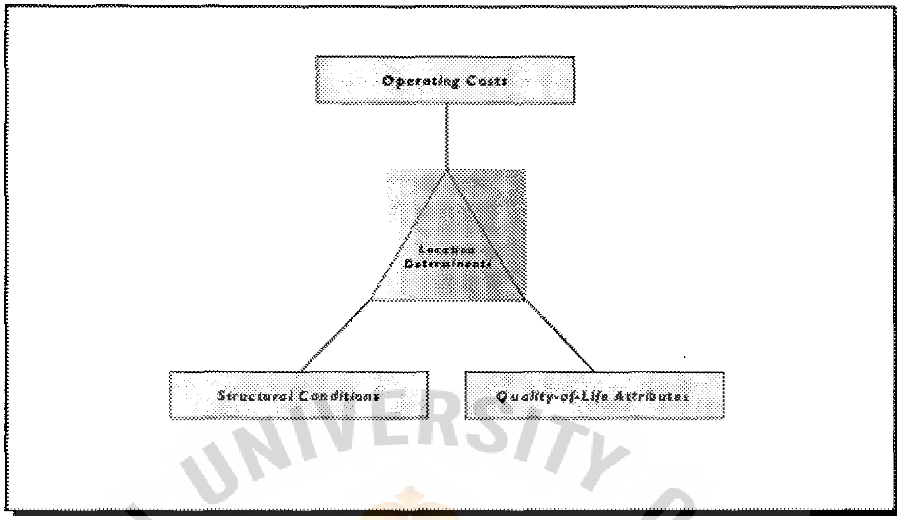
Making location decisions for the production of products is a key aspect of strategic and logistical decision-making for manufacturing firms. The optimum locations may offer competitive advantage and may contribute to the success of an enterprise. The number of firms considering location on a worldwide basis continues to increase. A very wide range of factors may potentially influence firms in deciding to locate production facilities across national boundaries. Location factors can be considered and classified in a variety of ways. Table 2.1 summarizes the major criteria and sub-factors affecting international location decisions (Flaherty, 1996).

Location factors that have been widely used in industrial location research generally can be grouped into the following categories: Market, Transportation, Labour, Site considerations, Raw materials and services, Utilities, Governmental regulations, and Community environment (Levine, 1991), as shown in Table 2.2. Facility location has a long-term impact on the supply chain and must be an integral part of the firm's supply chain strategy. Firms might choose to locate a plant near customers not only to reduce distribution cost, but also to create cultural ties between the firm and the local community Thus, facility location in the network can be considered the most important logistics and supply chain strategic planning for most firms. It sets the conditions for the proper selection and good management of transport services and inventory (Amitabh and James, 2005).

According to Matthew, Paull, and David (1999), business location is a game of strategy with the two major players being firms and the governments of competing states or local communities. From the firm's perspective, the basic approach to site selection is matching the company's needs with community characteristics. Often, businesses start with a broad array of locations and systematically narrow the choices until the location with the most advantages and fewest disadvantages emerges. Firms use a myriad of criteria to evaluate potential locations. These factors are divided into three main categories: operation costs, structural conditions, and quality-of-life attributes. Operating costs include such items as labor cost, utility cost, transportation cost, and tax cost. Structural conditions include access to markets (both final product and input markets), labor force, quality, and the overall business climate. Quality-of-life characteristics may include cultural activities, sporting opportunities, and environmental quality.

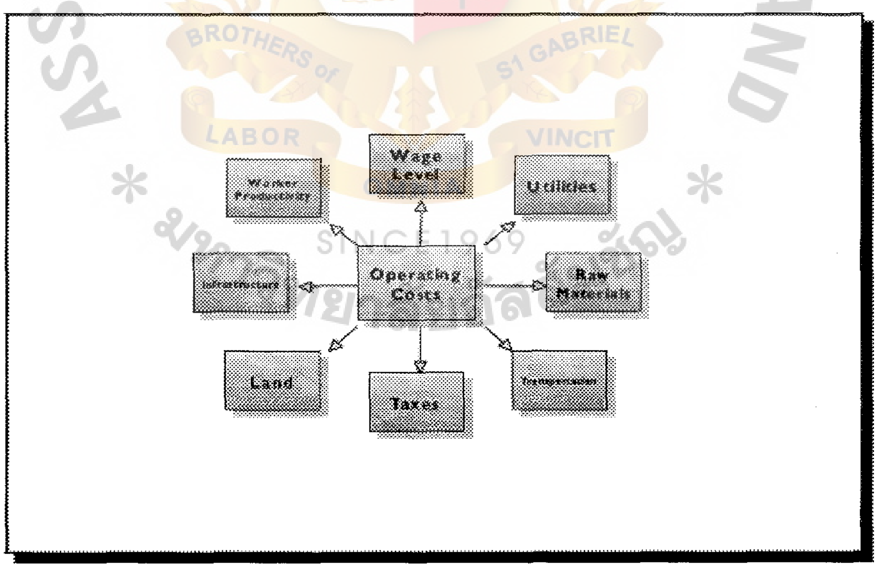
State and local governments, in their competition for capital investment and jobs, face the challenge of enhancing the attractiveness of their region to businesses. They actively compete for firms and capital investment by setting tax policies, choosing public service levels, structuring regulations, and promoting an overall pro-business attitude. In addition, they may offer special incentive packages consisting of wage and training subsidies, land grants, special financing arrangements, and tax concessions, just to name a few (see Figure 2.2).

Figure 2.2: Categories of Location Determinants



Operating Costs: Cost factors have traditionally been the cornerstone of location theory (see Figure 2.3).

Figure 2.3: Operating Cost Significance in Site Selection



The costs for other inputs, such as labor and land, may still differ significantly across locations and can influence location decisions. Firms are ultimately concerned with their cost per unit of output produced, so productivity of inputs will also be important in evaluating operating costs. Accordingly, wage levels may not be the primary criteria used in a firm's decision process. Instead, factors measuring worker productivity, such as educational attainment and worker training might play a more significant role. Firms in the automotive industry have historically been willing to pay higher wages for more skilled and productive workers, and invest in these same workers through on-the-job training. The same is also true of other inputs. Being the nominal low-cost leader in land prices and wage rates does not automatically give a region a competitive advantage.

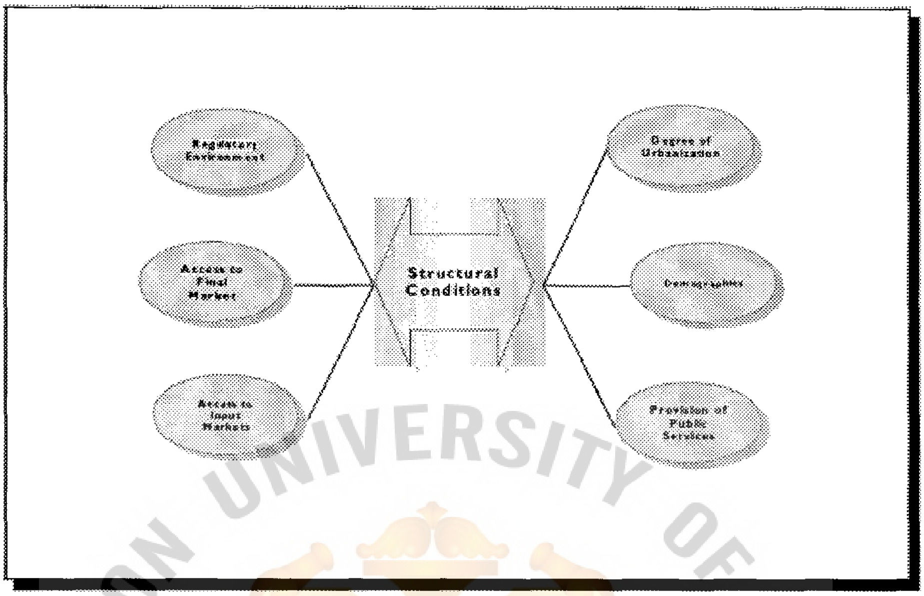
Taxes represent another set of costs that can influence business location, but as with wage rates, firms may be more concerned about the public service benefits received in exchange for payment of taxes. Conventional wisdom is that high taxes can be expected to make a state less attractive. However, research on the role of taxes has not been as clear cut. Generally, it is agreed that taxes influence the site choice, but the effect is small relative to other location determinants.

Notably, taxes play a larger role in intra-regional, relative to inter-regional, location decisions due to small or non-existent differentials in other costs within a region. Regardless, states continue to overestimate the extent to which taxes influence industry location, often resulting in ad-hoc tax reforms and specific tax incentives aimed at improving the business climate of the state. However, a state that systematically alters its tax system in efforts to enhance its competitiveness could ultimately discourage business location due to heightened concerns about the state's overall fiscal stability and health. Moreover, some of the policy changes directed at new firms may simply hurt existing industry. In general, firms do not focus on specific taxes when making location decisions but instead prefer a stable business tax system that efficiently funds the services demanded by businesses and residents of the state. It is important to note that businesses are also sensitive to issues of tax fairness in addition to efficiency. A tax structure that is perceived to place a disproportionate burden on businesses may negatively impact location decisions.

The other side of the fiscal coin is provision of public services, such as education, infrastructure, and public safety, which have also been shown to be a significant factor in influencing firm location decisions. Because public services can serve as inputs in a firm's production process, they can lower the cost of producing final goods and services. For example, good higher education services can result in more skilled employees, better highways reduce transportation costs, and higher police expenditures may result in lower crime rates that can reduce the cost of a firm's insurance. The level and quality of these and other services provides a measure of the benefits a company receives in return for its tax payments by determining the magnitude of cost savings to the company. These public expenditures can also influence business locations by improving the overall quality-of-life available in a community. Remember, plant executives and plant mangers, as well as workers themselves, prefer quality, livable communities.

Structural Conditions: Structural conditions of the state encompass many elements important in location decisions; including access to markets, regulatory environment, provision of public services, degree of urbanization, and demographic makeup of the population (see Figure 2.4). Market access (input and final product) continues to be a prominent location determinant. The degree to which a firm values final market access will depend upon its output. For example, the final goods market for automotive assemblers includes national and international markets. Therefore, while still important, access to final markets is most likely not the top factor influencing location. However, for automotive parts suppliers as opposed to assemblers it may well be a top priority due to the importance of JIT inventory practices. For some firms, proximity to input markets will play a more significant role in site selection. For example, a firm requiring a specific natural resource found only in a specific region could be expected to place a higher value on locating close to the source of that input.

Figure 2.4: Structural Condition Important to Location Decision

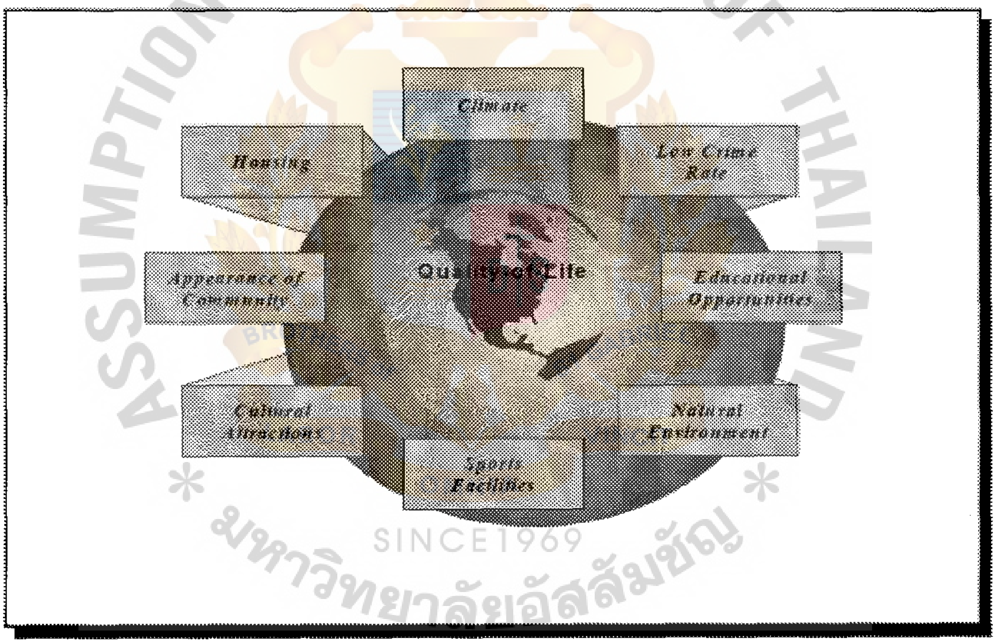


A state's regulatory environment is important to businesses. The effect of many state regulations is to raise the costs of production and/or diminish input productivity by internalizing negative spillover effects (e.g., cost of polluting a river), constraining technological choice, and requiring outputs (e.g., periodic reports and consumer information) that producers would not otherwise provide. Regulations receiving the most attention with regards to industrial location are workforce related regulations and environmental regulations.

The state regulations pertaining to the labor force that have been considered most widely are right-to-work laws and worker compensation rules. Right-to-work laws have consistently been shown to be very important in location decisions. The significance of such laws can be attributed to their effect on minimizing unionization, retarding wage levels, and promoting a pro-business attitude on the behalf of policymakers. Tennessee's status as a right-to-work state has played to its advantage in recruiting and retaining industry.

Quality-of-Life: More and more, developers are hearing that quality-of-life attributes are important in a firm's location decision. Livability was ranked as the fifth most important factor in influencing a firm's location. The importance of quality-of-life factors is two-fold: (i) managers and executives want to enjoy time spent with their families in a safe, enjoyable community and (ii) increased quality-of-life leads to happier workers and increased labor productivity. As shown in Figure 2.5, some attributes influencing firm location are beyond the control of state policymakers such as climate (e.g., average rainfall or average temperature) and natural environment. However, attributes significant in the location decision that can be influenced by public policy include a low crime rate, amenities such as sports facilities and cultural attractions, educational opportunities, and the overall appealing appearance of the community.

Figure 2.5: Quality of Life Attributes Important in Location Decisions



Tomoo Marukawa, Automobile Industry Clusters in China, 2006,

Spatial concentration of an industry will emerge as a result of the combination of large economies of scale and low transportation costs (Krugman, 1991). However, high transportation cost, resulting from frequent delivery, together with the car maker's requirement for exact delivery, provides a strong reason for a supplier to locate its plant in the vicinity of its main customer.

But, as there is scale economy in most kinds of automobile component production, locating the plant near to the customer's plant may sacrifice economies of scale, especially when the customer's demand for the component is small. Hence, suppliers face a trade-off between enjoying scale economy at the price of higher transportation cost, and economizing on transportation cost at the sacrifice of scale economy. The situation is illustrated in Figure 2.6.

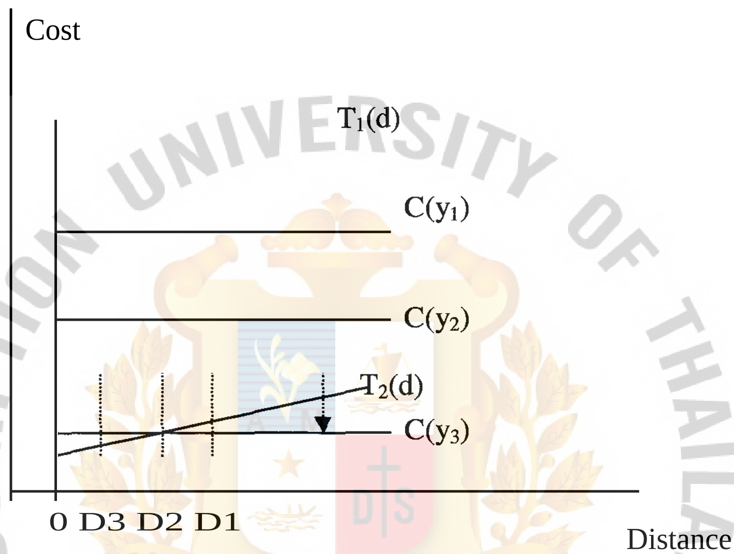


Figure 2.6: Determining Transportation Cost and Cost of Sacrificing Scale Economy

Suppose that there is a component supplier considering supplying a car plant located far away from the supplier's existing plant. I will hereafter name the car plant and its location "0". The supplier must make a decision whether to supply 0 from its existing plant, or to establish a new plant at 0. The supplier's decision will rely on the comparison between transportation costs and the cost penalty of sacrificing scale economy. The cost of sacrificing scale economy is the cost of components remaining in un-supply due to no more demand from the car manufacturer.

The transportation cost for bulky components such as seats is high, and rises sharply as the distance of transportation increases. That case is depicted by the transportation cost curve, $T_1(d)$. On the other hand, the transportation costs of small components like car audio equipment and electronic engine control units are low and they will not rise so much even if the transportation distance gets longer $T_2(d)$. The cost of sacrificing scale economy depends on the amount of orders which the new plant can expect from 0, denoted by y. If the orders are few the cost is large $C(y_1)$, but if the orders are many the cost is small $C(y_3)$. The cost penalty also depends on the types of component production. For those that require large fixed costs, such as engine control units, the cost penalty is large, but for those labor intensive components that require little fixed costs, such as seats, the cost penalty is small

When the size of demand from 0 is as small as y_1, resulting in high cost penalty, $C(y_1)$, the light components will not be produced locally (location 0), and the bulky components will not be produced locally (location 0) if the existing plant of the supplier is located within the distance of D_1 from 0. When the supplier's existing plant is farther than D1 from 0, however, the supplier of bulky equipment will establish a new plant at 0. As the size of demand increases, $C(y)$ will move downwards, inducing more and more components to be produced locally. When demand reaches y_3, bulky components will always be produced locally (location 0), and if there are no existing plants within D2, light components will also be produced locally (location 0).

Suppose now that the size of demand from 0 is y3 and both the bulky and light components are produced at 0. Then, what happens when a new car plant emerges at a place like D3, which is located between the supplier's initial plant and the supplier's new plant at 0? The supplier's decision whether to supply the new car plant from the initial plant, or supply it from 0, or erect a new plant at D3, will depend on the comparison between $T(D_0D_3)$, $C(y_3)+ T(OD_3)$, and $C(y')$, if we denote the location of the initial plant Do, and the size of demand from the new car plant y'. If we ignore the first choice, the choice depends on the comparison between $T(OD_3)$ and $C(y')-C(y_3)$, that is, the transportation cost from 0 and the gap of cost penalties depending on the sizes of demand at both locations. If the component's transportation cost is fairly small, or the difference of sizes between the two car plants is large, it becomes likely that the component will be supplied from the plant at 0.

Note that when the component plant at 0 begins supplying the new car plant at D3, it will enjoy more scale economy by having additional orders, pushing down its cost penalty curve from **C(y_3)** to **C(y_3+y').** This will, on the one hand, attract more component suppliers to establish plants at 0, as enlarged demand makes the production of more components at 0 economically viable, and on the other hand, enable the suppliers at 0 to supply the car plants located farther than D_3.

As the cost penalty of component production at **O** decreases, one may expect that the place can even attract new car plants because they can procure components there at low transportation cost. The calculations of transportation costs of components, however, seem to have little influence on the location decision of car plants. It is especially so in the case of large car manufacturers, because they think that the suppliers will locate plants to wherever they place new plants. But if some car manufacturers do place their plants where there is a large production of components, this will push the cost penalty curve further downwards, making the place more attractive for component suppliers.

In sum, the above discussion suggests that automobile production at a certain place will attract component production by the combination of high transportation cost and large scale economy, and component plants which enjoy scale economy can even supply automobile manufacturers in remote places.

2.6 Supplier Selection

Supplier selection strategy is the strategy adopted by the manufacturer, to evaluate and select suppliers, which fulfills the requirements of the manufacturer. To build more effective relationships with suppliers, organizations are using supplier selection criteria to strengthen the selection process. It is indicated that the supplier selection criteria is changing with the new challenge to select suppliers who can add long-term value to the manufacturer (Lemke., 2000).

Based on the empirical data collected from 170 purchasing managers and members of the National Association of Purchasing Management, Dickson (1966) identified quality, cost and delivery performance history as the three most important criteria in supplier selection. According to a review of 74 articles discussing supplier selection criteria, quality was perceived to be the most important, followed by delivery performance and cost (Weber and Current, 1991). The selection of suppliers is critical for several reasons. First, the trend toward "just-in-time" manufacturing practices has resulted in a supply base reduction (Pearson and Ellram, 1995). Second, due to resource scarcity, there is a need for greater interaction between the buyer and the supplier. Third, many firms involve their suppliers early in the planning process so that they are able to deliver superior value to their customers (Trent and Monczka, 1998). In order to release products quickly, supplier selection occurs at the front end of the program, long before the specifications are laid out.

Currently, many manufacturers are trying to operate in a just-in-time environment. When manufacturers reduce their raw materials inventory, they increase their reliance on receiving the "right parts at the right time in the right condition" from their suppliers. In addition, firms, whether or not they are operating in a JIT environment, have been encouraged to develop longer-term trust-based relationships with fewer suppliers (Ellram,1990). In a JIT environment, the development of closer, more collaborative supplier relations has been cited as critical in allowing manufacturers to " 'dare' to make (themselves) vulnerable by reducing 'just-incase' inventory" (Nelson and Jambekar, 1990). In fact, the degree of success of JIT implementation has been linked to JIT vendor strategies which include such aspects as sole sourcing and certification programs (Mehra and Inman 1992). Having less inventory and fewer suppliers increases the dependency of the manufacturer on its suppliers. As such, many manufacturing organizations feel that it is essential to evaluate and certify their suppliers to ensure that reductions in inventory and supplier base will not adversely effect their business (Inman, R.A.,1990). Within many sectors of manufacturing, the evaluation of suppliers has become a more common activity. In particular, the automotive manufacturers and large electronics manufacturers have been conducting either process-based evaluations (i.e. looking at the supplier organization's systems for costing, delivery, quality, management, and technology) or performance based evaluations (i.e. looking at the supplier's quality and delivery performance) (Millen, 1991). According to (Robert, 2005), Geographical location is another important factor in supplier selection, as it impacts delivery lead-time, transportation, and logistical costs. Some firms require their suppliers to be located within a certain distance from their facilities

Looking first the viewpoint of the assembler, two types of sourcing strategy can be distinguished. The first strategy is single sourcing, where assemblers procure the entire volume of a given part from a single supplier. Assemblers generally use this method if they have sufficient trust in a supplier to meet necessary quality standard. Such trust is usually built through long-term relationships. Apart from trust, another possible reason for relying on single sourcing is that a supplier possesses certain patents that make it the only possible source. A further possible reason for single sourcing is that the demand for a specific part is too small to split and economies of scale could otherwise not be attained. Single sourcing may have other advantages, such as volume discounts for large orders or cost savings in managing the supplier data base (Bross and Zhao, 2005).

At the same time, however, this sourcing strategy carries some disadvantages; for example, single sourcing provides suppliers with some monopolistic power (Nabeoka, 1996). The second strategy is multiple sourcing, where an assembler procures a given part from several suppliers. Multiple sourcing, introduced in Thailand in the 1980s (Maruhashi, 1995), provides several advantages. Competition between suppliers usually brings about quality improvements and price reductions. Furthermore, multiple sourcing makes assemblers more independent of individual suppliers and allows them to penalize suppliers that do not meet required quality standards or fail to deliver on time. Assemblers can, for example, penalize suppliers by shifting a fraction of their orders to other suppliers. This pressure will force suppliers to improve their performance to meet assemblers' requirements. In addition, parts supplies become more stable due to the availability of several supply sources. Lastly, multiple sourcing also provides an opportunity to test potential new suppliers with trial orders.

CHAPTER III
METHODOLOGY

There are several ways to choose a proper location for an automotive supplier. In this chapter, the researcher selected theoretical framework for use in this study: it explains the two major factors affecting a location decision: the transportation cost and the cost of sacrificing scale economy. Then, the conceptual framework is applied and developed according to the theoretical framework.

3.1 Theoretical Framework

Toyota is a successful leader in the automotive industry that obtains, applies and also develops logistics theory in order to produce world-class, quality automobiles at competitive price levels. Toyota introduced the Toyota Production System (TPS) built on two main principles, "Just-In-Time" production and "Jidoka", which has come to be well known and studied worldwide. This production control system has been established based on continuous improvement, with the objective of "making the vehicles ordered by customers in the quickest and most efficient way, in order to deliver the vehicles as quickly as possible. Underlying this management philosophy and the entire Toyota production process is the concept that "Good Thinking Means Good Product" (www.toyota.co.jp, 2007).

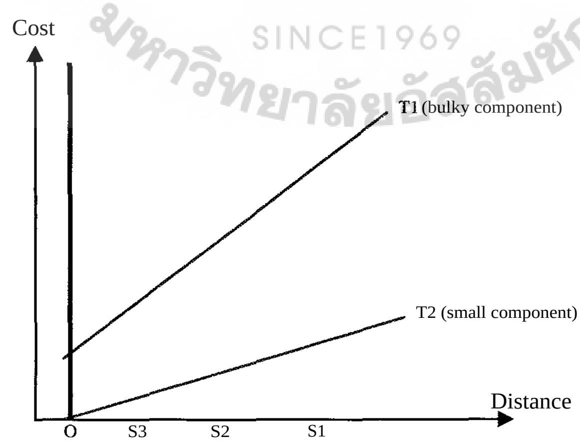
Automobile plants today expect low cost, high quality, and reduced lead time. The response is to emphasize speed, innovation, cooperation, quality, cost effectiveness, and Just-in-Time (JIT). A geographical location introduces an important factor in supplier selection, as it impacts delivery lead-time, transportation, and logistical costs (Monczka, 2005). As mentioned in the literature review, there are many factors which influence the location decision, including major criteria and sub-factors affecting international location decisions (see Table 2.1), major facility location factors (see Table 2.2), and three factors affecting a location decision: operating costs, structural conditions, and quality-of-life characteristics. Most of these researchers normally use survey methodology in the location analysis. The survey approaches are popular because (1) data are obtained; (2)

the actual decision maker provides the information; (3) the researcher can learn about the interrelationships among location factors; (4) a weighting of all factors can be obtained; (5) The results are easily interpreted.

In this study, the researcher maps the research of Tomoo Marukawa (2006) in evaluating potential locations for an automotive supplier. The researcher does not follow the survey methodology as mentioned above because the survey approach also has some disadvantages. These include: (1) the expense of survey research is high; (2) the often low response rate of survey; (3) the difficulty in contacting the correct person.

Tomoo Marukawa's research presents two major parameters affecting location decisions. One is the transportation cost between manufacturer and supplier. The relationship between the transportation cost and the distance depends on the type of car component which can be classified into two types: bulky component and small component. The transportation cost for bulky components such as seats is high and rises sharply as the distance of transportation increases. That case is depicted by the transportation cost curve, T1 of Figure 3.1. On the other hand, the transportation costs of small components like car audio equipment and electronic engine control units are low and they will not raise so much even if the transportation distance gets longer T2.

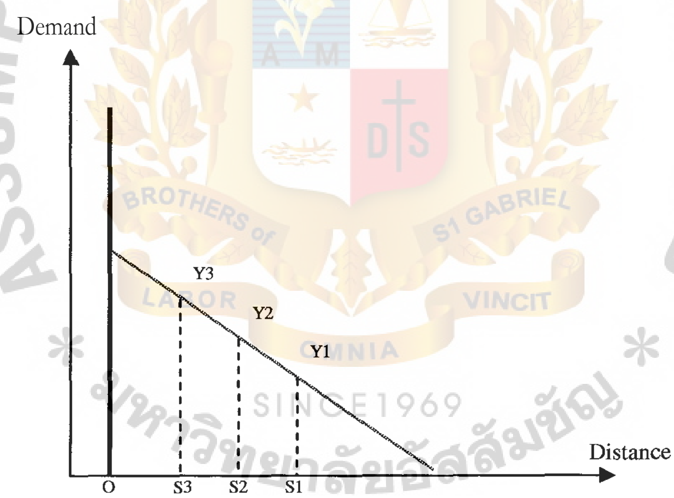
Figure 3.1: The Relationship between the Transportation Cost and Distance



O	=	Car manufacturing plant
Si	=	Supplier at location 1
S2	=	Supplier at location 2
S3	=	Supplier at location 3
T1	=	Transportation cost of bulky component
T2	=	Transportation cost of small component

The demand also affects the location decision. In this theory, it is called auto component demand which means the number of orders placed by car manufacturers. The relationship between the demand and supplier location is represented in Figure 3.2. Theoretically, the farther the distance between the car manufacturer and the auto part supplier, the less the demand (order) to be obtained from the car manufacturer will be.

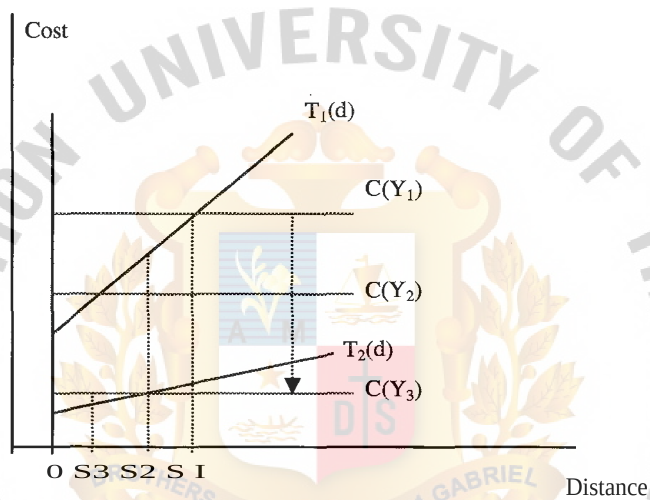
Figure 3.2: The Relationship between Demand and Supplier Location (distance)



O	=	Car manufacturing plant
S1	=	Supplier at location 1
S2	=	Supplier at location 2
S3	=	Supplier at location 3
Y1	=	Demand of manufacturer at location 1
Y2	=	Demand of manufacturer at location 2
Y3	=	Demand of manufacturer at location 3

According to the transportation cost and the demand, it is obvious that locating the supplier plant near to the car manufacturer plant is beneficial in term of the transportation cost and the demand. Nevertheless, another parameter affecting the location decision is the cost of sacrificing scale economy which is present in most kinds of each location. The suppliers may sacrifice economics of scale, especially when the customer's demand for the component is small (see Figure 3.3).

Figure 3.3: Determining Transportation Cost and Cost of Sacrificing Scale Economy



O	=	Car manufacturing plant
S1	=	Supplier at location 1
S2	=	Supplier at location 2
S3	=	Supplier at location 3
C(Y1)	=	Cost of sacrificing at location 1
C(Y2)	=	Cost of sacrificing at location 2
C(Y3)	=	Cost of sacrificing at location 3

Therefore, Figure 3.3 can be summarized that if there is a supplier locating at 0, this supplier can fully support auto components for ac car manufacturer at 0. But, if there is another car manufacturer located at Si with high production volume, the supplier will decide whether to supply auto components from its initial plant (location 0) or relocate or establish a new plant at location S1. The decision will rely on the comparison between the transportation cost T(OS1) and the gap of cost of sacrificing scale economy C(y')-C(y3).

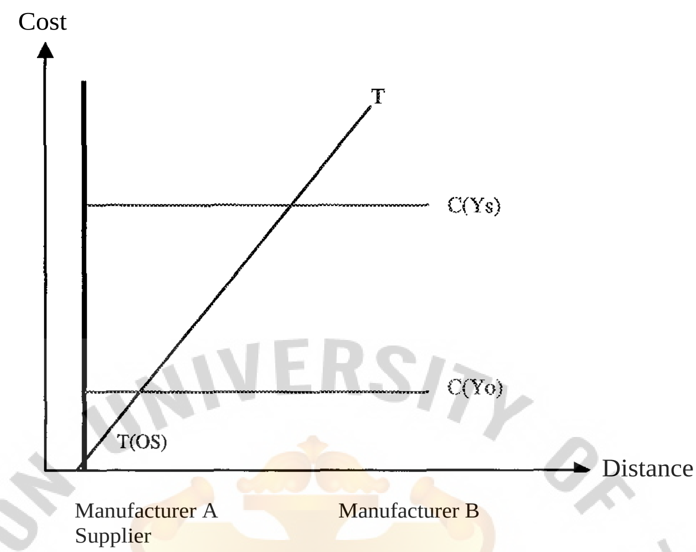
3.2 Conceptual Framework

In this study, the researcher develops research by Tomoo Marukawa (2006) to the conceptual framework. I do not follow the survey methodology because there are some disadvantages as mentioned above. In reality, there are several car manufacturers and also suppliers in the market. One supplier can supply the auto components to more than one car manufacturer. However, as examined in the theoretical framework, the demand will be the highest when the supplier location is the nearest to the car manufacturer. If there are more than one car manufacturers in the area, the supplier must know how to evaluate each factor in order to know where it is best to locate the supplier plant.

The evaluation of a proper location can be divided into two steps: One is the transportation cost for auto components. The transportation cost is high since the car manufacturers require just-in-time (JIT) deliveries to the component suppliers, obliging the suppliers to deliver their products in small lots and more frequently. High transportation cost, resulting from frequent delivery, together with the car manufacturer's requirement for exact delivery, provides a strong reason for the supplier to locate its plant in the vicinity of its main customer

Another is the cost of sacrificing scale economy, which depends on the amount of orders from car manufacturers. Each location must have the volume which refers to the cost of sacrificing scale economy. The cost of sacrificing scale economy will be calculated based on goods remaining in the warehouse of a supplier due to no order from the car manufacturers. If the remaining products are many, the cost is large, but if the remaining products are few the costs is small. (see Figure 3.4).

Figure 3.4: Identify the Transportation Cost and the Gap of Cost of Sacrificing Scale Economy



O	=	Location of car manufacturer A and supplier
S	=	Location of another car manufacturer B
Supplier	=	Initial supplier plant at location 0
T(OS)	=	Transportation cost from location 0 to location S
C(Yo)	=	Cost of sacrificing scale economy at location 0
C(Ys)	=	Cost of sacrificing scale economy at location S

In the conceptual framework, if a supplier locates at location 0, it can fully support the car manufacturer at location A. However, a supplier at location 0 also loses some demand from another car manufacturer which is located further than location 0. The cost of sacrificing scale economy of a supplier at location 0 is defined as C(Yo). In the meantime, car manufacturer B has more production volume, an expanding market, as well as seeking potential suppliers. To relocate or establish a new plant at location S, the supplier's decision should compare the potential location between the transportation cost T(OS) and the gap of cost of sacrificing scale economy C(Ys-Yo).

3.3 Method of Research

There are various research methods for different research problems. Choosing one suitable concept is very important to get a persuasive result. In this section, the researcher discusses methodological issues related to the identified problem. Some methods will be used to develop a better understanding of the study. The methods of research are categorized as follows:

1 Identify the Transportation Cost

According to the theoretical framework, the transportation cost depends on the distance between two locations. The higher the distance is, the more expensive the transportation cost. As a result of JIT strategy, higher demand from the manufacturer results in frequent shipment (the number of trips). Therefore, the total cost of transportation depends on the transportation cost per trip and the number of trips a supplier will have to deliver the components. This model of the transportation cost is very simple, based on the following parameter and calculation.

Transportation cost per trip	=	T	baht
The number of trips	=	n	trips
The total cost of transportation	=	T x n	baht

2. Identify the Cost of Sacrificing Scale Economy

In order to create the model for the cost of sacrificing scale economy, the following parameters must be obtained from the supplier plant: the cost of each component, the supplier plant capacity, and the demand from the car manufacturers. Given that all parameters are named as follows:

Cost of each component	=	X	baht
Supplier plant capacity	=	U	units
Demand from the car manufacturers	=	Y	units

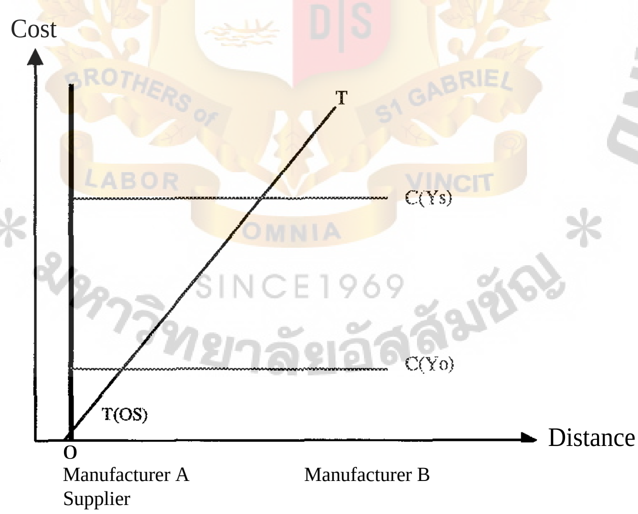
According to the conceptual framework, each location must know the cost of sacrificing scale economy which depends on the remaining components at the supplier warehouse. A supplier must predict how many remaining components at the expected location. The cost of sacrificing scale economy can be calculated as below:

Remaining components		U-Y	baht
The cost of sacrificing scale economy	=	(U-Y) x X units	

3. Evaluate the Trade Off between the Transportation Cost and the Gap of Cost of Sacrificing Scale Economy.

According to the conceptual framework, to seek a potential location for an automotive suppler, the evaluation is a trade-off between the transportation cost and the gap of cost of sacrificing scale economy, which can be summarized as in Figure 3.4.

Figure 3.4 Identify the Transportation Cost and the Gap of Cost of Sacrificing Scale Economy



O	=	Location of car manufacturer A and supplier
S	=	Location of another car manufacturer B
Supplier	=	Initial supplier plant at location 0
T(OS)	=	Transportation cost from location 0 to location S
C(Yo)	=	Cost of sacrificing scale economy at location 0
C(Ys)	=	Cost of sacrificing scale economy at location S

Given that a supplier locates at location 0 together with manufacturer A, then what happens when another car manufacturer B locates at S with a higher demand? The supplier will decide whether to supply auto components to the car manufacturer B from the initial plant (location 0) or establish a new plant at location S to serve higher orders from car manufacturer B. If a supplier decides to supply auto components from the initial location (0) to a car manufacturer at location S, the parameters to be focused on are as follows.

The cost of transportation	=	T(OS)	baht
The cost of sacrificing scale economy	=	C(Yo)	baht
The total cost at location 0	=	T(OS) + C(Yo)	baht

On the other hand, if a supplier decides to establish the car manufacturer plant at location S and starts supplying auto component from this location, there will not be the transportation cost because the supplier and manufacturer are located together. However, it definitely has the cost of sacrificing scale economy at this location.

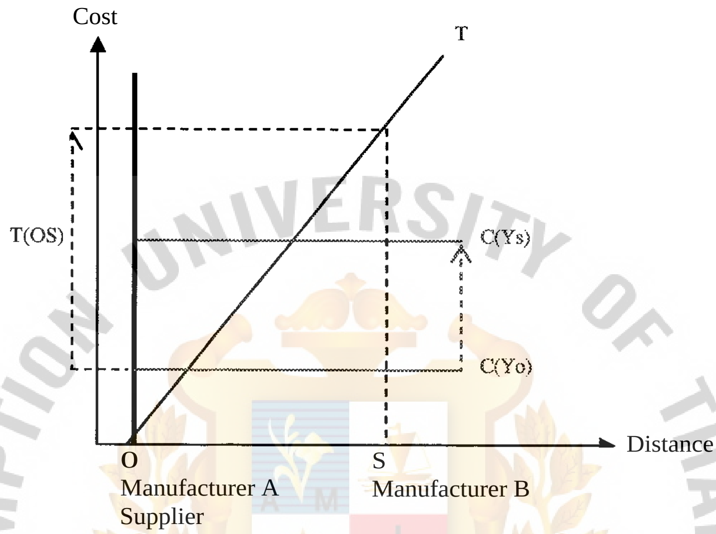
The cost of sacrificing scale economy	=	C(Ys)	baht
The total cost of transportation	=	0	baht
The total cost at location S	=	C(Ys)	baht

Therefore, the comparison is made between two locations. Whichever lodcation has the lower cost, the supplier should locate there. Therefore, the supplier should establish the new plant at location S when:

The total cost at location 0	>	The total cost at location S
T(OS) + C(Yo)	>	C(Ys)
T(OS)	>	C(Ys) - C(Yo)

From the above equation, it can easily be seen that the location decision is the comparison between the transportation cost from the initial location (0) to the new location (S) and the gap of cost of sacrificing scale economy between two locations (see Figure 3.5).

Figure 3.5: The Conclusion between the Transportation Cost and the Gap of Cost of Sacrificing Scale Economy between Two Locations



If the transportation cost T(OS) is much more than the gap of the cost of sacrificing scale economy C(Ys-Yo), the supplier's decision should be to establish the new plant at location S. However, if the transportation cost is fairly small, as the gap of cost of sacrificing scale economy is large, it becomes likely that the supplier should supply auto components from the initial plant at location 0.

3.4 Data Collection Method

When conducting a study, plenty of data and information can be found to simplify the ability to make the right conclusion. It is important to separate essential from non-essential data (Lekvall & Wahlbin, 2001). There are two general ways of collecting data: primary and secondary data collection. Primary data is gathered and assembled specifically for the current study. The data is usually collected through observation, surveys and interviews. Secondary data, on the other hand, is data assembled and produced for another project and can be found in journals, books, databases or in the internet (Zikmund, 2000). To make a successful study, both primary and secondary data has been gathered and analyzed as follows:

1. Primary data

The capturing of the primary data was conducted though personal interviews. The researcher decided the personal interview would be preferable in the study area, as it helped me to acquire the just-in-point information and precise pictures of what and how business works. This gave me the following information: the study problem, background of the Ford Company, location of auto part suppliers plant of the Ford company (see Table 1.1), top ten annual sales in 2006 of automotive suppliers to the Ford company (see Table 1.2), axle components price, and transportation structure in different locations (see Table 4.1). All this information was necessary and essential when conducting the study.

2. Secondary data

The secondary data consists of textbooks, journals, research papers, Ford company database, and some websites. The researcher collected this data from the library, from the Ford intranet and through internet. It comprises the literature review in Chapter 2. Then, the researcher applied and developed this data in identifying evaluation parameters in order to seek potential locations for an automotive supplier.

CHAPTER IV
DATA ANALYSIS

In this chapter, the evaluation of the trade-off between the transportation cost and the gap of cost of scale economy is analyzed according to the method of research. Consequently, it is one of the important factors to justify a suitable location for an automotive supplier.

Generally, when one visits the major car manufacturers in Thailand, one will see that automotive suppliers are clustered around car manufacturers. In recent years, Western auto companies have been actively expanding into Thailand and later Western auto parts manufacturers will also expand into Thailand in order to coordinate with Western automakers and increase business with Japanese auto makers (see Appendix L). As described in the background of the Ford Company, Ford first established its plant in 1960, and its biggest supplier in Thailand is Dana Spicer, as in the Table below:

Top Ten Annual Sales in 2006 of Automotive Suppliers to the Ford Company

No.	Supplier Name	Location of Supplier	Auto Component	Total
1	MAZDA MOTOR CORPORATION	Japan	Engine/PT	8,287,675,005.11
2	FORD MOTOR COMPANY PHILLIPPINE	Philippine		2,949,735,050.64
3	DANA SPICER (THAILAND)	Rayong	Chasis	2,765,564,304.93
4	BOSCH AUTOMOTIVE (THAILAND)	Rayong	Chasis	1,778,913,902.41
5	HALLA CLIMATE CONTROL (THAILAND)	Rayong	A/C system	1,595,902,950.59
6	THAI SUMMIT PKK	Chonburi	Stamping	1,298,600,74590
8	GENERAL SEATING (THAILAND)	Rayong	Interior	1,027,868,992.12
9	VISTEON (THAILAND)	Rayong	Interior	967,968,611.13
10	THAI SUMMIT EASTERN SEABOARD	Samutprakarn	Stamping	751,727,699.54

Presently, the trade of Japanese auto manufacturers has made rapid growth in the market. Toyota is the largest auto maker in Thailand (see Figure 4.1). In the current situation, Toyota sees that in order to create economy of scale, its production of passenger cars should reach 200,000 units per year. In 2005, Toyota produced 111,000 passenger cars per year, comprising of 40-50,000 units of Vios and Corolla Altis, as well as 20,000 units of Yaris. In the future, Toyota say that total production of passenger cars could reach 200,000 units in order to enable it to compete globally.

The pick-up truck production is approximately 239,800 units per year. Moreover, Toyota's way is to expand the production capacity to consumers. So, the consumers will be able to use cars that are cost-effective, efficient, and environmentally-friendly. It is a win-win situation for producers and consumers.

Figure 4.1: Car Assemblers in Thailand, Ranked by Production Capacity in 2005

	..........[illegible]		[illegible]
	Toyota Motor Thailand Co.,Ltd.	350,800	27.62
2	Isuzu Operations (Thailand) Co. Ltd.	200,000	15.75
3	Mitsubishi Motors (Thailand) Co.,Ltd.	170 200	13.40
	Auto Alliance (Thailand) Co.,Ltd.	135,000	10.63
S	Honda Automobile (Thailand) Co Ltd.	120,000	9.45
6	General Motors (Thailand) Co.,Ltd.	115,000	9.05
7	Siam Nissan Automobile Co.,Ltd.	102,000	8.03
8	Nina Motors Sale (Thailand) Ltd.	28,800	2.27
9	Thonburi Automotive Assembly Co.,Ltd.	16,300	1.28
10	Y.M.C Assembly Co.,Ltd.	12,000	0.54
11	BMW Manufacturing (Thailand) Co.,Ltd.	10,000	0.79
12	Thai Swedish Assembly Co.,Ltd.	10,000	0.79
13	Bangchan General Assembly Co.,Ltd.	6	0.00
	Total	1,270,100	100.00

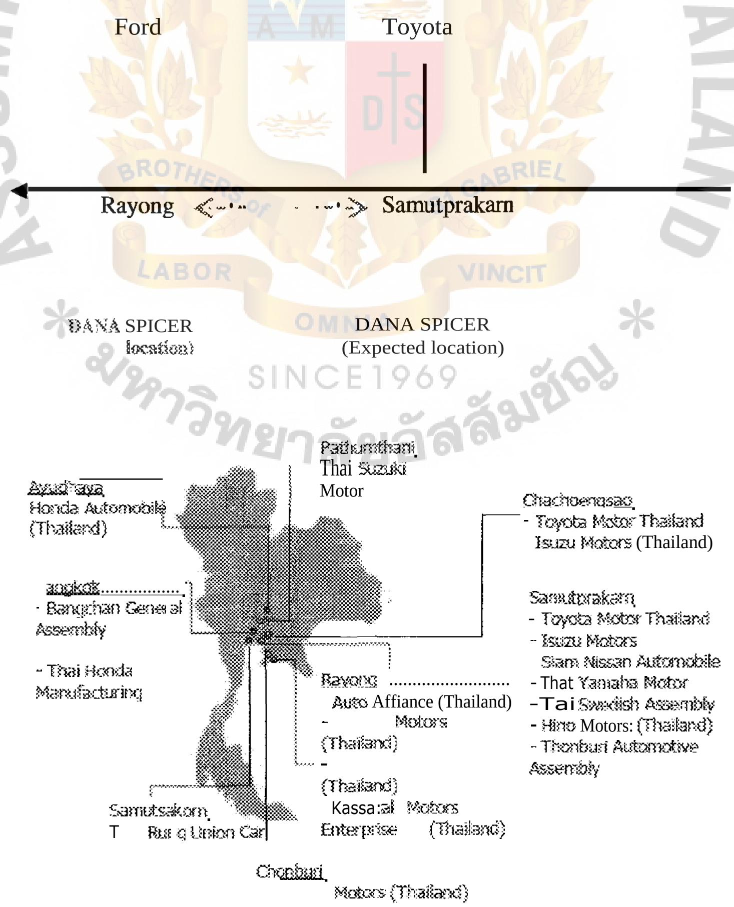
Source : Office of Industrial Economics, Ministry of Industry.
Remark excluding Motorcycles

Using the above data, this study will analyze Dana Spicer, which presently is the biggest Thailand supplier of Ford Company (see Table above). In the past 5 years, Toyota had the highest production capacity. It is possible that Toyota has even more demand for axle components from Dana Spicer. Axle components are grouped as a chassis component as shown in Table 1.1. To seek the potential location, Dana Spicer should decide either to establish the new plant to support the production volume of Toyota company or to continue support Ford company wherever the best location is. Furthermore, the analysis will be conducted in order to make a judgment of a suitable location for a Dana Spicer plant. The calculation is performed based on both the conceptual framework and method of research. Some figures or numbers are simulated in order to give a better understanding of this analysis.

Case Study: Locate a New Plant for Dana Spicer

Dana Spicer is the biggest supplier to the Ford manufacturing plant. The annual sales to Ford in 2006 were approximately 2,765 million baht per year. The production line of Toyota tends to be higher over the past five years, and it is possible that Toyota will have even more orders for Dana Spicer. In order to gain the benefits of sales, Dana Spicer wants to compare the trade-off between the transportation cost and the gap of cost of sacrificing scale economy in seeking a proper location, in either Rayong province or Samuprakarn province (see Figure 4.2). The research methods are analyzed as follows:

Figure 4.2: The Current Car Manufacturing Plants and Dana Spicer Locations

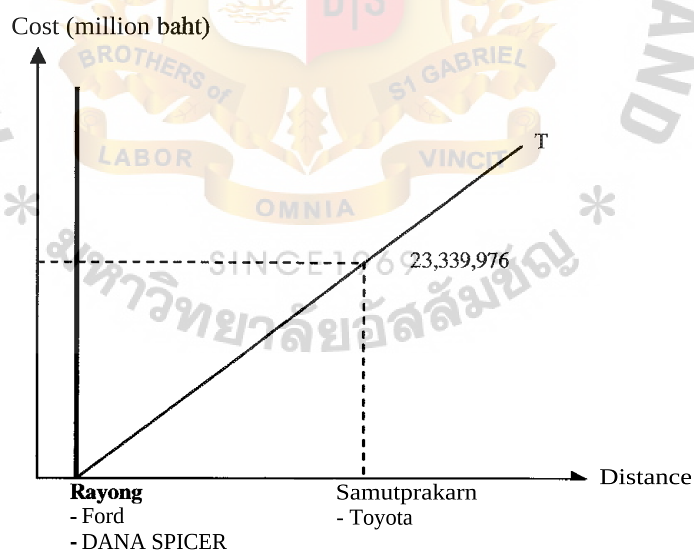


4.1 Analysis of the Transportation Cost between Two Locations

Transportation cost will occur from delivery, and the distance represents distance between the provinces in which the assembly plant and the supplier are located. Given that Dana Spicer also supplies axle components to Toyota plant, when Dana Spicer locates at Rayong, it is assumed that the demand from Toyota plant is 27,655 units/year. Table 4.2 shows transportation rate; the distance from Rayong to Samutprakarn is 100 km., the transportation rate from Rayong to Samutprakarn is 5,064 baht per trip for 6-axle units and transit time is 14.50-15.99. Therefore, the number of trip comes from 27,655/6 = 4,609 trips/year. The model of the transportation cost is shown below:

Transportation cost per trip	T	5,064	baht
The number of trips	n	4,609	trips/year
The total cost of transportation	T x n	23,339,976	baht

Figure 4.3: Evaluation of the Transportation Cost between Two Locations



Referring to theoretical framework, transportation cost will especially occur in the different locations. If the demand in different locations is great, it will cause a highly increasing transportation cost for axle components. Hence, the transportation of axle components increases sharply as the distance of transportation increases. In this case, the total transportation cost of Dana Spicer from Rayong to Samutprakarn is 23,340,820 million baht per year.

4.2 Analysis the Cost of Sacrificing Scale Economy in Two Locations

Following are the structure analyses of the cost of sacrificing scale economy:

1. Dana Spicer locates at Rayong

Rayong:	Annual Sales to Ford	=	2,765,564,304	baht
	Axle cost	=	20,000	baht/unit
	Demand from Ford	=	138,278	units
	Demand from Toyota	=	27,655	units
	Total demand	=	165,933	units

As mentioned, the current sale of Dana Spicer to Ford is 2,765,564,304 baht per year. Figure 4.4 shows the axle price per unit. The price of axle cost varies so the assumption is that axle price is approximately 20,000 baht/unit. Hence, demand from Ford is 2,765,564,304/20,000 = 138,278 units. Given that Dana Spicer also supplies axle component to Toyota plant is 27,655 units, the total demand at Rayong is 165,933 units per year.

Figure 4.4: Axle Price per unit of Dana Spicer Company

DANA

(ประเทศไทย)

DANA SPICER (THAILAND) LIMITED.

นิคมอุตสาหกรรมอีสเทิร์นซีบอร์ด (ระยอง)
64/7 หมู่ที่ 4 ตำบลปลวกแดง อำเภอปลวกแดง จังหวัดระยอง 21140
1r5. (66-38) 954330-40 แฟ็กซ์ (66-38) 954341
EASTERN SEABOARD INDUSTRIAL ESTATE (RAYONG)
64/7 MOO 4 TUMBOL PLUAKDAENG AMPHUR PLUAKDAENG, RAYONG 21140. THAILAND.
TEL (66 381954330 40 FAX (66 381 954341
Tax Number 3011070871

ORIGINAL TAX INVOICE

Page 2 of 2

(เอกสารออกเป็นชุด)

เลขที่อินวอยซ์ Invoice No.	1188 Dale	วันครบกำหนดชำระ Due Dale	เงื่อนไขการชำระเงิน Terms
100003003	06-JUL-06	05-AUG 06	30 DAYS

ขายให้ Sale to: AUTOAILIANCE (THAILAND) CO., LTD.
49 MOO 4
EASTERN SEABOARD
INDUSTRIAL. ESTATE
PLUAKDAENG
RAYONG 21140

697

ส่งของที่ : Delivery to: AUTOALLIANCE (THAILAND) CO.. LTD.
49 MOO 4
EASTERN SEABOARD
INDUSTRIAL ESTATE,
PLUAKDAENG
RAYONG 21140

รหัสลูกค้า Customer Code	เลขที่ Order Order No.	ใบสั่งซื้อเลขที่ P/0 No.	วันที่ Dale	รหัสพนักงานขาย Sales person No
Q300	100002616		06 —JUL —06	KT061

รหัสสินค้า Key	รายการสินค้า Description		จำนวน Quantity	ราคาต่อหน่วย	จำนวนเงิน Amou
2001618-1	UR5805800H AXLE ASSY - REAR	D/O#FSA69520	32.00	18,215.78	582,904.96
2001620-1	UR6105800K AXLE ASSY REAR (ABS)	D/O#FSA69720	52.00	20,657.57	1,074,193.64
2001619-2	UR62 OS 800K AXLE ASSY - REAR (ABS)	D/O#FSA69820	4.00	19,701,67	78,806.68
606037-33	UR63 OS 800, REAR—AXLE REAR	D/O#FSA69920	2.00	15,239.86	30,579.72
2001618-3	UR6605800E AXLE ASSY - REAR (ABS)	D/O#FSA70020	3.00	20,885.00	62,655.00
2001620-3	UR7605800G AXLE ASSY - REAR (ABS)	D/O#FSA70220	49.00	20,641.70	1,011,443.30
2001617-2	UR60 05 800H AXLE ASSY - REAR	D/O#FSA69620	26.00	17,273.77	449,118.02
	ผิด ตก ยกเว้น E.&O.E.				
				SUB TOTAL	5,634,533.08
					397,917.32
	(SIX MILLION EIGHTY-TWO THOUSAND FOUR HUNDRED FIFTY AND 40/100)			จำนวนเงินรวม TOTAL	6,082,450.40

ในกรณีที่จ่ายเป็นเช็ค บิลนี้จะสมบูรณ์ต่อเมื่อบริษัทฯ เรียกเก็บเงินตามเช็คได้เรียบร้อยแล้ว

อัตราภาษี อัตราร้อยละ 7 อัตราศูนย์

ได้รับสินค้าตามรายการข้างต้นนี้ไว้ถูกต้องในสภาพเรียบร้อยดี จำนวนและราคาถูกต้องแล้ว			DANA SPICER (THAILAND) LIMITED.
ผู้รับสินค้า .... RECEIVED BY	ผู้นำส่ง .... DELIVERED BY	ผู้จัดสินค้า .... PREPARED BY	อำนาจลงนาม SIGNATURE
วันที่ .... DATE.	วันที่ .... DATE	Dee .... DATE	DANA SPICER (THAILAND) LIMITED

FORM# F-7A, 05, REV.0 1 JANUARY 04

2. Dana Spicer locates at Samutprakarn

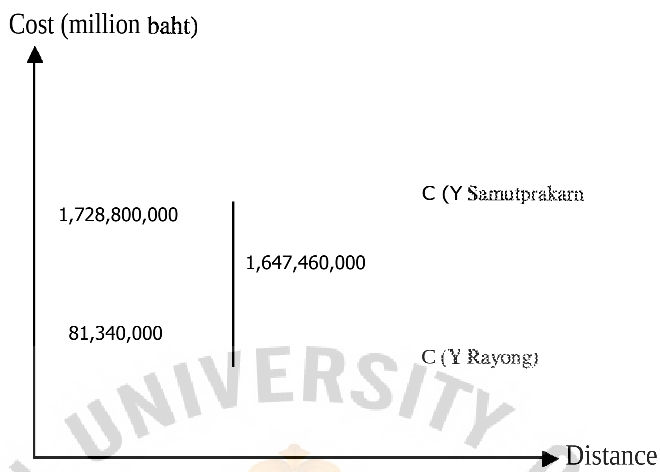
Bangkok:	Annual Sales to Ford	=	11,904,433	baht
	Axle cost	=	20,000	baht/unit
	Demand from Ford	=	595	units
	Demand from Toyota	=	82,965	units
	Total demand	=	83,560	units

Suppose that Dana Spicer locates at Samutprakarn, the expected annual sales to Ford would be 11,904,433 baht. Referring to the personal interviews, the expected annual sales from Ford are 11,904,433 baht due to being located in different location, so the demand is less as the distance increase. The demand from Ford is 11,940,433/20,000 = 595 units. Referring to Figure 4.1 Toyota's production is three times higher than the Ford Company. If Dana Spicer wants to relocate the new plant at Samutprakarn, the demand should increase three times when comparing demand from Toyota at Rayong. The demand from Toyota is 27,655 x 3 = 82,965. Thus, the total demand at Samutprakarn is 83,560 units per year.

Based on the given information, the total demand for axle components when Dana Spicer locates at Rayong is 165,933 units/year. If Dana Spicer decides to establish the new chassis plant at Samutprakarn, the total demand would be 83,560 units/year. Suppose that supplier plant capacity is 170,000 units, then the cost of sacrificing scale economy can be calculated as follows:

	Equation	**Rayong**	**Samutprakarn**	
Cost of axle component	X	20,000	20,000	baht
Supplier Plant Capacity	U	170,000	170,000	units
Total Demand from the car manufacturers	Y	165,933	83,560	units
Remaining components in warehouse	U-Y	4,067	86,440	units
Cost of sacrificing scale economy	(0-Y) x X	81,340,000	1,728,800,000	baht

Figure 4.5: The Cost of Sacrificing Scale Economy at Rayong and Samutprakarn.



Dana Spicer will lose much demand if the plant is newly established at Samutprakarn. This will consequently result in an increase of the cost of sacrificing scale economy from 81,340,000 million baht to 1,728,780,000 million baht per year.

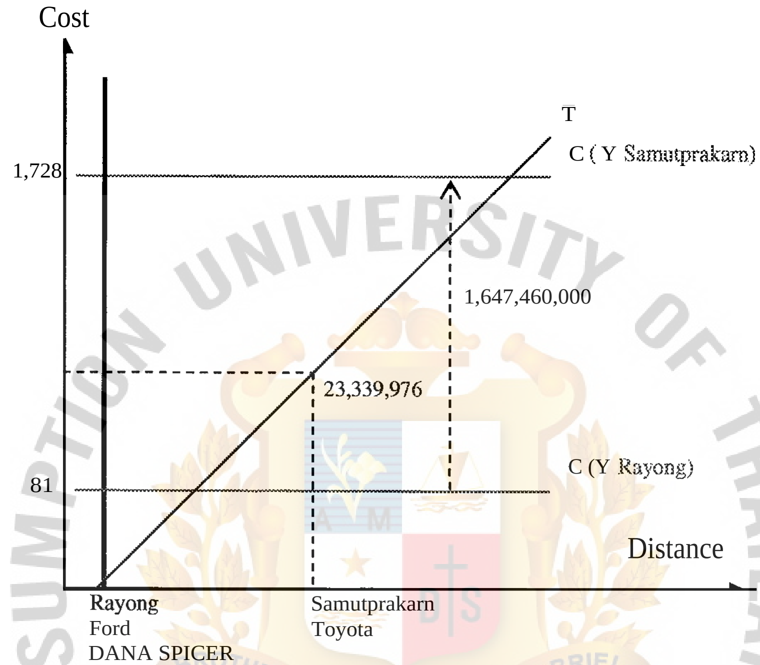
4.3 Evaluation of the Trade-Off between the Transportation Cost and the Gap of Cost of Sacrificing Scale Economy

To seek the proper location for Dana Spicer, The Dana Spicer's decision will depend on the comparison between the transportation cost from the initial location (Rayong) to the new location (Samutprakarn) and the gap of the cost of sacrificing scale economy between two locations as simulated below:

The total cost at Rayong	•	The total cost at Samutprakarn
T(Rayong-Samutprakarn) + C(Y Rayong)	•	C(Y Samutprakarn)
T(Rayong-Samutprakarn)	•	C(Y Samutprakarn) - C(Y Rayong)
23,339,976	•	1,647,460,000

Refer to above equation, the transportation cost cannot overcome the cost of sacrificing scale economy. The gap of the cost of sacrificing scale economy between two locations is very large when compared to the transportation cost between those locations which is fairly small (see Figure 4.6).

Figure 4.6: Evaluation of the Trade-Off between the Transportation Cost and the Gap of Cost of Sacrificing Scale Economy between Rayong and Samutprakarn.



As a result of this evaluation, it is obvious that establishing the plant at Samutprakarn is not worthwhile. Dana Spicer should continue to supply axle components from its initial location in Rayong province.

CHAPTER V
RESULTS AND RECOMMENDATIONS

This chapter is divided into three sections: summary of findings, conclusions, and recommendations. The first section summarizes the finding of this study. The second section concludes and discusses the important of findings of this study. The last section offers recommendations and suggestions for further research.

5.1 Summary of Findings

Presently, most car manufacturers require the JIT concept for the success of their supply chains. To enable the JIT concept, geographical location is one of the important factors in supplier selection. Thus, how can automotive supplier speedily deliver the required auto components to the car manufacturer within the time-line schedule. The way to solve this problem is evaluating a potential location based on specific factors. The researcher found that there are many factors which can influence the location decision. The researcher mapped some factors to evaluate proper locations in the study. The benefits of the study in seeking a suitable location are low transportation cost, reduced lead time, as well as achieving economics of scale.

In Chapter 2, the researcher considers relevant theories, journals, and information in order to support finding and analyzing proper locations for an automotive supplier including the auto industry in Thailand, logistics management, transportation, economics of scale, facility location decision, and supplier selection.

In Chapter 3, after studying the relevant theories, the researcher chose Tomoo Marukawa's research (2006) to develop the conceptual framework, due to limits of data collection, limited time, and some disadvantages of the survey method. To evaluate a proper location in the study, there are two major parameters affecting the location decision. One is the transportation cost and another is the cost of sacrificing scale economy. Then, the researcher determines a methodology related to the identified problems.

In Chapter 4, is presented the method and the result of the case study. The researcher chose Dana Spicer supplier for then evaluation of a suitable location for its plant. Location analysis was based on Ford and Toyota companies. Dana Spicer will decide whether to locate plant near to Ford or Toyota companies by depending on two parameters: the transportation cost and the gap of cost of sacrificing scale economy. The result of simulating two parameters indicates that establishing or relocating the new plant close to the Toyota company is not worthwhile when comparing it to the initial plant.

5.2 Conclusions

Broadly, the automotive industry emphasizes minimizing costs, accessing stable markets, and havintg available automotive suppliers near to its plant. Not only will the automotive industry require supplier availability in its plant but also wants to develop a win-win strategy and long-term relationships with its automotive suppliers.

Therefore, establishing or relocating the automotive suppliers' plant is the most critical decision since the total cost of supply chain will obviously appear when the operation is set up. This study analyzed the key elements in evaluating the proper location of an automotive supplier. The important elements include the transportation cost and the cost of sacrificing scale economy. The study examines the transportation cost in different locations and ignores transportation cost in the same location according to the theoretical framework.

The researcher concludes that transportation costs will be increasing based on the distance and type of material throughout the supply chain. Also, the cost of sacrificing scale economy depends on the amount of orders from the manufacturers. Supplier in each location must have the cost of sacrificing scale economy. To seek the potential location of an automotive supplier, the location decision comes from evaluating the transportation cost and the gap of the cost of sacrificing scale economy in each location. If the transportation cost is greater than the gap of cost of sacrificing scale economy, the automotive supplier should establish or relocate the new plant to the expected location. On the other hand, if the gap of cost of sacrificing scale economy is greater than transportation cost, the supplier should maintain the plant at the initial location.

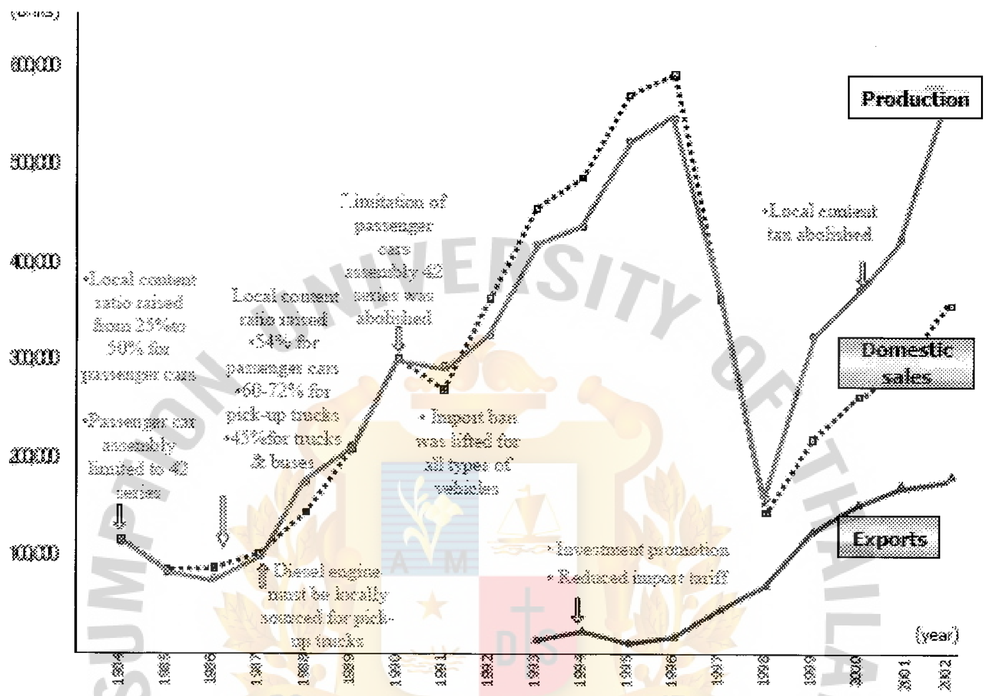
5.3 Recommendations

This study focuses on some factors affecting the location decision: The transportation cost and the cost of sacrificing scale economy are simulated as in the analysis structure in this study. In order to achieve the most accurate result, it depends on how the data is collected. It would be more precise if each of the suppliers has its sales record, demand record, and shipment record to each car manufacturer. With accurate and sufficient information, the evaluation can be developed swiftly and precisely. As a result, poorly placed plants can result in excessive cost in long-term operational performance. Locating a facility is an important decision affecting the cost of managing the supply chain.

Furthermore, making location decisions for the production of products is a key aspect of strategic and logistical decision-making for manufacturing firms. The optimum locations may offer competitive advantage and may contribute to the success of an enterprise. Location factors can be considered and classified in a variety of ways including transportation cost, manufacturing cost, labor cost, infrastructure, proximity to suppliers, proximity to markets, proximity to competition, quality of life, legal and regulatory framework, economic factors, and etc. For future research, to obtain the most accurate decision, these factors should be included in the study. More or less, it depends on the country or location selection.

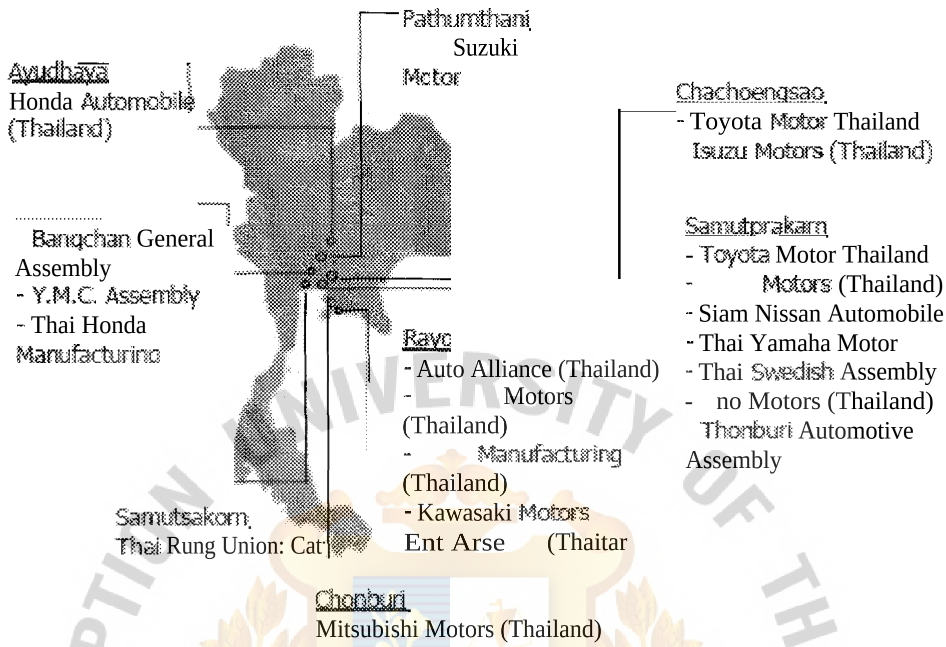
APPENDICES

Appendix A: The Thai Automotive Industry Development under the Government Action

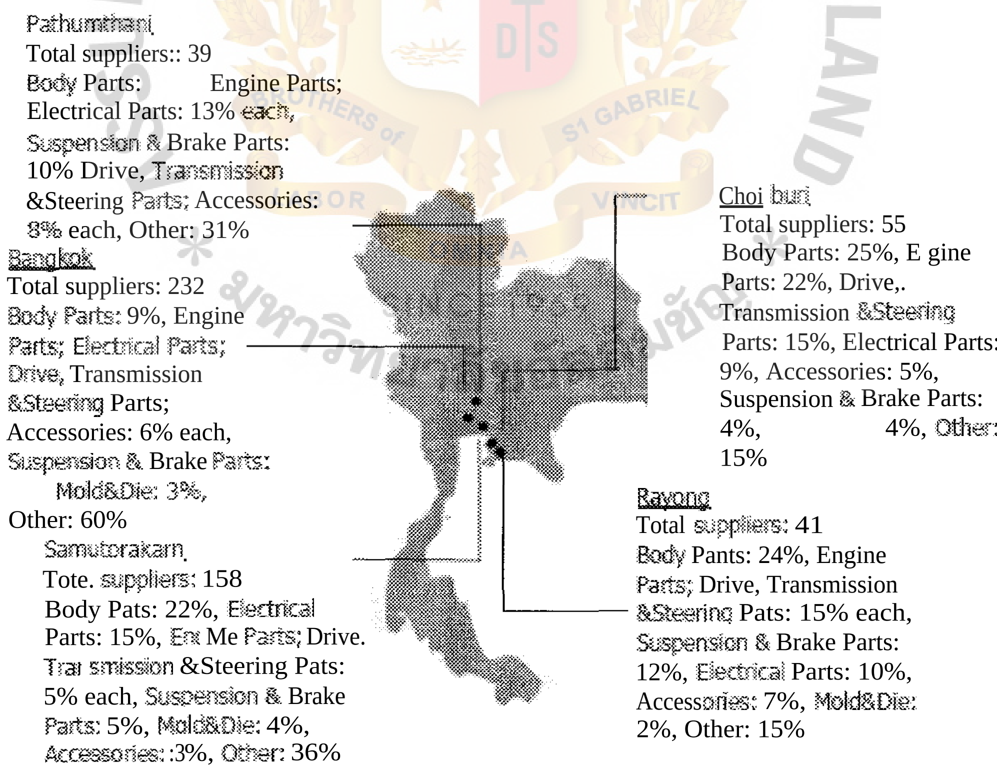


Source: Thai Auto-Parts Manufacturers Association, "Trends and Developments in Thailand's Auto Market." Online,<www.thaiautoparts.or.th/fileupload/AutomotiveHistory.ppt>.

Appendix B: Location of Automotive Assemblers

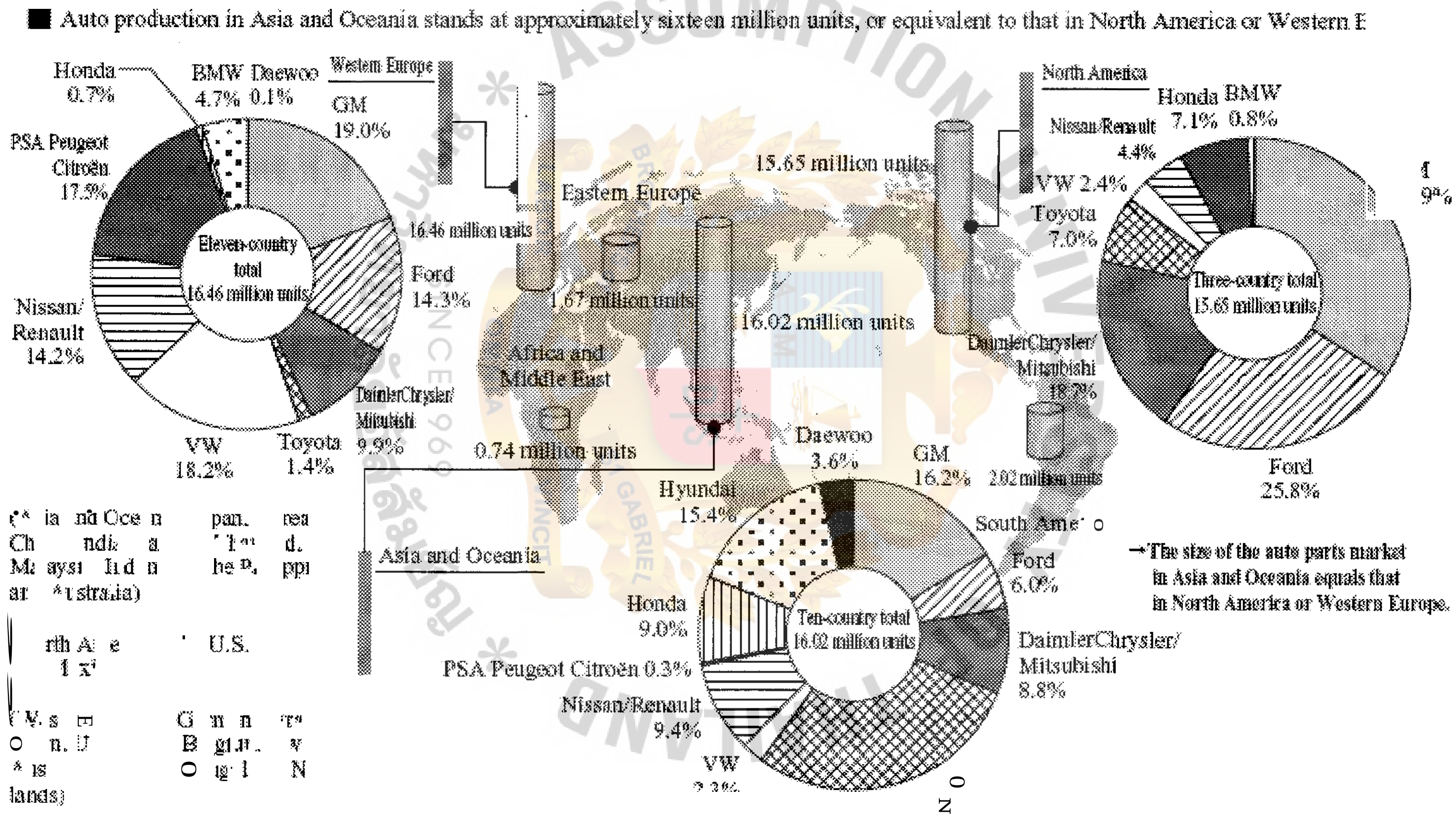


Appendix C: Location of Automotive Parts Makers



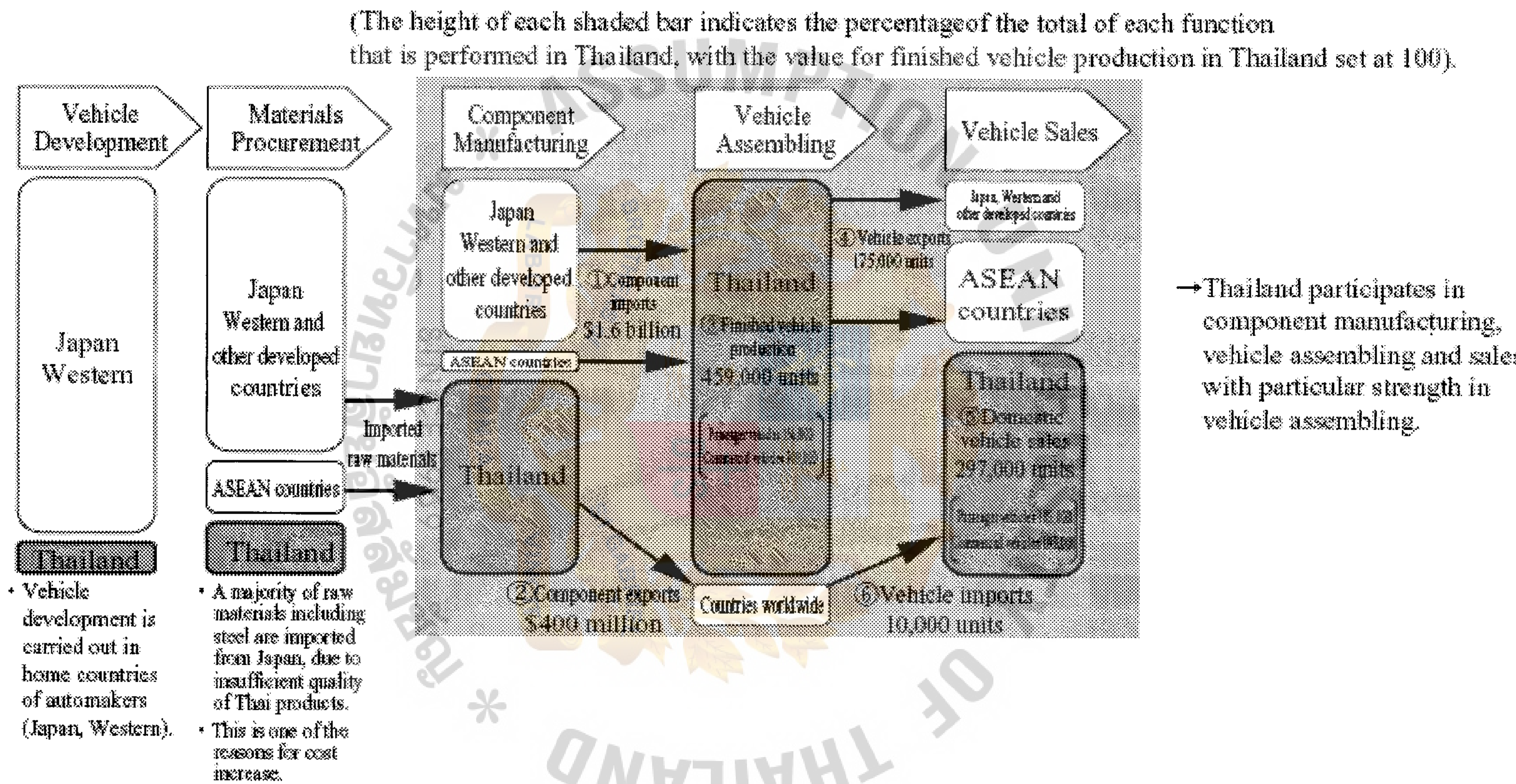
Source: Thai Automotive Institute (2002)

Appendix D: Total Auto Production by Region and Production Share by Manufacturer by Region (2001 data, passenger and commercial vehicles combined)



Source:Braxton.Inc., based onFOURIN (2002)

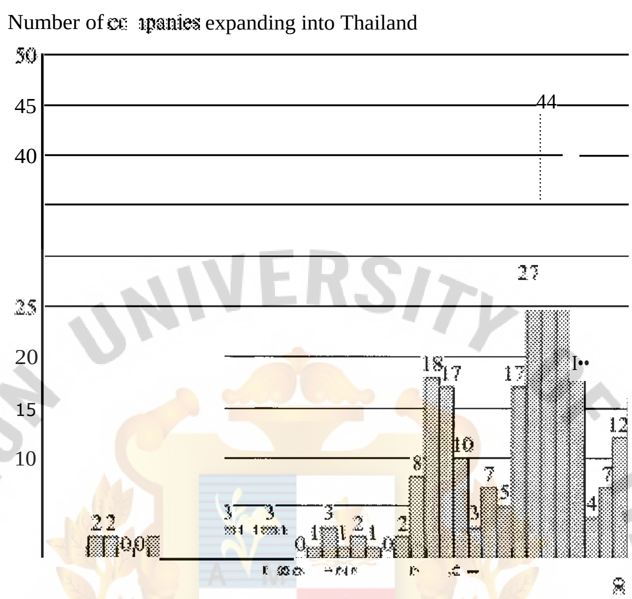
Appendix E: Positioning of Thailand in a Supply Chain



rs. Inventory levels of commercial vehicles are relatively high, as there are post-manufacturing modifications that need to be performed on those vehicles in order to meet customer specifications before they are actually sold. (Source: Braxton Inc., based on various materials)

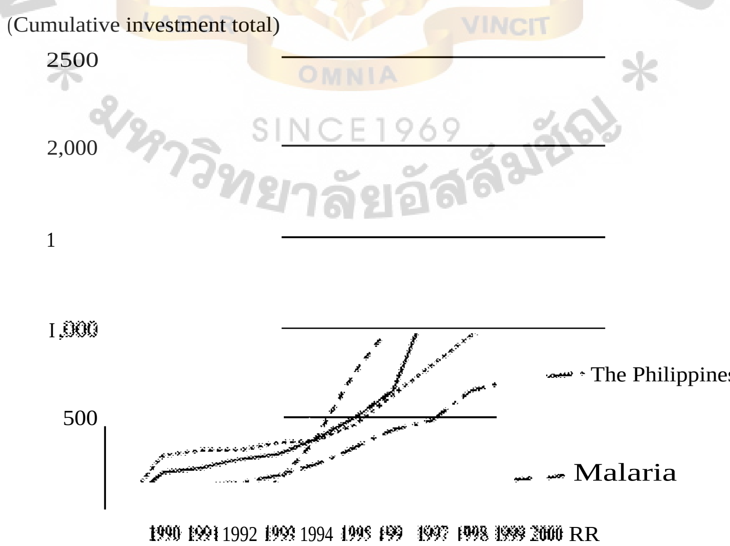
Appendix F: Expansion Activities of Japanese Auto and Auto Parts Manufacturers into Thailand

Expansion activi of Japanese auto-related companies, by war (2001 data)



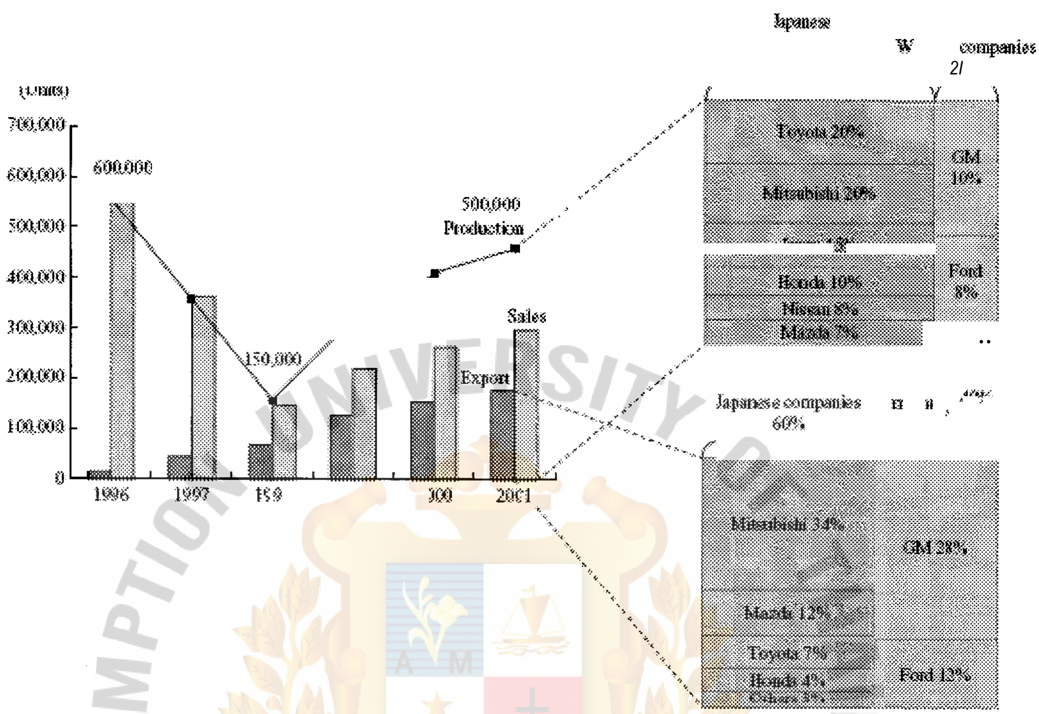
Source: Toyo Keizai (2001)

Cumulative total of foreign direct investment in the transport sector
Cumulative total of investment fro Japan in the petted between FYs 1989 and 2001



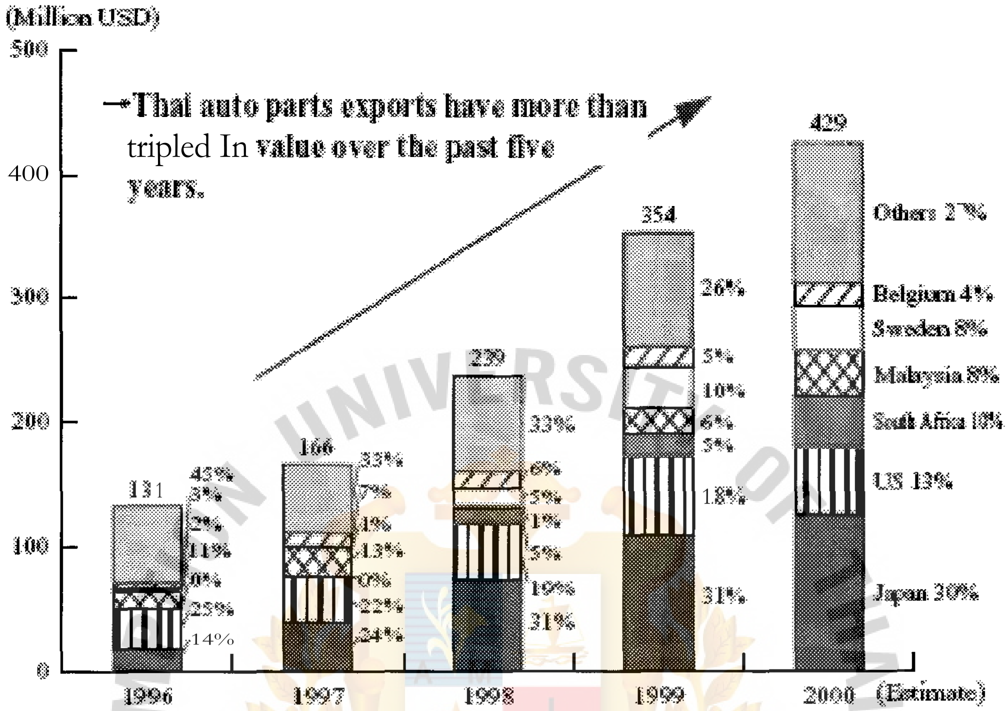
Source: Ministry of Finance, Foreign Direct Investment (FDI) of Japanese companies overseas and FDI by foreign companies into Japan

Appendix G: Thai Auto Production and Export, Total and Manufacturer Shares



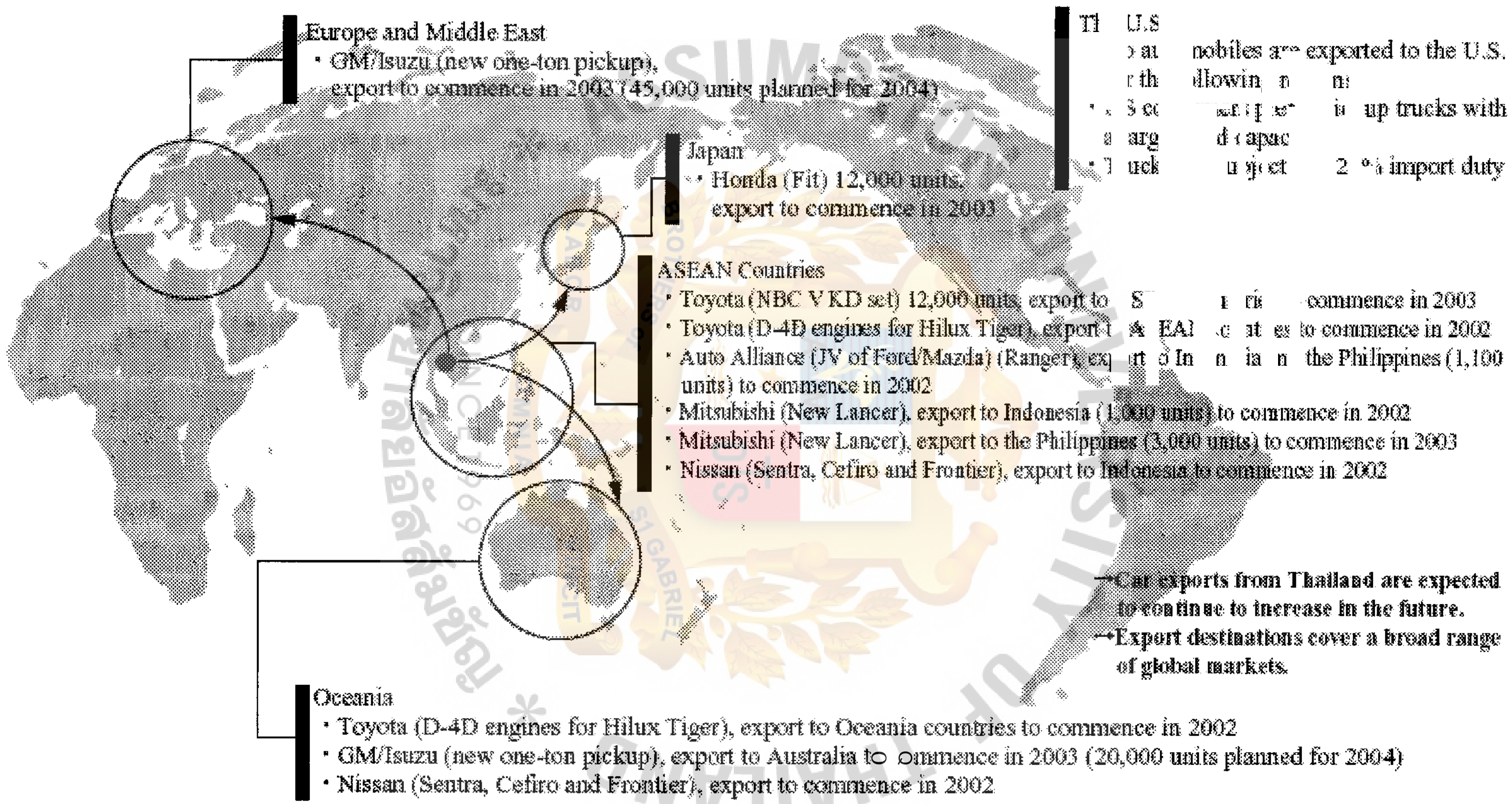
Source: FOURIN Inc., 2002 Asian Automotive Industry (2002 Ajia Jidousya Sanyo), the Thai Automotive Industry Association and the Japan Automobile Manufacturers Association Inc. (JAMA).

Appendix H: Changes in Thai Auto Parts Exports and Destination Shares



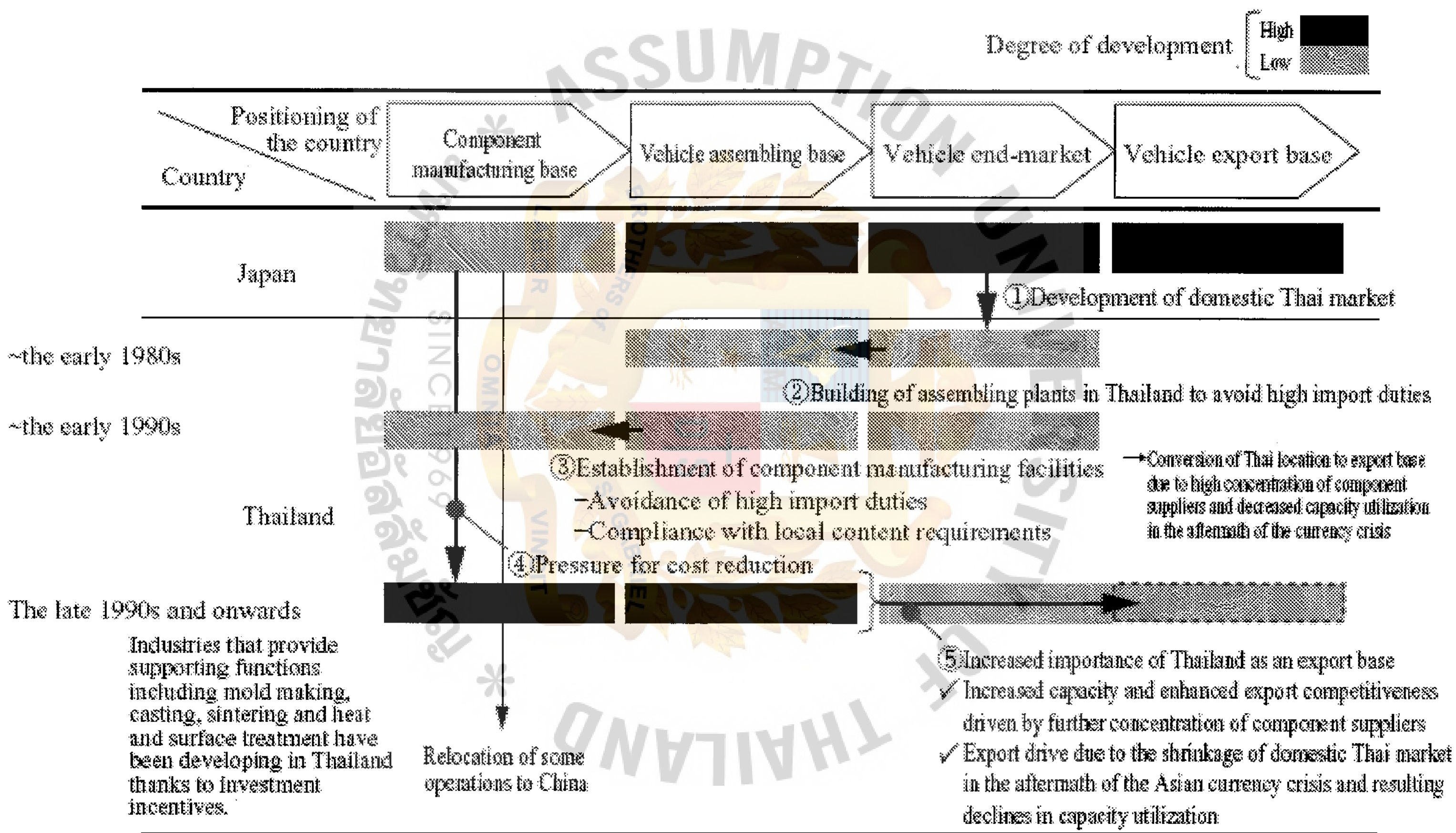
Source: Department of Customs, Trade Statistical Centre

Appendix I: Export Plans of Auto Manufacturers in Thailand in 2002 or later



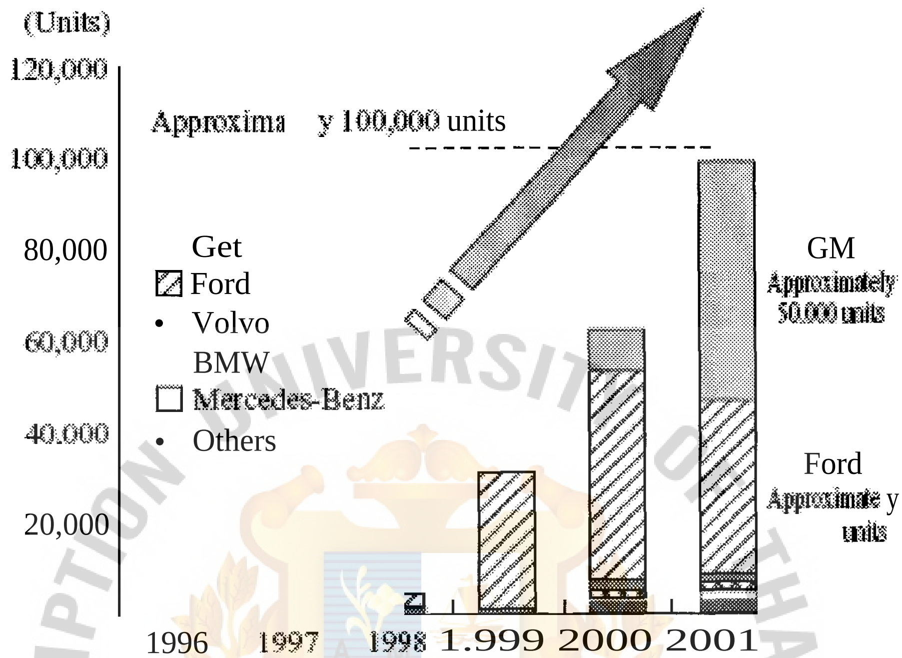
Source: Braxton Inc., based on various materials.

Appendix J: Establishment of Thailand as an Export Base



Source: Braxton

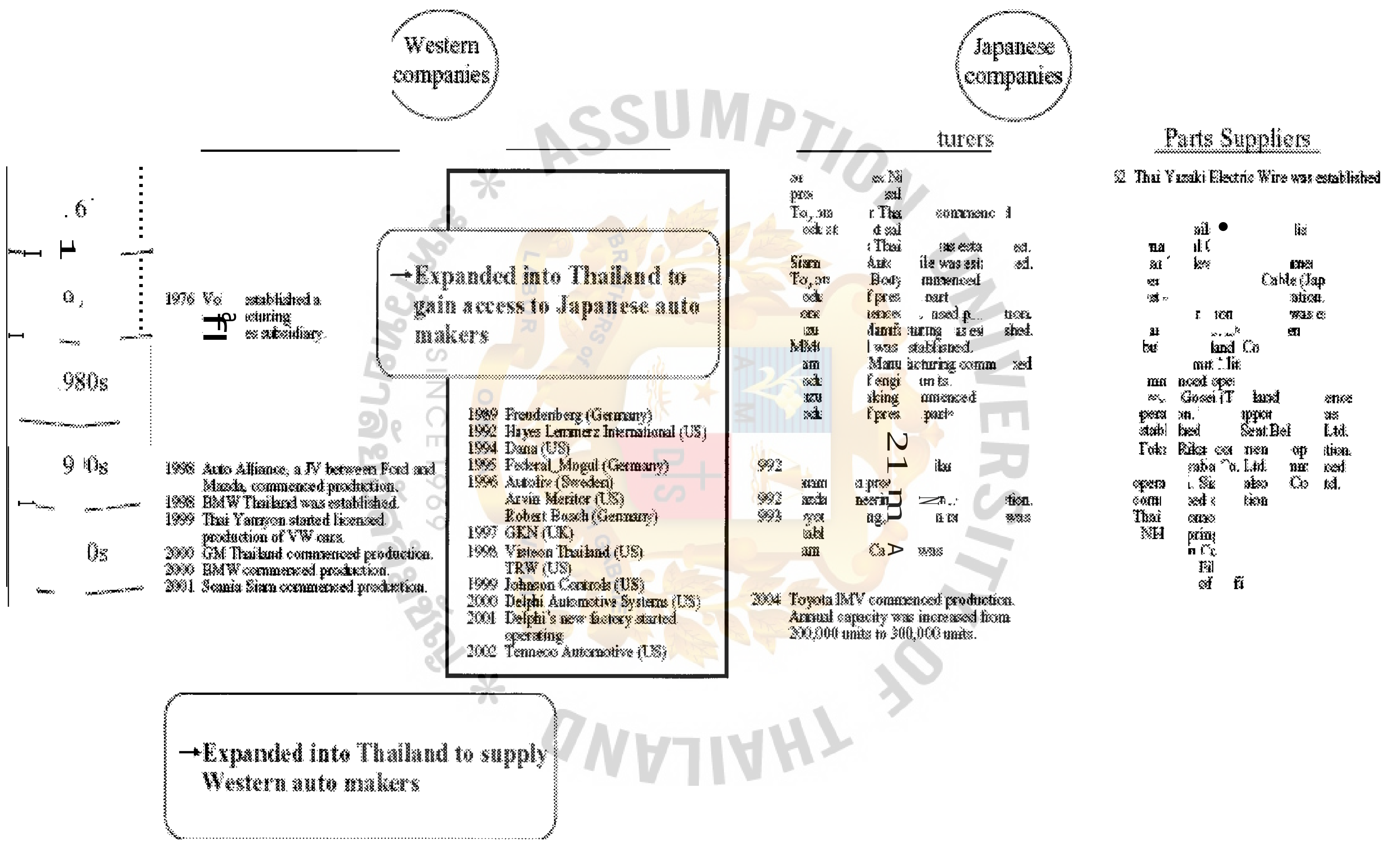
Appendix K: Unit production of Western auto manufacturers in Thailand



→Western auto manufacturers expanded into 'Thailand in 1990 or later and have ii. rapidly increasing their presence.

Source: FOURIN Inc., 2002 Asian Automotive Industry (2002 Ajia Jidousya Sangyo)

Appendix L: History of Thai Expansion by estern and Japanese Auto-related Companies



Source: Braxton Inc., based on various materials.

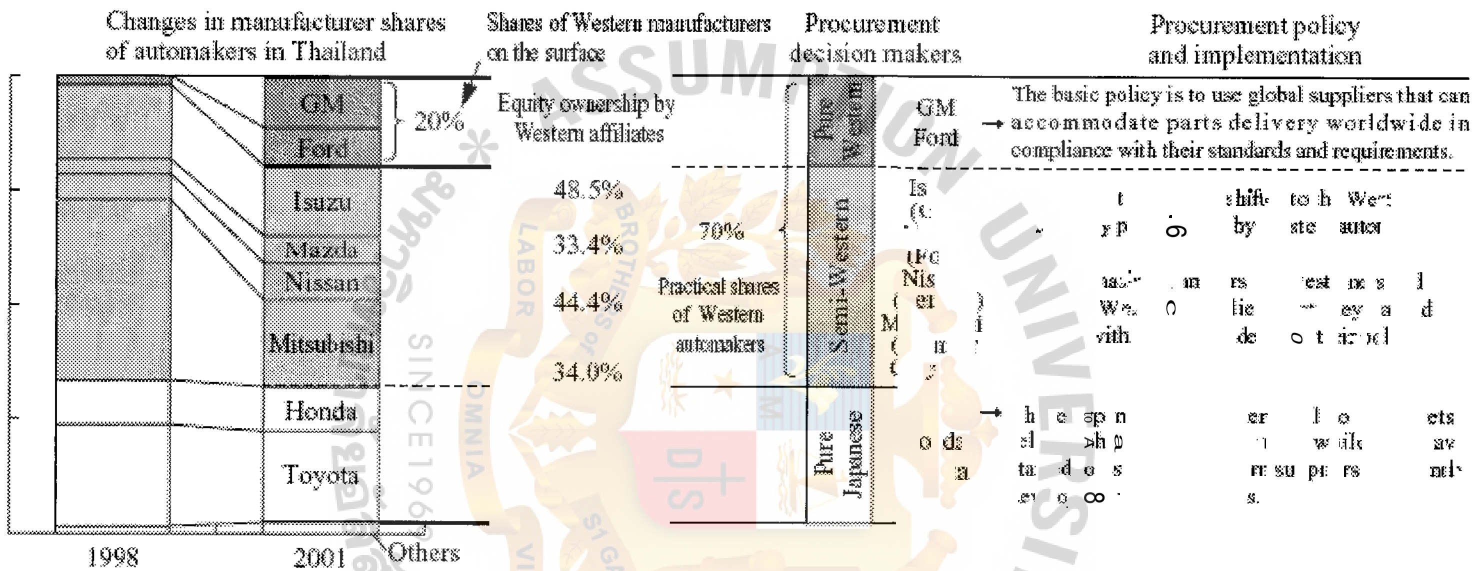
Appendix M: Equity Ownership of Leading Western Parts Suppliers in Thai Subsidiaries

Parent Company	Thai Subsidiary	Equity Ownership
Autoliv (Sweden)	Autoliv (Thailand)	50%
Robert Bosc (Germany)	BJKC (Thailand)	100%
GKN (UK)	GKN Driveshafts (Thailand)	100%
Dana	Dana Spicer Thailand	95%
Visteon	VisteonThailand	100%
Lear	General Seating (Thailand)	50%
TRW	TRW Steering & Suspension	100%
Johnson Controls	Johnson C & Summit Interiors	60%
Delphi	Delphi automotive Symms	100%

→ Secured a majority stake mad control.

Source: Compiled from annual reports, company web sites and others.

Appendix N: Manufacturer Shares of WesternAutomakers in Thailand



s Association Inc ("AMA).

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LIST OF TABLES

Table 1.1 Location of Auto Part Suppliers Plant of Ford Company

No.	Supplier name	Parts	Plant Location
1	Halla Climate Control (Thailand) Co., Ltd.	A/C system	Rayong
2	Aoyama Thai Co., Ltd.	Chassis	Samuthprakarn
3	Asahi Tec Aluminium (Thailand) Co., Ltd.	Chassis	Samuthprakarn
4	Koyo Steering (Thailand) Co., Ltd.	Chassis	Chachoengsao
5	Bosch Automotive (Thailand) Co.,Ltd.	Chassis	Rayong
6	Kallawis Auto Parts Industry Co., Ltd.	Chassis	Samuthprakarn
7	KLK Industry Co., Ltd.	Chassis	Bangkok
8	Jtekt (Thailand) Co.,Ltd.	Chassis	Chachoengsao
9	Nisshinbo Somboon Automotive Co., Ltd.	Chassis	Rayong
10	NSK Bearings (Thailand)Co., Ltd.	Chassis	Bangkok
11	Siam Kayab a C o., Ltd.	Chassis	Samuthprakarn
12	Dana Spicer (Thailand) Ltd.	Chassis	Rayong
13	Summit Steering Wheel Co., Ltd.	Chassis	Samuthprakarn
14	Thai Bridgestone C o., Ltd.	Chassis	Bangkok
15	Thai Steel Cable Plubic Co., Ltd.	Chassis	Samuthprakarn
16	Tokic o (Thailand) Ltd.	Chassis	Bangkok
17	Yarnapund Public Co.,Ltd.	Chassis	Samuthprakarn
18	KYB Steering (Thailand) Co.,Ltd	Chassis	Chonburi
19	Siam NSK Steering System Co., Ltd.	Chassis	Chachoengsao
20	Enkei Thai Co., Ltd.	Chassis	Samuthprakarn
21	P.C.Products International Co., Ltd.	Chassis	Samuthprakarn
22	NTN Bearing (Thailand) Co., Ltd.	Chassis	Rayong
23	Unisia Jecs (Thailand) Co., Ltd.	Chassis	Chachoengsao
24	Lucasvarity (Thailand) Co., Ltd.	Chassis	Rayong
25	Feltol Manufacturing Co., Ltd.	Chassis	Samuthprakarn
26	Federal-Mogul Friction Products (Thailand) Ltd.	Chassis	Ayudhaya
27	NSK Bearings Manufacturing (Thailand) Co., Ltd.	Chassis	Chonburi
28	Chuo Thai Cable Co., Ltd.	Chassis	Rayong
29	GKN Driveline (Thailand) Ltd.	Chassis	Rayong
30	NTN Manufacturing (Thailand) Co.,Ltd.	Chassis	Rayong
31	Sumitomo Electric Wiring Systems (Thailand) Ltd.	Chassis	Bangkok
32	Nabtesco Automotive Products (Thailand) Co.,Ltd.	Chassis	Samutprakarn
33	Dionys hofmann (Thailand) Co., Ltd.	Chassis	Bangkok
34	Michelin Siam Company Limited	Chassis	Chonburi
35	Sanko Kiki (Thailand).Co.,Ltd	Chassis	Chonburi
36	Ohashi Technica (Thailand) Co.,Ltd	Chassis	Samutprakarn
37	Summit Auto Body Industry Co.,Ltd	Chassis	Samutprakarn
38	PBR Automotive (Thailand) Ltd.	Chassis	Rayong
39	TRW Steering & Suspension Co., Ltd.	Chassis	Rayong
40	Panasonic Industrial (Thailand) Ltd.	Electrical	Bangkok

Table 1.1 Location of Auto Part Suppliers Plant of Ford Company

No.	Supplier name	Parts	Plant L ation
41	Siam GS Battery Co., Ltd.	Electrical	Samuthprakarn
42	Thai Arrow Products Co., Ltd.	Electrical	Samuthprakarn
43	Kintetsu World Express (FAThailand) Co., Ltd.	Electrical	Bangkok
44	Tokai Rika (Thailand) Co., Ltd.	Electrical	Rayong
45	Dens o International Thailand Co., Ltd.	Electrical	Samuthprakarn
46	Omron Automotive Electronics Co., Ltd.	Electrical	Ayutthaya
47	Thai Asahi D ens o Co., Ltd.	Electrical	Rayong
48	KPN Plastic Public Company Limited	Electrical	Samuthprakarn
49	Thai Escorp Ltd.	Electrical	Chonburi
50	ArvinMeritor (Thailand) Co., Ltd.	Engine&P/T	Rayong
51	Able Sanoh Industries(1996) Co Ltd.	Engine &DT	Ayutthaya
52	Art-Serina Piston Co., Ltd.	Engine&P/T	Bangkok
53	Dyna Metal Co., Ltd.	Engine&P/T	Chachoengsao
54	International Casting Co., Ltd.	Engine&P/T	Chonburi
55	KPN Automotive Public Co. ,Ltd.	Engine&PVT	Chonburi
56	MAHLE Engine Components (Thailand) Co.,Ltd.	Engine&P/T	Bangkok
57	Jibuhin (Thailand) Co., Ltd.	Engine&P/T	Chonburi
58	NHK Gasket (Thailand) Co., Ltd.	Engine&P/T	Samuthprakarn
59	Nichias Rungruang Co., Ltd.	Engine&P/T	Samuthprakarn
60	Nittan (Thailand) Co., Ltd.	Engine&P/T	Chonburi
61	Siam Hitachi Automotive Products Ltd.	Engine&P/T	Chonburi
62	Mitsubishi Electric Thai Auto-Parts Co Ltd.	Engine&P/T	Rayong
63	S.W. & Sons Co., Ltd.	Engine&P/T	Nakhonrajsima
64	EXEDY (Thailand) Co., Ltd.	Engine&P/T	Chonburi
65	Siam Riken Industrial Co., Ltd.	Engine&P/T	Chonburi
66	Somboon Malleable Iron Industrial Co., Ltd.	Engine&P/T	Samuthprakarn
67	Aisin-Ai (Thailand) Co.,Ltd.	Engine&P/T	Chachoengsao
68	Thai Asakawa Co., Ltd.	Engine&P/T	Rayong
69	Siam AT Industry Co., Ltd.	Engine&P/T	Prathumthanee
70	Thai Meira Co., Ltd.	Engine&P/T	Rayong
71	Thai NOK C o., Ltd.	Engine&P/T	Samutprakarn
72	Thai Summit Engineering Co., Ltd.	Engine&P/T	Samuthprakarn
73	Thongchai Industries Co., Ltd.	Engine&P/T	Samuthprakarn
74	Engelhard Chemcat (Thailand) Ltd.	Engine&P/T	Rayong
75	Yamada Somboon Co., Ltd.	Engine&P/T	Rayong
76	Cherry Serina C o., Ltd.	Engine&P/T	Chonburi
77	Summit Chugoku Seira Co Ltd.	Engine&P/T	Chonburi
78	Thai Fukoku Co., Ltd.	Engine&P/T	Chachoengsao
79	MAHLE Siam Filter System Co., Ltd.	Engine&P/T	Samuthprakarn
80	Siam NGK Spark Plug Co., Ltd	Engine&P/T	Chonburi

Table 1.1 Location of Auto Part Suppliers Plant of Ford Company

No,	Supplier name	Parts	Plant Location
81	Siam Calsonic Co., Ltd.	Engine&P/T	Chonburi
82	MI Turbo (Thailand) Co.,Ltd.	Engine &PIT	Chonburi
83	Gate Unitta (Thailand) Co.,Ltd.	Engine&P/T	Rayong
84	Sanoh Industries (Thailand) Co.,Ltd.	Engine&P/T	Rayong
85	Calsonic Sales (Thailand) Co.,Ltd.	Engine&P/T	Chonburi
86	Taiho (Thailand) Co.,Ltd.	Engine&P/T	Pathumthani
87	Maruyasu Industries (Thailand) Co.,Ltd.	Engine&P/T	Rayong
88	TBKK (Thailand) Co.,Ltd.	Engine &DT	Chonburi
89	Usui International Corporation (Thailand) Ltd.	Engine&P/T	Chonburi
90	Siam Metal Technology Co.,Ltd.	Engine&P/T	Rayong
91	Togo Seisakusyo (Thailand) Co.,Ltd	Engine&P/T	Rayong
92	Sumitomo Electric Sintered Components (Thailand) Co.,Ltd.	Engine&P/T	Bangkok
93	Calsonic Kansei (Thailand) Co. ,Ltd.	Engine&P/T	Chonburi
94	P. C. S. Precision Works Co. ,Ltd.	Engine&P/T	Nakorn-Rajsima
95	Autrans (Thailand) Co., Ltd.	Engine&P/T	Bangkok
96	Mitsui Siam Components Co., Ltd.	Exterior	Rayong
97	Saint-Gobain Sekurit (Thailand) Co., Ltd.	Exterior	Rayong
98	Thai Decal Co., Ltd.	Exterior	Samuthprakarn
99	Daiwa Kasei (Thailand) Co., Ltd.	Exterior	Ayutthaya
100	Thai Koito C o., Ltd.	Exterior	Samuthprakarn
101	AGC Automotive (Thailand) Co.,Ltd.	Exterior	Chonburi
102	3M Thailand Limited	Exterior	Bangkok
103	To ac s (Thailand) C o., Ltd.	Exterior	Chonburi
104	Union. Nifc o Co., Ltd.	Exterior	Chachoengsao
105	Delta-TR Co., Ltd.	Exterior	Bangkok
106	Alpha Industry (Thailand) Co., Ltd.	Exterior	Prachinburi
107	Piolax (Thailand) Ltd.	Exterior	Bangkok
108	Siam Nikech Co. ,Ltd.	Exterior	Samuthprakarn
109	Toyo Roki (Thailand) Co. ,Ltd.	Exterior	Rayong
110	Able Progress Industry Co., Ltd.	Exterior/plastic	Pathumthani
111	Sanko Gosei Technology (Thailand) Ltd.	Exterior/plastic	Rayong
112	Molten Asia Polymer Products Co., Ltd.	Exterior/plastic	Chonburi
113	Hitachi Chemical Automotive Product (Thailand) Co.,Ltd.	Exterior/plastic	Rayong
114	Toyoda Gosei (Thailand) Co., Ltd.	Exterior/plastic	Chonburi
115	Thai Stanley Electric Public Co., Ltd.	Exterior/plastic	Pathumthanee
116	Thai Starlite Manufacturing Co., Ltd.	Exterior/plastic	Chachoengsao
117	Ampas Industries Co., Ltd.	Exterior/plastic	Samuthprakarn
118	Inoac Automotive (Thailand) Co. ,Ltd.	Exterior/plastic	Prachinburi
119	Topy Fasteners (Thailand) Limited	Fastener	Chonburi
120	Visteon (Thailand) Limited	Interior	Rayong

Table 1.1 Location of Auto Part Suppliers Plant of Ford Company

No.	Supplier name	Parts	Plant Location
121	General Seating (Thailand) Co Ltd.	Interior	Rayong
122	Ashimori (Thailand) Co. Ltd.	Interior	Chachoengsao
123	Takata TOA Co., Ltd.	Interior	Chachengsao
124	T.C.H. Suminoe Co., Ltd.	Interior	Bangkok
125	Autoliv Thailand Ltd.	Interior	Chonburi
126	Bangkok Foam Co., Ltd.	Interoir	Bangkok
127	Hayashi Telempu (Thailand) Co., Ltd.	Interoir	Chonburi
128	NHK Spring (Thailand) Co., Ltd.	Interoir	Samuthprakarn
129	S.K.Auto Interior Co., Ltd.	Interoir	Chachoengsao
130	SNC Sound Proof Co., Ltd.	Interoir	Chonburi
131	Tigerpoly (Thailand) Ltd.	Interoir	Ayuthaya
132	Summit Laemchabang Auto Seats Manufacturing Co Ltd.	Interoir	Samuthprakarn
133	Kurashiki Siam Rubber Co., Ltd.	Rubber Part	Prachinburi
134	Nishikawa Tachaplalert Rubber Co., Ltd.	Rubber Part	Bangkok
135	Bando Manufacturing (Thailand) Ltd.	Rubber Part	Samutsakorn
136	Yokohama Rubber (Thailand) Co., Ltd.	Rubber Part	Rayong
137	Toyoda Gosei Rubber (Thailand) Co., Ltd.	Rubber Part	Chonburi
138	Tokai Eastern Rubber (Thailand) Ltd.	Rubber Part	Bangkok
139	Inoue Rubber (Thailand) Public Co., Ltd.	Rubber Part	Ayutthaya
140	Inoac Tokai (Thailand) Co., Ltd.	Rubber Part	Ayutthaya
141	CPR Gomu Industrial Public Co. ,Ltd.	Rubber Part	Ayutthaya
142	Kinugawa (Thailand) Co.,Ltd.	Rubber Part	Ayutthaya
143	Thai Kokoku Rubber Co.,Ltd.	Rubber Part	Ayutthaya
144	M & T Allied Technologies Co., Ltd.	Rubber Part	Rayong
145	Ayutthaya HCL Co.,Ltd.	Rubber Part	Bangkok
146	Aapico Hitech Plublic Company Limited	Stamping	Ayuthaya
147	CH.Auto Parts Co., Ltd.	Stamping	Samuthprakarn
148	Summit Laemchabang Auto Body Work Co., Ltd.	Stamping	Chonburi
149	Takao Eastern Co., Ltd.	Stamping	Rayong
150	Thai Summit Laemchabang AutoParts Co., Ltd.	Stamping	Samuthprakarn
151	Thai Summit PKK Co., Ltd.	Stamping	Chonburi
152	Yorozu (Thailand) Co., Ltd.	Stamping	Bangkok
153	Thai Summit Hirotech Co., Ltd.	Stamping	Rayong
154	Asno Horie(Thailand) Co., Ltd.	Stamping	Rayong
155	Thai Summit AutoParts Industry Co., Ltd.	Stamping	Samuthprakarn
156	Siam Aisin Co, Ltd.	Stamping	Prachinburi
157	Kiat Charo en City Parts Co., Ltd.	Stamping	Bangkok
158	Hino Motors Manufacturing (Thailand) Ltd.	Stamping	Samuthprakarn
159	Thai Summit Eastern Seaboard Autoparts Industry Co.,Ltd.	Stamping	Samutprakarn
160	Ingress Autoventure s Co., Ltd.	Stamping	Rayong

Table 2.1: Summary of Major Criteria and Sub-Factors Affecting International Location Decisions

Major	
	wag(; . and trends in w'ige manufacturing land arid other R&D costs etc)
Labour characteristics	of labour font; unemployment attitude towards work and force management
frastr icture	roads and tsk and f f transportation; ;d .
Proxi ty su	for
	,peed s of
markets/customers	Proximity market that can am! time to and nature and if demand
Proximity company	
	and in clima hospitals, al children); crime rate and standard
and regulatory	
	. ventures transfer rate
nii factors	ncentives; ry ....
	cumate; debt; t per
Government and political factors	Ps: gove: y; government policy; and attitude of government d
and cultural f tors	. culture; and customer characteristic
location	a specinc A 1?;i '...... anituide. of r c to
	... a raw of and

Table 2.2: Major Facility Location Factors

Location factors	Decription
1 Access to markets/distribution centres	Cost of serving markets
	Trends in sales by areas
	Ability to penetrate local market by plant presence
2 Access to supplies/resources	Transportation costs
	Trends in supplier by area
3 Community/government access	Ambience/cost of living
	Co-operation with established local industry
	Community pride
	Housing/churches
	Schools and colleges
4 Competitive considerations	Location of competitors
	Likely reaction to the new site
5 Environmental factors	Community attitude
	State/local governmental regulations
6 Labour	Prevailing wage rates
	Extent and militancy of unions in the area
	Productivity
	Availability
	Skill levels available
7 Taxes and financing	State income tax/local property and income taxes
	Unemployment and compensation premiums
	Tax incentive concessions
	Industrial pollution control revenue bonds
8 Transportation	Trucking service
	Rail service
	Air freight service
9 Utilities services	Quality and price of water and sewerage
	Availability and price of electric and natural gas
	Quality of police, fire, medical services

Table 4.1: Transportation Rate from **Rayong** to Selected Locations

No.	Province	Distance (Km)	Transit rate for 6 units							
			10.00-11.49		11.50-12.99		13.00-14.49		14.50-15.99	
			Per Unit	Per Trip	Per Unit	Per Trip	Per Unit	Per Trip	Per Unit	Per Trip
1	Ayuthaya	193	1,003	6,018	1,033	6,198	1,063	6,378	1,093	6,558
2	Bangkok	117	844	5,064	869	5,214	895	5,370	920	5,520
3	Burin=	467	2,015	12,090	2,075	12,450	2,136	12,816	2,196	13,176
4	Chachoensao	79	684	4,104	705	4,230	725	4,350	746	4,476
5	Chainat	311	1,444	8,664	1,487	8,922	1,513	9,186	1,574	9,444
6	Chonburi	36	445	2,670	458	2,748	472	2,832	485	2,910
7	Kanchanaburi	245	1,165	6,990	1,200	7,200	1,235	7,410	1,270	7,620
8	Khan Kaen	506	2,121	12,726	2,185	13,110	2,248	13,488	2,312	13,872
9	Nakon Pathom	173	815	4,890	839	5,034	864	5,184	888	5,328
10	Nakorn Ratchasima	316	1,397	8,382	1,439	8,634	1,481	8,886	1,523	9,138
11	Nonthaburi	137	886	5,316	913	5,478	939	5,634	966	5,796
12	Phetchaburi	240	1,144	6,864	1,178	7,068	1,213	7,278	1,247	7,482
13	Prachinburi	155	923	5,538	951	5,706	978	5,868	1,006	6,036
14	Pathumthanee	145	903	5,418	930	5,580	957	5,742	984	5,904
15	Ratchaburi	217	1,047	6,282	1,078	6,468	1,110	6,660	1,141	6,846
16	Samutprakarn	100	809	4,854	833	4,998	858	5,148	844	5,064
17	Samutsakorn	153	919	5,514	947	5,682	974	5,844	1,002	6,012
18	Samut Songkhram	189	994	5,964	1,024	6,144	1,054	6,324	1,083	6,498
19	Saraburi	224	1,077	6,462	1,109	6,654	1,142	6,852	1,174	7,044
20	Trat	198	1,013	6,078	1,043	6,258	1,074	6,444	1,104	6,624