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Abstract

This paper uses agglomeration theory to analyze the impact of Thai government policies on the development of the Thai automotive industry and cluster formation in Central and Eastern Thailand. Using cross-section data on 162 auto-parts suppliers from the Thailand Automotive Directory 2003-2004, the paper examines the criteria of supplier selection in the Thai automotive industry. Using logit models and cross-section data on 162 auto-parts suppliers from the Thailand Automotive Directory 2003-2004, the paper examines the effects of economies of scale, technology, distance between suppliers and assembler plants, and nationality on the likelihood of a supplier being selected as a subcontractor. Furthermore, the paper compares the role of these factors for different types of assemblers – Japanese and American, automobile and motorcycle. The findings suggest that scale of production is a dominant factor while there is no significant preference for suppliers of the same nationality as the assembler. In addition, assemblers are more likely to choose parts makers located in close proximity as their subcontractors, as the agglomeration theory predicts. Finally, the comparison of supplier selection criteria for different types of assemblers shows that there exists commonalities in valuing economies of scale while the automobile assemblers is the group that mostly concern technological level of suppliers.

1. Introduction

The economic significance of the automobile industry lies both in its scale and the complexity of its direct and indirect links with many other industries. For this reason, the sector has received considerable attention, both by policy makers and by researchers. One area of particular focus is the local subcontracting arrangements of vehicle manufacturers because of the vertical spillovers these generate. In addition, an abundance of previous studies has paid significant attention to the effect of geographical economies and/or agglomeration economies on the supplier selection decision. Marukawa (2003), for example, has examined the criteria of supplier selection and trends in component outsourcing within and across regions in China, while Ono (2001) has focused on the relationship between local market size, the degree of outsourcing, and the productivity of local firms. Agglomeration economies and the location decisions of domestic and foreign auto-parts suppliers are also examined in Klier et al. (2004), Nagao (2002), and Muray et al. (1999).

The automotive industry is also of considerable importance for the Thai economy. According to the Thailand Automotive Industry Directory 2003－2004, the automotive industry is Thailand's third largest industry and, directly and indirectly, accounts for more than 200,000 jobs. In 2004, Thailand produced more than 900,000 cars and trucks and approximately 2.8 million motorcycles. However, there are only a few studies that have quantitatively examined the local subcontracting decisions of automobile manufacturers. Maruhashi (1995) and Chareonporn (2001), for example, have looked at supplier selection in the Thai automotive industry, focusing in particular on the vertical integration decisions of assemblers, but their analysis is largely of a qualitative nature. In addition, especially in the case of Thailand, there are few studies examining the criteria based on which auto-parts suppliers are selected. This paper attempts to fill this gap by examining supplier-selection criteria quantitatively, focusing in particular on the role of distance between trading partners. If we view the Thai automotive industry as a cluster, distance is a crucial variable that may help to explain the supplier system in the industry.

The paper is organized as follows. The next section provides a historical overview of the development of the Thai automotive industry and discusses the effects of government policies on the concentration of auto-parts and automobile manufacturers in Central and Eastern Thailand by using agglomeration theory. The structure and current situation of the Thai automotive industry are outlined in Section 3. Section 4 explains general concepts of subcontracting and compares Japanese and Western subcontracting systems in Thailand. Section 5 presents the theoretical framework, model and data sources. Using cross-section data from 162 auto-parts suppliers, the study employs logit models to examine the role of economies of scale, technology, distance, location advantages, and nationality in supplier selection. Furthermore, differences in supplier selection criteria between Japanese and American assemblers as well as between automobile and motorcycle manufacturers are explored. Section 6 then presents the results and their interpretation, while Section 7 offers concluding remarks.

2. The Thai Automotive Industry

2.1 Development, Structural Changes and Government Policies

Thailand has become the world's second largest market for 1 ton pick-up trucks after the US 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 unusual policies toward the 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 Figure 1.

Insert Figure 1

2.2 Cluster Formation

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 (BOI)'s incentive systems. According to a study on 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. Samut Prakan, Chon Buri and Rayong 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 Samut Prakan Provinces. The location distribution of assembly plants and first-tier auto-parts suppliers is shown in Figures 2 and 3.

Insert Figures 2 and 3

Reasons for the 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 Samut Prakan. 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 Chon Buri 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. These factors are consistent with agglomeration theory, which will be explained in more detail in Section 5 and considers the trade-off between negative and positive externalities.

In aggregate, the described developments indicate that auto-parts firms in Thailand have tended to locate in the vicinity of an agglomeration of assembly plants and vice versa.

3. The Structure and Current Situation of the Thai Automotive Industry

3.1 The Structure of the Thai Auto-Parts Industry

The Thai automotive industry is composed of fourteen car assemblers, five motorcycle assemblers, and 1,709 auto-parts manufacturers, 709 of which are first-tier suppliers. According to the Office of Industrial Economics, Ministry of Industry, in 2002, Thailand's car and motorcycle production capacity per year was 1,073,700 and 2,080,000 units, respectively. The production capacity of each assembler is shown in Table 1.

With respect to ownership of first-tier suppliers that supply parts to assemblers directly, the following pattern emerges: approximately 50 percent are wholly Thai-owned, 10 percent are Thai majority-owned and 40 percent are foreign majority-owned. The structure of the industry is depicted in Figure 4.

Insert Table 1, Figure 4

Major parts that are produced in Thailand include engines, suspension systems, brakes, clutches, steering wheel systems, body parts, electronic parts, accessories, tires, plastics and glasses, etc. Table 2 divides first-tier auto-parts makers into eight categories according to the parts they supply. The table indicates that wholly Thai-owned firms account for 50 percent of all auto-parts makers. However, it also shows that it is foreign majority-owned firms that are the dominant players in each of the major parts categories (categories 1-7) except for "body parts," which do not require a very high level of technology.

Insert Table 2

3.2 The Current Situation of the Thai Automobile and Auto-Parts Industry[1]

<u>3.2.1 Automobiles</u>

Thailand's automobile industry rapidly recovered from the 1997/98 Asian crisis and production has been steadily increasing since 1999. Between 1997 and 2004, production on average increased by 81.2 percent a year. Growth continued in the first six months of 2005, with production rising by 15.9 percent, sales going up by 15.8 percent, and exports increasing by 25.9 percent compared with the corresponding period a year earlier. Automobile production in the first half of 2005 amounted to 517,829 units, domestic sales came to 345,897 units, and exports reached 191,180 units.

Thailand's auto market has been dominated by Japanese brands. Based on domestic sales in the first half of 2005, Toyota, the best-selling brand in Thailand, occupied a domestic market share of 40.6 percent while Isuzu and Honda had the second and third highest market shares, with 25.4 percent and 7.1 percent respectively. The major export destinations for Thai automotive production are Indonesia, Singapore, the Philippines, Australia and Japan. Pick-up trucks, which are also the best-selling vehicle type in the domestic market, are the major export item, followed by passenger cars.

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[1] Data referred to in this section are from the Thai Automotive Institute, online: <www. thaiauto.or.th>

The trends in the production, sales, and exports of automobiles from 1996 to 2005 are shown in Tables 3 to 5.

Insert Tables 3, 4 and 5

3.2.2 Motorcycles

During the first half of 2005, motorcycle production volume dropped to 1,179,443 units from 1,442,133 units during the corresponding period in 2004, representing a decrease of 18.2 percent (see Table 6). However, motorcycle sales still posted a small increase of 1.2 percent from 1,031,577 units to 1,044,247 units in the first six months of 2005. The best-selling motorcycle brand in Thailand is Honda. Based on sales in the first half of 2005, Honda occupied a market share of 69.6 percent, followed by Yamaha with a market share of 14.2 percent.

Insert Table 6

3.2.3 Auto-Parts

According to data from the Department of Trade Negotiations, Ministry of Commerce, the export value of Thailand's automobile and motorcycle parts from January to June 2005 totaled 111,311.8 million baht, an increase of 27.3 percent from the corresponding period in the previous year. The major export markets for auto-parts are Japan, the United States, Malaysia, South Africa and Indonesia. The most important auto-parts exports items are OEM parts (33,695.73 million baht), engines (3,951.53 million baht), and spare parts (1,804.73 million baht) (see Table 7).

Insert Table 7

4. Subcontracting Concepts and Patterns

4.1 Types of Subcontracting

Broadly speaking, there are two approaches to analyzing subcontracting systems: the first looks at subcontracting arrangements from the point of view of the assembler, examining the number of suppliers an assembler uses to procure a certain type of component. The second looks at subcontracting arrangements from the point of view of the subcontractor, considering the subcontractor's position in the overall supply system and its number of clients. The following subsections look at subcontracting arrangements from both points of view in greater detail.

4.1.1 Single and Multiple Sourcing

Looking first at subcontracting arrangements from 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.

4.1.2 Exclusive and Shared Suppliers

Turning to subcontracting arrangements from the viewpoint of suppliers, again two approaches can be distinguished: exclusive supply arrangements and shared supply arrangements. *Exclusive suppliers* are those who exclusively supply a particular part to an assembler whereas *shared suppliers* supply parts or services to several vehicle manufacturers.

For assemblers, the merits of using exclusive suppliers are access to customized products and a strong bargaining position vis-à-vis exclusive suppliers. On the other hand, using shared suppliers allows assemblers to enjoy lower prices resulting from economies of scale suppliers can attain. In addition, a system of shared suppliers also generates positive network externalities. Shared suppliers gain access to the technologies and know-how of several vehicle manufacturers and are in tune with the needs of a variety of customers. Such access helps to improve product quality and ultimately benefits all vehicle manufacturers (Nabeoka, 1996). However, using shared suppliers also carries some risks, such as the leakage of proprietary knowledge or having little negotiation power over suppliers.

4.2 Japanese and Western Subcontracting Systems

4.2.1 The Japanese Subcontracting System in Thailand

The primary features of Japanese vehicle manufacturers' outsourcing arrangements are long-term relationships, *QCDEM* systems (explained below), and suppliers' associations.

Long-Term Relationships

Japanese vehicle manufacturers usually develop long-term relationships with their parts suppliers. Long-term relationships allow Japanese assemblers to recognize suppliers' capabilities and technologies through ongoing relational contracting. In addition, such relationships provide incentives to suppliers to perform well in order to maintain the relationship. Furthermore, suppliers are provided with the necessary certainty to invest in research and development as it is unlikely that a contract will be completely terminated once a "formal purchase agreement"[2] is signed. Put simply, long-term relationships simultaneously

[2] According to a survey by Maruhashi (1995), in Toyota's case, for example, a formal purchase

function as monitoring and incentive systems and help assemblers to economize on their supplier monitoring costs.

QCDEM Criteria

Japanese assemblers commonly use QCDEM criteria to select auto-parts suppliers and to measure supplier performance, where QCDEM stands for Quality, Cost, Delivery, Engineering and Management.

Assemblers place high importance on the quality of components while at the same time trying to control their costs. To achieve this, in their dealings with suppliers, assemblers set cost reduction schedules in advance and adjust target prices periodically, taking innovation and movements in raw material prices into account. This schedule propels suppliers to conduct research and work toward innovations to meet the cost target and enhance their profitability. Both Japanese and Western assemblers employ cost reduction schedules to enhance supplier performance.

Delivery performance is another important requirement of Japanese vehicles manufacturers. To economize on inventory costs, Japanese assemblers rely on lean production and just-in-time (JIT) systems which require suppliers to deliver the necessary volume of auto-parts at the time they are needed. Consequently, suppliers must provide high delivery performance and act as inventory buffers for vehicle manufacturers.

Lastly, production efficiency, design capabilities, quality control as well as on-time delivery are generally determined by engineering and management know-how. Engineering capabilities include capabilities in the areas of design and cost reduction thorough Value

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agreement is valid until the model is phased out. The usual period for a full model change is four years and for a minor model change two years.

Analysis (VA) and Value Engineering (VE).[3] Most of the technologies used in Thai auto-parts firms have been transferred from Japanese, American and European firms through licenses or technical assistance. Regarding management systems, local suppliers are also accustomed to Japanese management systems such as *kaizen*, *kanban* and Total Quality Management (TQM).

According to a survey by the Thai Auto-Parts Manufacturers Association (TAPMA) (2002), first-tier suppliers in Thailand perform well in the area of quality control. They can supply parts with average defect rates of 25-50 parts per million (ppm) which is below the 100 ppm target rate. Concerning cost reductions, assemblers set targets of 3 to 25 percent for OEMs for automobile parts and of 40 percent for motorcycles parts. The relatively high reduction rate for motorcycle parts is due to strong international competition and an influx of cheap motorcycle parts from China. The replacement market in Thailand also has to contend with fierce price competition, especially from Taiwan, China and India. Regarding the technological capabilities of Thai suppliers, TAPMA (2002) found that the lack of high-end technologies as well as new trends in outsourcing systems, such as global sourcing policies, design-in or module sourcing, and shorter life-cycles for parts has relegated Thai suppliers from first-tier to second- or lower-tier suppliers. TAPMA (2002) also identified three major management problems in small Thai auto-parts firms: the scarcity of skilled workers, low management abilities in the area of quality control and working environment, and a lack of knowledge about international standards such as ISO 9000/1400/16949. These problems are responsible for the fact that Thai auto-parts firms, especially SMEs, have difficulties in gaining certification to international quality standards.

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[3] Value Analysis is used to modify a design to reduce costs in the production stage while Value Engineering helps suppliers to attain efficiency in production by reducing costs in design and the trial production stage.

Supplier Associations

There are two main objectives underlying the establishment of supplier associations: to improve performance and to create strong relationships among suppliers.

Supplier associations help suppliers to more quickly resolve problems and create an environment conducive to innovation. Suppliers can use these associations as a forum for consultations to share techniques and know-how. Furthermore, the use of shared technologies and management systems facilitates understanding among suppliers and assemblers and brings about higher productivity and efficiency in vehicle production (Maruhashi, 1995; Charoenporn, 2001). Moreover, assemblers can use the association as a forum to announce cost reduction schedules and other basic policies.

Another purpose of the associations is to help strengthen relationships among suppliers. The associations hold annual meetings, golf and bowling tournaments and sport days, as well as organize case study activities, lectures, factory visits, and overseas seminars to improve suppliers' skills.[4] Apart from uniting and training suppliers, these activities also contribute to developing and sustaining long-term relationships between assemblers and suppliers. In Thailand, suppliers are allowed to join several supplier associations, providing the advantage that suppliers' know-how can be improved through working with several automobile manufacturers.

In contrast with Japanese carmakers, Western manufacturers do not rely on suppliers associations, although they also have supplier quality development (SQD) departments, hold quality contests, and rely on supplier ratings to improve the quality of supplies. For example, Auto Alliance, a joint venture of Ford and Mazda, uses QOS and APQP[4] to enhance the

[4] Toyota Motor Thailand (1992: 22), *TCC-A History of the First 10 Years*

[4] A Quality Operation System (QOS) helps to increase the competitiveness of a firm by generating continuous improvement via strategic goals based on the organizational mission, customer expectations and competitive benchmarks.

performance of suppliers and awards the AAT (Auto Alliance Thailand) Preferred Suppliers Quality Award to encourage suppliers to continually improve. Similarly, GM employs a “16-step global supplier quality improvement process” designed to help suppliers understand GM’s business procedures around the world and to work toward continuous improvements.

4.2.2. The Western Subcontracting System in Thailand

The four major features of subcontracting systems used by Western manufacturers in Thailand are the use of market mechanisms, international standards, and global sourcing, and little investment in local auto-parts firms. First, Western assemblers prefer to use market mechanisms and international standards to control supplier performance. Western assemblers, for example, have spun off former affiliates to establish these as independent suppliers: Delphi Automotive became independent of GM in June 1999, while Visteon now also is independent of Ford.

Second, Western assemblers introduced QS9000, ISO/TS16949 standards to Thailand. Such international standards benefited both assemblers and suppliers by reducing waste and inventories, increasing customer satisfaction, and injecting robust management and control. The leading parts suppliers of Western assemblers such as Delphi, in turn, require their suppliers to meet QS9000 standards and participate in SPDPs (Supplier Performance Development Programs. This trend pushes auto-parts suppliers in Thailand to meet Western standards.

In addition, international standards also play an important role in the global sourcing strategies of Western assemblers. Uniform standards of production allow assemblers

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Advanced Product Quality Planning (APQP) is a cross-functional approach to ensure that the quality of products will satisfy customers.

flexibility in procuring parts globally. Using global sourcing, assemblers gain greater negotiating power, achieve lower procurement costs and benefit from economies of scale. Compared to Western assemblers and component suppliers, who progressively use internet links to procure and supply parts globally, Japanese automobile manufacturers are still lagging behind. Japanese electronic interchange data systems such as Commerce at Light Speed (CALS), jointly developed by Toyota and the Ministry of International Trade and Industry (MITI, now the Ministry of Economy, Trade and Industry, METI), are still more expensive than Western systems (Paopongsakorn, 2003).

Regarding investments in local auto-parts suppliers, Western assemblers have been less aggressive than their Japanese counterparts. Only their former affiliated suppliers such as Delphi and Visteon have invested in Thai suppliers. In fact, GM, for example, tries to utilize suppliers that also supply Japanese assemblers in Thailand as part of its "zero tooling policy," avoiding investing in suppliers' moulds, dies and machinery. In fact, 89 percent of GM's suppliers also supply parts to Isuzu. In addition, as part of its global sourcing policy, GM imports parts such as engines, transmission parts and air conditioners from Europe and Japan, with such imports accounting for 43 percent of total parts procurements (Chareonporn, 2001).

The fact that Western assemblers have not aggressively invested in Thai auto-parts manufacturers can be explained as follows. First, there were already plenty of Japanese-affiliated suppliers with satisfactory technological capabilities when Western assemblers entered the market. This situation contrasts with that of Japanese automobile manufacturers, who entered Thailand at a time when there were only a small number of local suppliers. In addition, by the time that Auto Alliance and GM entered Thailand, local content regulations, which had impelled Japanese assemblers to invest in and transfer technology to

Thai auto-parts suppliers, were being abolished. Without local content regulations, Western assemblers have been able to flexibly purchase necessary parts from the global market without limiting themselves to local suppliers. Finally, due to Western assemblers' relatively small scale of production in Thailand[5] it is not worthwhile for them to invest in suppliers of specific parts such as engines, which require high levels of technology and large amounts of investment.

4.2.3. A Comparisons of Japanese and Western Subcontracting Systems

Both Japanese and Western assemblers show a high concern for the quality of suppliers. They typically select reputable auto-parts firms and always push their suppliers to improve quality levels and to innovate by relying on supplier development departments, cost reduction schedules and quality contests. However, the method of selection and the ways that Japanese and Western assemblers deal with their suppliers are quite different.

First of all, Japanese assemblers usually test an auto-parts firm by awarding a small order for a preliminary assessment while Western assemblers typically rely on global standards such as QS9000 as a requirement. Second, Japanese assemblers commonly develop close long-term relationships and provide support with regard to both financial and technical aspects, which is rarely the case for Western assemblers. In addition, the supplier associations set up by Japanese makers arrange a variety of activities that do not directly improve parts quality but are aimed at creating unity and/or a good rapport among suppliers and assemblers. In other words, the methods that Japanese assemblers rely on to control their suppliers are more informal compared to those of Western assemblers. Turning to the scale of production of auto-parts suppliers, Western firms usually take advantage of economies of scale generated

[5] For example, in 2002, GM's production capacity in Thailand was only 40,000 vehicles per year compared with Toyota's capacity of 240,000 vehicles per year.

from the production of standardized products for the global market while Japanese suppliers, who are typically affiliated with a *keiretsu*, usually produce specialized parts on a small scale meeting the particular needs of assemblers (Kasuga et al., 2003). Finally, Western assemblers tend to rely on formal and explicit written contractual agreements, whereas Japanese assemblers typically pay attention to past performance and relationships.

In sum, Western assemblers typically use market mechanisms and depend on global standards while Japanese assemblers tend to rely on close and informal relationships when dealing with suppliers.

5. Theoretical Framework, Model and Data Sources

Section 6 below will analyze the criteria based on which assemblers choose their suppliers. This section introduces agglomeration theory and Williamson's (1985) transaction cost theory, which will be used as the conceptual framework to analyze the clustering of production in the Thai automotive industry and in examining assemblers' supplier selection behavior.

5.1 Theoretical Framework

5.1.1 Agglomeration Theory

Agglomeration theory tries to explain what factors contribute to the formation of industrial clusters by focusing on externalities. Agglomeration theory suggests that the formation of clusters is determined by the interaction of positive externalities resulting from localization and urbanization economies[6] and the negative externalities resulting from

[6] The concept of localization economies refers to the benefits arising from the clustering of

competition and transportation costs.

According to Marshall (1890), economies of agglomeration provide positive externalities through four major channels:

(1) mass production or internal economies;

(2) the availability of specialized input services;

(3) the formation of a highly specialized labor force and the creation of new ideas, both based on the accumulation of human capital and face-to-face communication; provided that firms own different types of information, the benefits of communication generally increase as the number of firms rises; the quality of information is also better the smaller the distance and the number of intermediates between trading partners;

(4) the existence of a modern infrastructure.

Additionally, Marshall argues that these externalities not only play a role in agglomeration formation, but also in generating something like a lock-in effect. Manufacturers tend to concentrate where there is a large market in order to benefit from spillovers and economies of scale, but the market will be large where manufacturers are concentrated. This circular causation process then leads to a snowball effect by which industrial firms are locked in in the same region for an extended period. Hence, when an industry has been located in a particular location, it is likely to remain there for an extended period (Fujita, Krugman, and Venables, 1999).

Proximity between firms is another significant factor. Proximity contributes to agglomeration economies by reducing transportation costs and facilitates information exchange, learning, and "standing on shoulder" effects.[7] According to search models, the costs

firms in the same or related industries, whereas the concept of urbanization economies relates to the advantages associated with the overall level of activity prevailing in a particular area.

[7] The "standing on shoulders" effect refers to the fact that new knowledge is often based on previous established knowledge.

of obtaining desired goods or services decreases as a result of the reduction in transportation and information gathering costs provided by a cluster. Therefore, agglomeration economies will raise firms' sales when they are concentrated rather than isolated. Thus, it is likely that the market size will increase as several firms are located together and the bigger market size will eventually bring a greater concentration of firms.

5.1.2 Transaction Cost Theory

Transaction cost theory, going back to Williamson's (1985) work, argues that there are costs involved in using the market mechanism, and the magnitude of such "transaction costs" depends on bounded rationality, opportunism, uncertainty, and asset specificity.

Williamson (1985) suggests that humans have bounded rationality and can act opportunistically. Bounded rationality occurs because economic agents can access only a limited amount of information and only have limited capacity for information processing, while opportunism arises because some economic agents will make an effort to mislead others or conceal information in order to maximize their own profit. Information gathering and processing as well as costs arising from opportunistic behavior or attempts to curtail it are all transaction costs.

Uncertainty is another factor giving rise to transaction costs. Williamson (1985) considers two forms of uncertainty: internal or behavioral uncertainty and external or environmental uncertainty. The former concerns the conduct of transaction partners and the possibility of opportunism whereas the latter relates to the contingencies that may arise as the transaction proceeds. In making a contract, behavioral uncertainty is reduced when firms have a long-term relationship or recurrent transactions.

Asset specificity refers to the degree to which durable human or physical assets are locked into a particular trading relationship, and hence the value of specialized assets will be lower if the contract is terminated. Transaction-specific assets make it costly to switch to a new partner. Williamson identifies three types of asset specificity: site specificity, human resources specificity, and physical asset specificity.

5.2 Model

Logit Model[8]

In order to examine empirically which of the factors suggested by theory plays a significant role in automobile manufacturers' selection of a particular supplier as a subcontractor, a binary response model, the logit model, is used. Based on the logistic probability density function, the logit model makes the relationship between a probability (P_i) and independent variables (X) non-linear, thus allowing the probability value to lie between 0 and 1. In the context of the supplier selection behavior of automobile manufacturers, the logit model can be applied as follows:

Assume $y_i{}^*$ is the unobservable net benefits that an assembler will obtain by selecting a parts manufacturer. If $y_i{}^*>0$, then the assembler will purchase parts from the auto-parts firm in question symbolized by $y=1$. If $y_i{}^*<=0$ then the assembler will select another auto-parts manufacturer as its supplier, i.e., $y=0$. The relationship can be summarized in the following equations:

$$y_i{}^* \text{ is an unobservable but } \begin{cases} y_i=1 \text{ if } & y_i{}^* > 0 \\ y_i=0 \text{ if } & y_i{}^* <= 0 \end{cases}$$

[8] For further detail see Hosmer and Lemeshow (2000), Long, J. Scott and Freese (2001) and Cramer (2003)

In addition, unobservable net benefits are influenced by a group of explanatory variables (X) and a random disturbance, u_i, which is uncorrelated with the regressors:

$$y_i^* = \beta_1 + \beta x_{2i} + \ldots + \beta x_{ki} + u_i$$

Thus, $\Pr(y_i = 1) = \Pr(y_i^* > 0) = \Pr(u_i > -\beta_1 - \beta x_{2i} - \ldots - \beta x_{ki})$

$= 1 - F(-\beta_1 - \beta x_{2i} - \ldots - \beta x_{ki})$ where F is the cumulative function of u_i (1)

$= F(\beta_1 + \beta x_{2i} + \ldots + \beta x_{ki})$ (2)

Here, u_i is assumed to be distributed logistically. Due to the symmetric and zero mean properties of the logistic distribution, equation (1) is equal to equation (2).

The cumulative distribution function for a logistic random variable is denoted by:

$$F(u_i) = e^{u} / (1+e^{u})$$

Therefore, $\Pr(y_i=1) = \exp(\beta_1 + \beta x_{2i} + \ldots + \beta x_{ki}) / [1+\exp(\beta_1 + \beta x_{2i} + \ldots + \beta x_{ki})]$

$\Pr(y_i=0) = 1 - \Pr(y_i=1)$

$= 1/[1+\exp(\beta_1 + \beta x_{2i} + \ldots + \beta x_{ki})]$

Thus, the odds or $\Pr(y_i=1)/\Pr(y_i=0) = \exp(\beta_1 + \beta x_{2i} + \ldots + \beta x_{ki})$

$$\ln(\Pr(y_i=1)/\Pr(y_i=0)) = \beta_1 + \beta x_{2i} + \ldots + \beta x_{ki}$$

Alternatively, the natural log of the odds or logit is a linear function of X, the explanatory variables. We can understand the effects of explanatory variables on the probability of being subcontracted by computing the marginal effect.

The marginal effect in the logit model or the increased probability of being chosen as a subcontractor, $\Pr(y_i=1)$, as a result of a unit change in x_{ji} is

$$\frac{\partial \Pr(y_i=1)}{\partial x_{ji}} = F'(\beta_1 + \beta x_{2i} + \ldots + \beta x_{ki})\, \beta_j$$

Description of Variables

Explanatory variables used in the paper are selected based on the theories explained above and the availability of data. The description of dependent and explanatory variables used is as follows:

1. **Dependent variable: the Transaction dummy,** which takes either 0 or 1. If a transaction between an assembler and a supplier occurs, the value of this variable will be 1; otherwise, it will be 0. The number of all possible transactions between suppliers and assemblers can be calculated by multiplying the number of suppliers by the number of assemblers. This paper uses data from 162 suppliers who supply parts to 14 automobile assemblers and 4 motorcycle assemblers. Therefore, in the full model the number of observations will be 2916 (=162*18).
2. **The Distance variable** represents the distance between the 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 Toyota, whose assembly plants are located in both Chachoengsao and Samut Prakan Provinces, and some suppliers whose plants are located in more than one district, the distance variable will be calculated by using an averaging method of the various distances between such firms and their trading partners.
3. **ln(labor)** is the natural logarithm of the number of employees in each supplier company. The ln(labor) variable is introduced in the models as a proxy for economies of scale. In order to alleviate problems associated with the fact that the distribution of labor is typically skewed, the natural logarithm is used.
4. **An ISO dummy** is used to proxy the technology level of suppliers. This dummy will be 1 if the supplier is certified with any of the following: QS9000, ISO9001, ISO9002, or ISO14001; it will be 0 if the supplier does not have any of these certifications.

5. **Location dummies** are a group of dummies that represent the locations of suppliers, such as Rayong, Samut Prakan etc. For example, the Rayong dummy will be 1 if the supplier in question has its factory in Rayong. As agglomeration theory suggests that markets are likely to grow where firms are concentrated, these location dummies are introduced to capture this agglomeration effect. To avoid multicollinearity, the paper did not include the dummy for Bangkok Province; in other words, the paper regards Bangkok Province as the base category. Thus, the marginal effects of the location dummies will represent the location advantages of other locations over Bangkok. It is hypothesized that the dummies for Samut Prakan and Chachoengsao Provinces take a positive coefficient while provinces where only a small cluster of firms exists, such as Prachinburi Province, will have a negative or insignificant coefficient.

6. **Same-nationality dummy**: if the major shareholders of an assembler and a supplier are of the same nationality, the same-nationality dummy will be 1 regardless of the nationality of the assembler and the supplier. However, to examine this effect in more detail, the same-nationality dummies for the three major nationalities of assemblers in Thailand are also included: the "same nationality (Japanese)" dummy, the "same nationality (Thai)" dummy and the "same nationality (American)" dummy. In the case that both the assembler and the supplier are Japanese, the "same nationality (Japanese)" dummy will be 1. Similarly, the "same nationality (Thai)" and "same nationality (American)" dummies will be 1 if the assembler and supplier in question both are Thai and American, respectively.

In this paper, the nationality of a firm is determined based on the nationality of the majority shareholder (50 percent or more) of the firm in question. If two shareholders of different nationalities each hold 50 percent of the shares, the firm will be considered to have two nationalities.

Hypotheses in the Logit Models

Next, this section will explain the hypotheses underlying this study in greater detail.

1. **The nearer a parts maker is to an assembly plant, the more likely it is to be chosen as a subcontractor.**

   Assemblers will benefit from proximity to their suppliers in several ways. First of all, proximity facilitates face-to-face communication, reinforces cooperation in design processes, and thus improves the quality of products and the relationships between the two firms. Second, proximity benefits suppliers, which ultimately benefits assemblers as well. For example, proximity generates external spillovers such as technology transfer within the region and lowers the transportation costs of suppliers, thus benefiting assemblers through lower price and a higher quality of products. Third, proximity to assemblers also helps suppliers to meet just-in-time requirements. Thus, it is expected that the effect of distance on the probability of a firm to be chosen as a subcontractor will be negative.

2. **A firm with a large scale of production and/or possessing high technological capabilities is more likely to be chosen as a subcontractor.**

   This is because a firm with a large scale of production and/or high technological capabilities is more likely to attain economies of scale and be more specialized. In short, this hypothesis accounts for the heterogeneity of technology levels and scales of production among auto-parts firms that will affect the likelihood that a firm will be chosen as a subcontractor.

3. **If the major shareholder of the assembler and the supplier are of the same nationality, it is more likely that transactions between them will occur.**

Based on transaction cost theory, we would expect a supplier to be more likely to be chosen as a subcontractor, the lower the degree of behavioral uncertainty involved. Behavioral uncertainty is likely to be reduced when the assembler and the supplier are of the same nationality because of the shared business culture which facilitates a mutual understanding of business practices.

4. **Japanese firms are more likely to conduct transactions with each other than firms of other nationalities.**

Several studies have found that Japanese firms usually bring their own suppliers to countries where they set up assembly factories. Such suppliers typically provide specialized components and assemblers have long-term relations with them, bringing greater transactional certainty (Hackett and Srinivasan, 1998). Therefore, we would assume Japanese firms to deal largely with other Japanese firms. This will be tested by examining the effect of the "same nationality (Japanese)" dummy compared with the effect of the other same nationality dummies.

5. **Since the components of motorcycles and automobiles have different characteristics, there are likely to be differences in the criteria for supplier selection of these two types of assemblers.**

Since motorcycle and automobile components differ in various ways, it may be suspected that other factors, such as investment amounts, technology levels, and the production level at which scale economies are reached, may all be different. Therefore, the criteria that automobile and motorcycle assemblers consider in selecting subcontractors may also differ. For example, due to the relatively low value of motorcycle parts compared to automobile parts, the amount invested by motorcycle parts makers to reach an efficient level of production likely is lower than in the case of automobile parts. Thus, motorcycle assemblers are likely to choose components makers that have a lower level of investment than automobile assemblers. This hypothesis will be examined by running two separate regressions, one using the data for motorcycle assemblers, and one using the data for automobile assemblers, and then comparing the results.

5.3 Data Sources

Most of the data are obtained from the *Thailand Automotive Industry Directory 2003-2004*, which is published by the five most important authorities in the Thai automotive industry: (1) the Thai Automotive Institute, (2) the Thai Auto-Parts Manufacturer Association, (3) the Thai Automotive Industry Association, (4) the Automotive Club, Federation of Thai Industries, and (5) the Auto-Parts Industry Club, Federation of Thai Industries. These data are complemented by data from company websites and financial statements obtained from the Ministry of Commerce, Thailand. Distance data between districts is obtained from the Department of Highways, Thailand. Basic descriptive statistics of the sample data are shown in Table 8.

Insert Table 8

Model Description

To examine the determinants of supplier selection, we run logit models to examine the effects of distance, economies of scale, the level of suppliers' technology, and nationality. The regressions are run for the automotive industry as a whole, for Japanese assemblers only, for American assemblers only, for automobile assemblers only, and for motorcycle assemblers only, to discover commonalities and differences between these groups.

The hypotheses will be tested using three different models. Model 1 aims at testing the effects of transportation costs, economies of scale, and suppliers' technology level by controlling for the effect of same nationality. Since the nationalities of assemblers vary from case to case, the dummy variables capturing the same-nationality effect in the respective models are different. In the estimation for the industry as a whole and for automobile assemblers only, the "same nationality" dummy is employed, while in the estimation for the Japanese assemblers only and the American assemblers only, the "same nationality (Japanese)" and "same nationality (American)" dummies respectively are employed to control for the effect of same nationality with the assemblers. Regarding the case of motorcycle assemblers, where all the major shareholders are Japanese, the same-nationality effect, thus, is measured by the "same nationality (Japanese)" dummy.

In contrast with Model 1, Model 2 focuses on a comparison of the effects of same nationality of the main assemblers (Japanese, American and Thai) in detail; i.e., Model 2 compares the effect of the "same nationality (Japanese)" dummy, the "same nationality (American)" dummy and the "same nationality (Thai)" dummy in order to test hypothesis 4. However, since there is only one nationality in the regressions using data of Japanese assemblers only, of American assemblers only, and of motorcycle assemblers only, a comparison of the same nationality effects cannot be conducted. Thus, Model 2 cannot be applied in the case of Japanese assemblers only, American assemblers only, and motorcycle assemblers only.

Lastly, Model 3 concentrates on supplier location advantages and uses Bangkok as the base category. The estimates of all location dummies in Model 3, therefore, can be interpreted as the comparative advantages of suppliers in those locations over those of suppliers in Bangkok.

6. Results and Interpretation

The results for Model 1 are shown in Table 9. The results for Model 1 generally suggest that the likelihood of being chosen as a subcontractor increases if suppliers have a large scale of production. On the other hand, same nationality appears to have a negative or insignificant effect, which may be a surprising result. However, if we take into account that the Thai automotive market is relatively small compared to that of Japan or the US, supplying parts to as many assemblers as possible would be advantageous both to suppliers and assemblers as it allows the exploitation of economies of scale to reduce unit costs. In addition, since several assemblers, such as Toyota, have recently made Thailand a platform for exports, the quality of parts has become more important. Thus, subcontracting with competent suppliers, even if they are of a different nationality, would be preferable. Finally, although the distance variable and the ISO dummy display the expected signs, they are generally statistically insignificant in Model 1.

Examining the effects of same nationality in detail in Model 2 (see Table 10), we find that the negative effect of same nationality in Model 1 is largely the result of the negative effect of the "same nationality (Thai)" dummy. A possible explanation for the negative effect of the "same nationality (Thai)" dummy is Thai suppliers' insufficient R&D effort and their inability to attain international quality standards, an interpretation which is supported by the significant positive estimate for the ISO dummy in the automobile assembler case and in the survey by the Thai Automotive Institute (2002). The study found that small Thai parts manufacturers had difficulties attaining ISO or QS9000 certification and had low management and design abilities.

Table 11 shows the results for Model 3, which examines location advantages and uses Bangkok as the base category. Therefore, the estimates of all location dummies in Model 3 can be interpreted as the comparative advantage of suppliers in those locations over suppliers in Bangkok. The results suggest that suppliers in Chachoengsao, Chon Buri, Pathum Thai and Samut Prakan Provinces are more likely to be chosen as subcontractors than those in Bangkok. This result holds both for the industry as a whole and for Japanese assemblers only. It should be noted that Japanese assembly plants are located in all of those provinces.

As for the comparison of Japanese and American assemblers, the results from both models are similar in that the ln(labor) variable is positive and significant, which means that the larger a supplier's scale of production, the more likely it is to be chosen as a subcontractor by assemblers from either country.

Next, Table 12 compares the results of the models for automobile and motorcycle assemblers. The results for the two are similar in that for both types of assemblers, the scale of production is importance but whether the supplier is of the same nationality is not. On the other hand, the results differ in that automobile assemblers value suppliers' level of technology, while motorcycle assemblers do not: the estimates for the ISO dummies are positive and significant in the models for the automobile assemblers, but insignificant (and negative) in the models for the motorcycle assemblers. It should also be noted that the estimates for the ISO dummies are higher than those for the ln(labor) variables in the case of automobile assemblers. This suggests that although automobile assemblers regard suppliers' scale of production as an important factor, they place greater importance on the technology level.

Regarding the significance of the models, the likelihood ratio test for overall significance is used. The p-values of all models are shown at the bottom of the tables. The results show that all models except Model 3 for the case of American assemblers are statistically significant. The p-values of all models, except for that one case, are lower than 0.07.

Finally, the ln(labor) variable is positive and significant in all models except the one model that is insignificant. Thus, the findings indicate that a large scale of production raises the likelihood that an auto-parts maker is chosen as a subcontractor.

Insert Tables 9-12

7. Concluding Remarks

This paper examined the determinants of supplier selection in the Thai auto industry, considering the role of transaction costs, economies of scale, nationality and the location of parts suppliers. In addition, the role of these factors for different types of assemblers – Japanese and American, automobile and motorcycle – were compared.

The findings suggest that parts makers' scale of production is a dominant factor in supplier selection while there is no significant preference for suppliers of the same nationality as the assembler. Concerning the role of location, it is found that all location dummies that are positive and significant are dummies for provinces where assembly plants are located. This suggests that parts makers are more likely to be chosen for subcontracting when they are located in the same province as the assembler. In terms of the theoretical considerations above, this result confirms that transportation costs and agglomeration economies play a role.

Next, it is found that the "same nationality" dummy has a significant negative effect in the case of Thai firms, which is probably the result of Thai suppliers' insufficient R&D and the inability to attain international quality standards. The Thai government therefore should devise policies to support and promote R&D by local firms. Finally, the government should enact policies for developing the automobile industry by taking the situation of the Thai auto-parts industry into account because of the extensive connection between the two industries.

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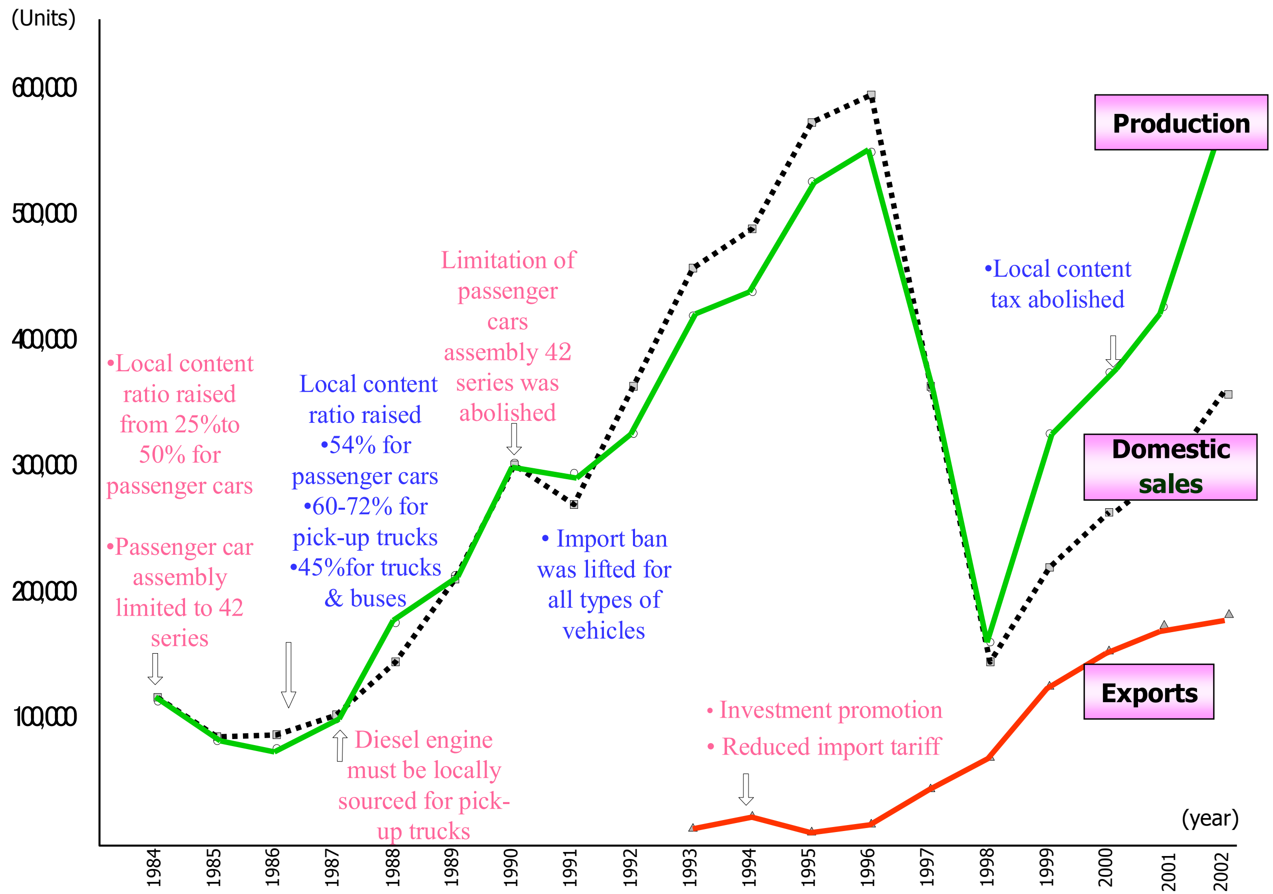
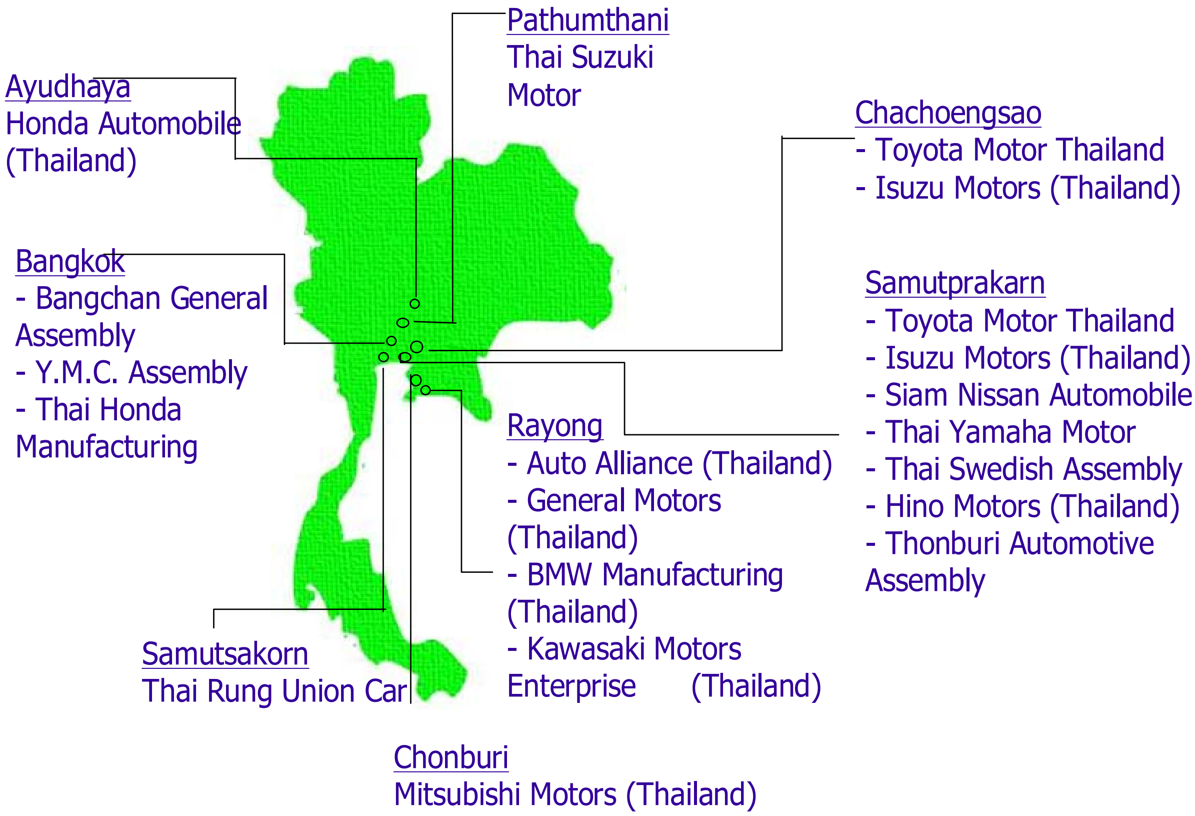
Figure 1: The Thai Automotive Industry Development under the Government Action



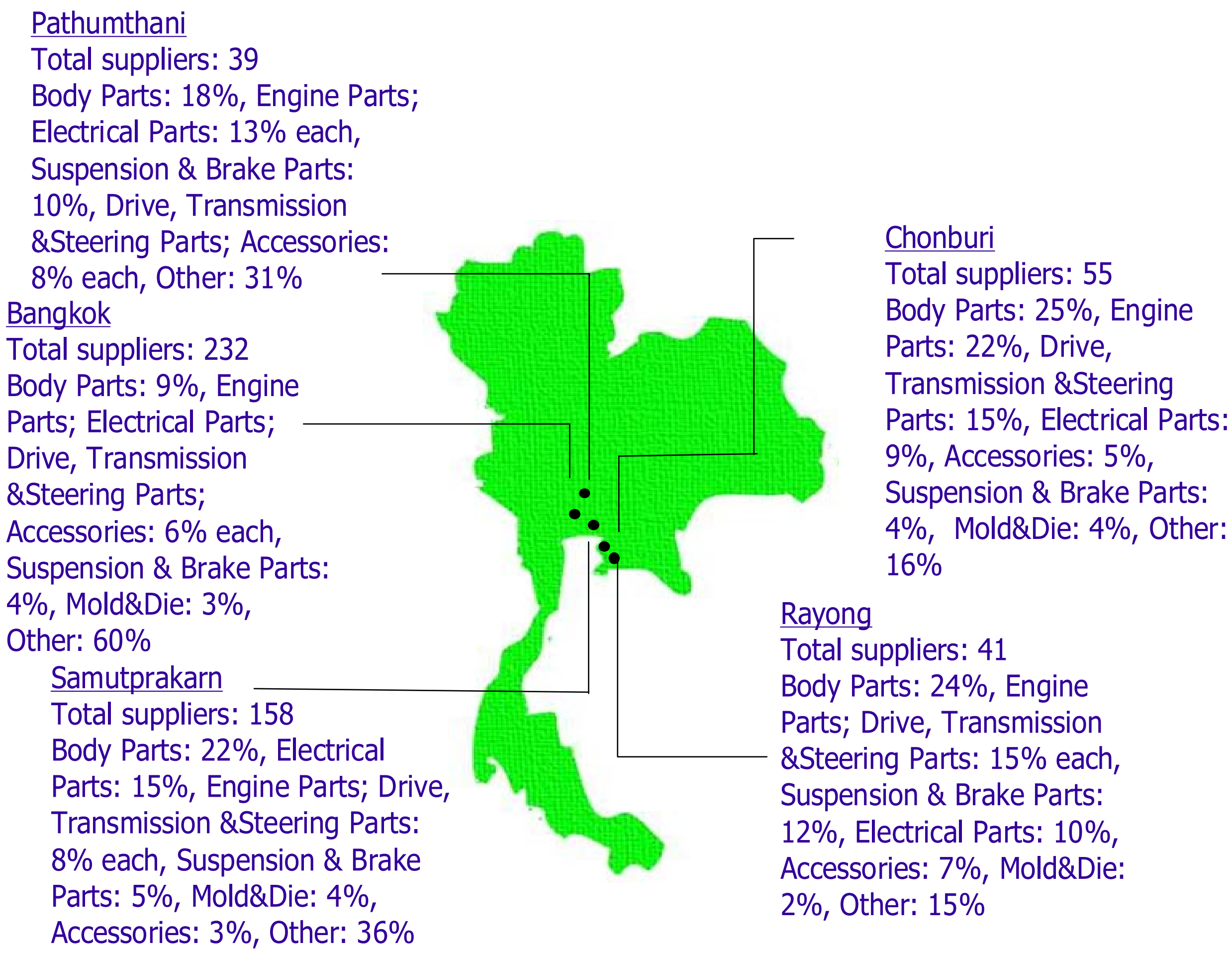
Source: Thai Auto-Parts Manufacturers Association, *"Trends and Developments in Thailand's Auto Market."* Online, < www.thaiautoparts.or.th/fileupload/AutomotiveHistory.ppt>.

Figure 2: Location of Automotive Assemblers



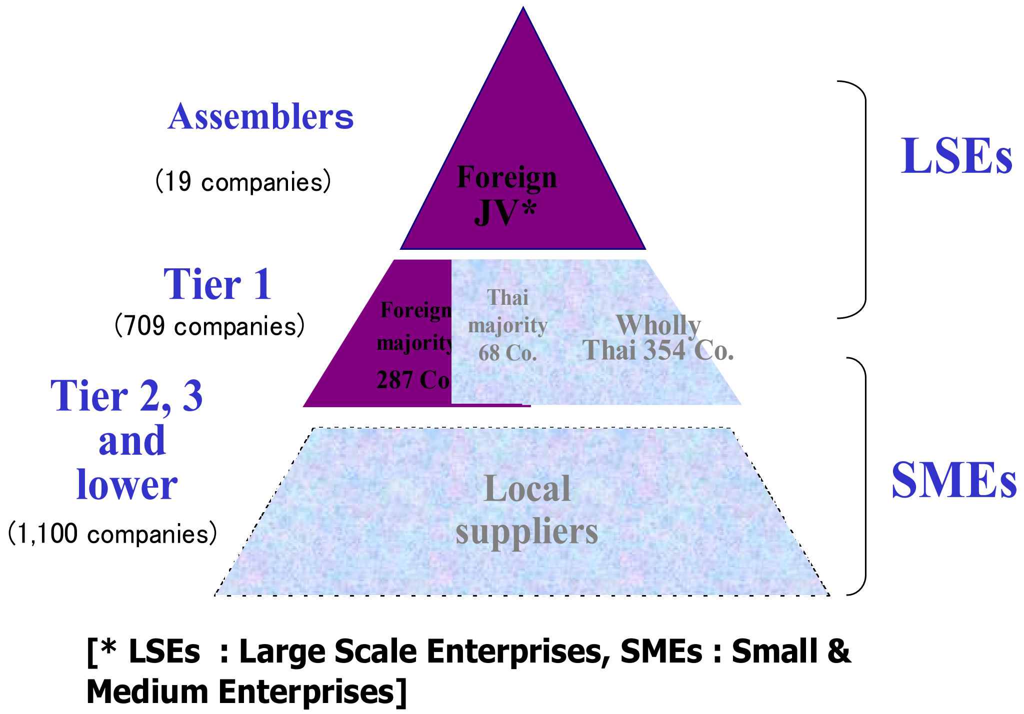
Source: Thai Automotive Institute (2002).

Figure 3: Location of Automotive Parts Makers



Source: Thai Automotive Institute (2002).

Figure 4: Structure of the Thai Automobile Industry



Source: *Thailand Automotive Industry Directory 2003-2004* (2003), p.83.

Note: * Joint Venture.

Table 1: The Production Capacity of Vehicle Manufacturers in Thailand, 2002.

No.	Car Assemblers	Brands	Location	Nationality of parent firm	Production capacity*
1	Auto Alliance (Thailand) Co., Ltd.	Ford & Mazda	Rayong	U.S.	135,000
2	Banchan General Assembly Co., Ltd.	Chrysler	Bangkok	Thai	20,000
3	BMW Manufacturing (Thailand) Co., Ltd.	BMW	Rayong	German	10,000
4	General Motors (Thailand) Co., Ltd.	GM	Rayong	U.S.	40,000
5	Hino Motors (Thailand) Co., Ltd.	Hino	Samut Prakan	Japanese	28,800
6	Honda Automobile (Thailand) Co., Ltd	Honda(Cars)	Ayutthaya	Japanese	60,000
7	Isuzu Motors (Thailand) Co., Ltd.	Isuzu	Chachoengsao& Samut Prakan	Japanese	180,000
8	MMC Sittipol Co., Ltd.	Mitsubishi	Bangkok & Chon Buri	Japanese	190,200
9	Siam Nissan Automobile Co., Ltd.	Nissan	Samut Prakan	Japanese	124,000
10	Thai Rung Union Car Public Co., Ltd.	Thai Rung and for Isuzu and Nissan	Bangkok	Thai	9,600
11	Thai-Swedish Assembly Co., Ltd.	Volvo	Samut Prakan	Swedish	6,000
12	Thonburi Automotive Assembly Plant Co., Ltd.	Mercedes Benz	Samut Prakan	Thai	18,100
13	Toyota Motor Thailand Co., Ltd.	Toyota	Chachoengsao & Samut Prakan	Japanese	240,000
14	YMC Assembly Co., Ltd.	Volkswagen, Audi, Peugeot	Bangkok	Thai	12,000
Total					1,073,700

No.	Motorcycles Assemblers	Brand	Location	Nationality of parent firm	Production Capacity*
1	Thai Honda Manufacturing Co., Ltd.	Honda (Motorcycles)	Bangkok	Japanese	850,000
2	Thai Suzuki Motor Co., Ltd.	Suzuki	Pathum Thani	Japanese	550,000
3	Thai Yamaha Motor Co., Ltd.	Yamaha	Samut Prakan	Japanese	420,000
4	Kawasaki Motors Enterprise (Thailand) Co., Ltd.	Kawasaki	Rayong	Japanese	200,000
5	International Vehicles Co., Ltd.	Cagiva	Samut Prakan	-	60,000
Total					2,080,000

Source: Office of Industrial Economics, Ministry of Industry, online: <www.oie.go.th>

Note: 1. International Vehicles Co., Ltd. is a small motorcycle manufacturer in Thailand. Its transaction data is not available, thus the company is not included in the empirical analysis.

Table 2: First-Tier Suppliers, Categorized by Parts Functions

First-tier suppliers, categorized by parts functions

Unit: Company

Group	Wholly Thai-owned	% of total (1)	Thai majority	% of total (1)	Foreign majority	% of total (1)	Total (1)
1. Engine parts	20	32%	8	13%	35	56%	63
2. Electrical parts	15	29%	10	19%	27	52%	52
3. Drive, Transmission & Steering parts	17	33%	6	12%	29	56%	52
4. Suspension & Brake parts	13	37%	1	3%	21	60%	35
5. Body parts	57	48%	17	14%	45	38%	119
6. Accessories	18	46%	2	5%	19	49%	39
7. Molds & Dies	8	36%	1	5%	13	59%	22
8. Other	206	63%	23	7%	98	30%	327
Total 1-7	148	39%	45	12%	189	49%	382
Total 1-8	354	50%	68	9%	287	41%	709

Source: The National Economic and Social Development Board, *Master Plan for the Thai Automotive Industry 2002-2006,* online: <www.nesdb.go.th>.

Note: There are a total of 709 suppliers that supply parts and materials directly to OEMs (386 supply parts and materials for cars, 201 for motorcycles, and 122 for both).

Table 3: Car Production in Thailand (Number of Units)

Type of car	1996	1997	1998	1999	2000	2001	2002	2003	2004	2004 (Jan-Jun)	2005 (Jan-Jun)	Percentage change
Passenger cars	138,579	112,041	32,008	72,716	97,129	156,066	169,321	251,684	299,439	151,240	131,881	-12.8%
Commercial vehicles (excluding 1 ton trucks)	66,385	28,322	4,186	8,326	13,798	9,382	12,774	20,925	34,753	8,221	12,600	53.3%
1 ton pick-up trucks	350,857	218,336	119,986	240,369	294,834	289,349	382,297	468,938	588,979	283,287	373,348	31.8%
OPVs	2,544	1,604	1,950	5,822	5,960	4,621	20,559	8,965	4,910	-	-	-
Total	558,365	360,303	158,130	327,233	411,721	459,418	584,951	750,512	928,081	446,625	517,829	15.9%
Percentage change	6.2%	-35.5%	-56.1%	106.9%	25.8%	11.6%	27.3%	28.3%	23.7%			

Source: Thai Automotive Institute, online : <http://www.thaiauto.or.th/Records/Records_Main.asp>.

Notes: 1. In 2004 (Jan.–Jun), passenger cars include OPVs due to a change in the exercise taxes system.

2. OPVs stands for off-road purpose vehicle.

Table 4: Car Sales in Thailand, 1996-2005 (Number of Units)

Type of Car	1996	1997	1998	1999	2000	2001	2002	2003	2004	2004* (Jan-Jun)	2005* (Jan-Jun)	Percentage change
Passenger cars	172,730	132,060	46,300	66,858	83,106	104,502	126,353	179,005	209,110	101,508	90,818	-10.5%
Commercial vehicles (excluding 1 ton trucks)	76,148	34,291	14,369	14,369	19,731	17,541	20,123	28,565	36,038	16,496	21,144	28.2%
1 ton pick-up trucks	327,663	188,324	81,263	129,904	151,703	168,639	241,266	309,114	368,911	174,767	230,788	32.1%
Other	12,585	8,481	4,275	7,199	7,649	6,370	21,620	16,492	11,967	5,933	3,147	-47.0%
Total	589,126	363,156	146,207	218,330	262,189	297,052	409,362	533,176	626,026	298,704	345,897	15.8%
Percentage change	3.1%	-38.4%	-59.7%	49.3%	20.1%	13.3%	37.8%	30.3%	17.4%			

Source: Thai Automotive Institute, online:
< http://www.thaiauto.or.th/Records/Records_Main.asp>.

Note: 1 ton pick-up trucks in Jan-Jun 2004 and Jan-Jun 2005 include PPV (Pick-Up Passenger Vehicle).

Table 5: Car Exports, 1996-2005 (Number of Units)

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2004 (Jan-Jun)	2005 (Jan-Jun)	Percentage change (05/04)
Volume (units)	14,020	42,218	67,857	125,702	152,836	175,293	181,471	235,042	332,053	151,910	191,180	25.9%
Value (million baht)	4,253.4	16,227	28,125.6	60,105.5	83,044.4	107,918	82,825.9	138,161.4	149,232.8	66,443. 9	89,092.5	34.1%
Percentage change (volume)	59.2%	201.1%	60.7%	85.3%	21.6%	137.5%	3.5%	63.9%	41.3%			
Percentage change (value)	104.3%	281.5%	73.3%	113.7%	38.2%	165.7%	-23.3%	84.6%	8.0%			

Source: Thai Automotive Institute, online:
< http://www.thaiauto.or.th/Records/Records_Main.asp>.

Table 6: Production of Motorcycles, 1996-2005 (Number of Units)

Type	1996	1997	1998	1999	2000	2001	2002	2003	2004	2004 (Jan-Jun)	2005 (Jan-Jun)	Percentage change (05/04)
Family	1,265,434	982,012	563,570	810,920	1,089,476	1,145,001	1,903,302	2,368,272	2,787,136	1,396,344	1,128,519	-19.2%
Sport	172,360	99,032	36,927	35,506	36,247	64,994	73,842	56,406	80,159	45,789	50,924	11.2%
Total	1,437,794	1,081,044	600,497	846,426	1,125,723	1,209,995	1,977,144	2,424,678	2,867,295	1,442,133	1,179,443	-18.2%

Source: Thai Automotive Institute, online:
< http://www.thaiauto.or.th/Records/Records_Main.asp>.

Table 7: Thailand's Major Auto-Parts Exports, 1996-2005 (Million Baht)

Type of parts	1996	1997	1998	1999	2000	2001	2002	2003	2004	2004 (Jan-Jun)	2005 (Jan-Jun)	Percent age change
Engines	802	2,023.9	1,536.8	3,731.8	7,106.2	8,309.8	6,094.1	5,376.4	4,316.1	1,985.7	3,951.5	99.0%
Spare parts	215.4	505.3	495.3	883.4	1,245.7	1,758.6	1,789.6	2,152.6	2,909.4	1,312.7	1,804.7	37.5%
Jigs & dies	43.66	56.3	63.7	141.4	120	141.2	145.3	312.5	797.5	254.9	203.7	-20.1%
OEM parts	975.78	1,882.8	3,488.6	5,103.3	11,087.6	13,736.9	17,076.1	27,554.8	38,488.6	18,304.1	33,695.7	84.1%
Other	5.33	27.6	25.9	58.5	336.7	96.7	150.1	604.1	920.7	590.3	1,554.2	163.3%
Total	2,042.2	4,495.9	5,610.2	9,918.3	19,896.1	24,043.1	25,255.1	36,000.2	47,432.3	22,447.6	41,209.9	83.6%

Source: Thai Automotive Institute, online :
<http://www.thaiauto.or.th/Records/Records_Main.asp>.

Table 8: Basic Descriptive Statistics of the Sample Data

Variable	Mean	Std. Dev.	Min.	Max.	Unit
distance_1	71.89	44.08	0	236.15	Kilometers
trans	0.19	0.39	0	1	–
asset	202.16	247.79	1	1500	Million baht
labor	364.23	506.30	12	4800	Persons

Source: Author's calculation.

Result Tables

Table 9: Model 1

Variables	Whole Industry			Japanese Assemblers			American Assemblers		
	Marginal Effect	z	P>|z|	Marginal Effect	z	P>|z|	Marginal Effect	z	P>|z|
Distance	−0.0003	−1.47	0.143	−0.0001	−0.4	0.686	−0.00001	−0.04	0.97
ln(labor)	0.0387 ***	4.25	0	0.0442 ***	3.71	0	0.0278 *	1.75	0.08
ISO Dummy	0.0369	1.49	0.137	0.0157	0.48	0.634	0.0605	1.46	0.144
Same Nationality Dummy	−0.0464 ***	−2.62	0.009						
Same Nationality (Japanese) Dummy				−0.0097	−0.39	0.696			
Same Nationality (American) Dummy							0.2431 **	2.39	0.017
Same Nationality (Thai) Dummy									
Ayutthaya									
Chachoengsao									
Chon Buri									
Nakhon Pathom									
Pathum Thani									
Rayong									
Ratchaburi									
Saraburi									
Samut Prakan									
Samut Sakhon									
Number of Observations	2241			1491			500		
Log Likelihood	−1069.87			−746.139			−204.567		
P−value of Chi−Square	0.000			0.0014			0.0121		

Note: *** Significant at the 1%-level, ** significant at the 5%-level, * significant at the 10%-level.
N/A: Dropped due to collinearity.

Table 10: Model 2

Variables	Whole Industry				Automobile Assemblers			
	Marginal Effect		z	P>|z|	Marginal Effect		Z	P>|z|
Distance	-0.00055	***	-3.13	0.002	-0.00062	***	-3.12	0.002
ln(labor)	0.03884	***	4.42	0	0.03738	***	3.75	0
ISO Dummy	0.03197		1.35	0.177	0.04951	*	1.94	0.053
Same Nationality Dummy								
Same Nationality (Japanese) Dummy	0.06490	**	2.47	0.014	0.14912	***	4.05	0
Same Nationality (American) Dummy	0.10948		1.15	0.252	0.12256		1.1	0.271
Same Nationality (Thai) Dummy	-0.15007	***	-9.9	0	-0.15949	***	-9.64	0
Ayutthaya								
Chachoengsao								
Chon Buri								
Nakhon Pathom								
Pathum Thani								
Rayong								
Ratchaburi								
Saraburi								
Samut Prakan								
Samut Sakhon								
Number of Observations	2241				1741			
Log Likelihood	-1037.678				-797.621			
P-value of Chi-Square	0.000				0.000			

Note: *** Significant at the 1%-level, ** significant at the 5%-level, * significant at the 10%-level.
N/A: Dropped due to collinearity.
Model 2 is not applicable because there are only assemblers of one nationality in the model sample range.

Table 11: Model 3

Variables	Whole Industry				Japanese Assemblers				American Assemblers			
	Marginal Effect		z	P>|z|	Marginal Effect		Z	P>|z|	Marginal Effect		z	P>|z|
Distance	−0.0002		−0.94	0.345	−0.0002		−0.52	0.603	0.00014		0.38	0.703
ln(labor)	0.0279	***	2.82	0.005	0.0283	**	2.21	0.027	0.02014		1.21	0.228
ISO Dummy	0.0306		1.2	0.231	0.0116		0.34	0.732	0.06800	*	1.71	0.087
Same Nationality Dummy												
Same Nationality (Japanese) Dummy												
Same Nationality (American) Dummy												
Same Nationality (Thai) Dummy												
Ayutthaya	0.0722		1.38	0.169	0.1080		1.56	0.119	−0.04169		−0.52	0.601
Chachoengsao	0.1025	**	2.15	0.031	0.1041	*	1.71	0.087	0.11905		1.27	0.203
Chon Buri	0.0905	***	2.82	0.005	0.1352	***	3.2	0.001	−0.02662		−0.51	0.612
Nakhon Pathom	−0.0991		−1.22	0.221	−0.0602		−0.48	0.632	N/A			
Pathum Thani	0.0887	*	1.82	0.068	0.1591	**	2.43	0.015	−0.06564		−1.07	0.284
Rayong	0.0465		1.22	0.221	0.0411		0.8	0.425	0.09272		1.21	0.227
Ratchaburi	−0.0094		−0.11	0.916	−0.0615		−0.63	0.532	0.08805		0.37	0.71
Saraburi	0.0289		0.26	0.792	0.1346		0.86	0.391	N/A			
Samut Prakan	0.0631	**	2.48	0.013	0.0866	***	2.64	0.008	0.00224		0.05	0.96
Samut Sakhon	0.0524		1.03	0.303	0.0665		1.01	0.311	−0.02924		−0.39	0.697
Number of Observations	2241				1491				492			
Log Likelihood	−1064.8853				−735.843				−203.763			
P−value of Chi−Square	0.0003				0.0009				0.385			

Note: *** Significant at the 1%-level, ** significant at the 5%-level, * significant at the 10%-level.
N/A: Dropped due to collinearity.

Table 12: Comparison of Automobile and Motorcycle Assemblers

Variables	Model 1						Model 3					
	Automobile Assemblers			Motorcycle Assemblers			Automobile Assemblers			Motorcycle Assemblers		
	Marginal Effect	z	P>|z|	Marginal Effect	z	P>|z|	Marginal Effect	z	P>|z|	Marginal Effect	z	P>|z|
Distance	−0.00022	−1.04	0.296	−0.00043	−1.04	0.299	−0.0001	−0.42	0.676	−0.0004	−1.03	0.303
ln(labor)	0.03663 ***	N3.52	0	0.04484 **	2.37	0.018	0.0253 **	2.22	0.027	0.0381 *	1.94	0.052
ISO Dummy	0.05812 **	2.15	0.031	−0.0328	−0.55	0.585	0.0553 **	2	0.045	−0.0624	−0.98	0.328
Same Nationality Dummy	−0.03993 *	−1.94	0.052									
Same Nationality (Japanese) Dummy				−0.0625 *	−1.67	0.095						
Same Nationality (American) Dummy												
Same Nationality (Thai) Dummy												
Ayutthaya							−0.0047	−0.09	0.929	0.4070 ***	3.18	0.001
Chachoengsao							0.1298 **	2.42	0.015	−0.0503	−0.56	0.579
Chon Buri							0.0496	1.47	0.141	0.2626 ***	3.16	0.002
Nakhon Pathom							−0.0937	−1.04	0.298	N/A		
Pathum Thani							0.0262	0.5	0.614	0.3500 ***	3.01	0.003
Rayong							0.0134	0.34	0.735	0.2026 *	1.86	0.063
Ratchaburi							−0.0057	−0.06	0.953	N/A		
Saraburi							0.0473	0.39	0.699	N/A		
Samut Prakan							0.0435	1.58	0.114	0.1505 **	2.36	0.018
Samut Sakhon							0.0842	1.45	0.147	N/A		
Number of Observations	1741			488			1741			464		
Log Likelihood	−840.517			−225.602			−836.772			−206.638		
P−value of Chi−Square	0.000			0.0247			0.0035			0.0007		

Note: *** Significant at the 1%-level, ** significant at the 5%-level, * significant at the 10%-level.
N/A: Dropped due to collinearity.