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Abstract

This paper seeks to analyze determinants of Asian countries' comparative advantage in the automotive industry. The effects of supporting industries, factor availability, factor intensity, transportation costs, and of the scale of foreign investment in the industry on the level of countries' comparative advantage are on focus. The results highlight the importance of strong supporting industries in raising a country's comparative advantage in the automotive industry. Furthermore, it is found that the role of factor endowments and intensities, and the role of the presence of Japanese firms, also became more important in determining a country's comparative advantage in the automotive industry following the decline in government intervention in the automotive industry. In addition, transportation costs play an important role in promoting costly-to-transport products to be likely to be produced in countries where there exists large local demand**.**

Introduction

Since the 1997 Asian financial crisis, the changes of vehicle manufacturers' strategies in Asia have been evident, such as shifting to be more export-oriented, to realign production network, to use more common platforms and local procurement, and so on (Fourin, 2003). Vehicle manufacturers have become focus more on how to utilize location-specific assets of East Asian markets including markets, technologies, human resources, and industry clusters to enhance their international competitiveness and to improve efficiency of their production network in East Asia (Takayasu and Mori, 2004). It was the intense competition, economic integration, deregulation, and the 1997 financial crisis that prompted and provided greater leeway for the vehicle manufacturers to alter their strategies to achieve cost-effectiveness.

With the similar production endowments among countries in the study, especially among the ASEAN4 countries (Thailand, Indonesia, Malaysia, and the Philippines), how and what factors determines the MNEs' decision in assigning which parts to be produced at which locations in the Asia region is an interesting issue. One possible explanation can be found on a country's comparative advantage. As noted by Vollrath (1991), comparative advantage can guide the direction of country's investment that should be taken to exploit the highest benefits from the international differences in product and in factor supply and demand. Furthermore, comparative advantage can also illustrate how a country has cost competitiveness compared to the other countries at equilibrium prices.

In the complex economy, the sources of comparative advantage, however, cannot directly derive from factor intensities and factor endowments as explained by the Heckscher-Ohlin theory. The positive influences from economies of scale, local supporting industries as well as market size and negative effects from transportation costs become crucial in determining a country's competitiveness. This chapter, thus, uses data from both trade and production data (input coefficients from the Input-Output Tables and vehicle production and sales) to account for these factors.

The purpose of this chapter is to examine the determinants of comparative advantage of the ASEAN4 countries, China, India, Korea, Australia, and New Zealand[1] in the automotive industry over the period 1988-2006 and to study how a country's comparative advantage has evolved over time. The comparative advantage can hint how assemblers are likely to realign their production network in the long run. In addition, the understanding of

[1] Note that Australia and New Zealand are included in the scope of study in this chapter because of their closer connections with Asian countries in regard to trade in the automotive industry. Australia and New Zealand have signed several FTA agreements with Asian countries such as Thailand and Australia FTA and AANZFTA ((ASEAN)-Australia-New Zealand Free Trade Area (AANZFTA) thus it cannot be ignored them in the study on the Asian automotive industry.

dynamic evolution of a country's competitiveness in the automotive industry could provide useful policy lessons and help developing countries to reach their goals in building up a successful automotive industry.

The organization of this chapter will be as follows. Section 2 gives an overview of complementary production network and common platform strategy of vehicle manufacturers. Then, theories regarding sources of comparative advantage, discussions on revealed comparative advantage indexes, and preceding empirical studies on comparative advantage are provided in section 3. Section 4 presents description of variables and hypotheses. The empirical results are shown in Section 5. Conclusions are in the final section.

2. Vehicle Manufacturers' Production Network Realignment

This section describes strategies of global assemblers to understand how vehicle manufacturers consolidate and exploit benefits from their scattered production facilities across countries. Among other things, two main strategies are adopted to attain economies of scales, which are complementary production and common platform strategies.

2.1 Complementary Production Network and Platform Strategy

Since the late 1990s, we can observe an increase in a realignment of production networks of global vehicle manufacturers. The vehicle manufacturers have taken benefits from low tariffs and their existing production bases scattered across countries in the region. They have streamlined and exchanged vehicle models produced by assembly plants across countries within the production networks of the same assemblers or of the same partner groups to increase scale economies. For example, in 2006, Toyota reduced production in Malaysia and let Malaysia import the Camry from Thailand (Fourin, 2007). Regarding Honda' s production networks, most of passenger cars (i.e. the Honda Accord, Civic and City) are manufactured in and exported from Thailand to other Southeast Asian countries whereas Honda minivans (the Stream) are produced in and exported from Indonesia. In addition, Honda also made an active use of trade agreements within the Asian region such as the AICO scheme to raise its local procurement and its "inter-group complementary supply ratio" (http://world.honda.com/investors/annualreport/2003/09.html).

The presence of these complementary production networks is not limited within the ASEAN4 countries but also found in the other countries such as China and India. According to Fourin (2003), Mitsubishi group has streamlined its production networks that are scattered in Asia to attain cost-effectiveness. Mitsubishi lets its one-ton pickups to be primarily produced in Thailand while the components and completely built units (CBUs) of the Dynamic Family Wagon (DFW) are produced in Taiwan. On the other hand, the production of components and CBUs of the Magna/Verada are centralized in Australia. Figure 1 presents the production network of Mitsubishi in Asia.

Insert Figure 1

The scope of complementary production networks beyond the ASEAN4 countries is also found in other companies. Daihatsu, for example, uses Indonesia as a production base for small Asian utility vehicles (AUVs) and lets Indonesia to export them to China, India, and to the other countries in the ASEAN4. In 2004 Toyota assigned India to produce components for the IMV project, which Thailand and Indonesia are the two major production bases. Another example is Suzuki. Aside from using local procurement, Suzuki planned to procure more parts and components from China and Korea by using supplier networks of GM to reduce production costs under its plan called Challenge 30, a target of a 30 percent cost reduction (Fourin, 2003).

Reasons behind an increase in the realignment and integration of production network of assemblers and auto-parts firms, particularly in the ASEAN4 countries, were the 1997 financial crisis, deregulation, trade agreements as well as an intense competition in the emerging vehicle markets. The eruption of the Asian crisis and the pressure from the Trade-Related Aspects of Investment Measures (TRIMs) agreement drove governments to relax their regulations such as the elimination of local content regulation and foreign ownership restriction. The crisis also stimulated vehicle manufacturers to shift their strategies from focusing primarily on the domestic market to be more export-oriented. The export-oriented strategy help assemblers to cancel out their idle capacity arising from a sudden shrinkage in local demand caused by the crisis and the overinvestment during 1994-1996, and to gain benefits from economies of scale. However, the complementary production strategy could be difficult to actualize if there was no reduction in tariffs on auto components and vehicles. The ASEAN Industrial Cooperation Scheme (AICO), AFTA and bilateral free trade agreements signed between Thailand and Australia, New Zealand, and India helped reduce trade impediments and facilitated the complementary production to occur.

The intense competition among vehicle assemblers was another impetus that drove vehicle manufacturers to use the complementary production network strategy. In fact, global assemblers planned to use complementary production networks within Asia to reduce their production costs before the outbreak of the 1997 financial crisis. GM, for example, invested in Thailand with an aim to use Thailand as its production facility for exports. The outbreak of crisis merely induced vehicle manufacturers to emphasize more on the complementary production networks and aroused vehicle manufacturers to integrate production networks in Asia into their global production networks (Fourin, 2003).

Other than complementary production networks, platform strategy is another strategy that is adopted to reduce production costs and to build competitiveness in an intense competition environment. The platform strategy, a use of small number of underbody platforms as the basis for a greater number of vehicle models, has merits in that it helps assemblers to economize on the costs of platform development and to encourage component sharing among models. Furthermore, the strategy also facilitates assemblers to reach economies of scale and be able to respond to diverse preferences in regional/global vehicle markets. The example of sharing platform can be found in Honda; the Honda Odyssey and Accord are produced based on the same platform. Likewise, the platform used for the Ford Everest is also the same platform as the Mazda Fighter, which is an example of platform sharing between firms in the same partner group. Another example is platform sharing between Chrysler and Mitsubishi that allowed Mitsubishi to reduce its number of light-vehicle platforms from 12 to six or seven, nearly half of its previous level (Doner et al., 2004).

2.2 Where to Produce

By using platform and complementary production network strategies, vehicle assemblers can concentrate production of each type of vehicles or components in one location or fewer locations to enjoy economies of scale. According to Doner et al. (2004), which models/parts are to be produced at which country for which markets chiefly depends on cost competitiveness. Cost competitiveness, in turn, is influenced by market size and demand characteristics, existing supplier base, assembler network presence, human resources, and government policies.

To begin with, market characteristics are regarded as a basic factor in determining which platform should be produced at which country. Japanese assemblers began to realign their production networks according to market size and demand characteristics to economize on transportation costs and increase economies of scale in their production (Doner et al., 2004).

Another important factor in choosing where to produce is the quality of supporting industries and the capabilities of local suppliers, both indigenous and foreign firms, since whether locally produced components and modules in a country can meet the global standard is wholly reliant on the capabilities and technology level of suppliers in that country. In addition, high level of design and development skill of local suppliers is conducive to make a rapid design development for new vehicle models, and therefore the shorter period of time required to launch new vehicle models into the market. The speed of launching new vehicle models is a crucial factor that can help vehicle manufacturers to gain market share under the severe competition. The supplier’s capabilities and technology level, hence, are important for helping increase competitiveness of assemblers and for determining production location.

Furthermore, the locations of existing production facilities of assemblers are also pertinent to where to produce. Even though a country’s cost competitiveness can help assemblers to determine where to produce and to know how to streamline their production facilities scattered across countries in the long run, it may not be applicable in the short and medium run. The decision is influenced by how automobile assemblers maximize their profits by using their existing production networks scattered in the region or around the world. The difference in locations of their existing production networks can lead strategies of production allocation to be varied from multinational enterprise (MNE) to MNE. For example, Toyota who has large operating scale in Thailand uses Thailand as a production and export base for both one-ton pickup trucks and small-to-medium passenger cars. In contrast, Ford and Mazda, whose their presence in Thailand is rather small, use their existing production base in Philippines to produce passenger cars (Ford Laser, Ford Escape, Mazda Protégé, and Mazda Tribute). However, it is common for Ford group and Toyota to assign Thailand to be their production base of one-ton pickups since Thailand is a large one-ton pickup market. Mazda assigns Thailand to produce one-ton pickups (e.g. Ford Ranger, Ford Everest, and Mazda Fighter) and export to more than 100 countries as well as to the Philippines while lets Thailand to import small-to-medium Ford and Mazda passenger cars from the Philippines (Kohpaiboon, 2008).

Aside from the discussed factors, human resources in regard to technicians and engineers, managerial skilled employees, government stance on the industry, and the stability of the government policies are also crucial for vehicle manufacturers in choosing their production locations and allocating their production activity.

3. Theoretical Framework and Literature Review

To provide general idea of comparative advantage and comparative advantage measurement, this section summarizes theoretical concepts concerning sources of comparative advantage and presents some revealed comparative advantage indexes. After that, the preceding empirical studies will be discussed.

3.1 Sources of Comparative Advantage

3.1.1 Traditional Trade Theories

Trade direction prediction and specialization measurement are ones of central issues in international economics study. Traditional trade theories suggest that trade patterns among nations are determined by comparative advantage (Deardorff, 1980). The Ricardian theory attributes the relative comparative advantage of a country to relative costs and technological differences while the Heckscher-Ohlin (H-O) theory to relative factor abundance and intensity. With assumptions such as identical technology, no government intervention, and no factor intensity reversal irrespective of factor prices, the H-O theory suggests that a country will export the commodity that uses relatively intensively its abundant factor and import commodity that relatively intensively uses its scarce factor of production. An important contribution of the H-O theory on predicting comparative advantage pattern when factor endowment changes is known as the Rybczynski theorem. The Rybczynski theorem postulates, in two goods and two factors model, that an increase in a factor endowment will induce the output of industry that uses it intensively to increase and reduce the output of the other industry.

However, these traditional trade theories solely regard supply-side factors as sources of comparative advantage and do not incorporate information on the other possible factors that could explain reasons for trade such as transportation costs and increasing returns, to name a few. This leads to a relaxation of several assumptions employed in the traditional trade model in recent trade literature. Ones of these relaxations are to consider the effect of demand-side factors and to allow for increasing returns to scale. Next, we discuss the role of home market effect and economies of scale in the context of comparative advantage. After that, we close this subsection (section 3.1) with the summary of the theoretical framework.

3.1.2 Home Market Effect and Economies of Scale

The role of demand on the pattern of trade is first addressed by Burenstam Linder (1961). He argues that countries tend to export goods that the countries have large demand for and tend to trade with similar income per capita countries. This is known as the Linder hypothesis (Krugman, 1995).

However, as shown by Krugman (1980), the same results as those in the Linder hypothesis can be obtained by resting on the interaction of scale economies and transportation costs in monopolistic competitive sector. Krugman (1980) sets up a two-country model with two sectors: one with Dixit-Stiglitz-type monopolistically-competitive sector[2] and the other with constant-returns sector. Suppose that labor is the only production factor and there is the iceberg transportation costs incurring in the monopolistically-competitive sector. This model turns out that large economy tends to be a net exporter in monopolistically-competitive sector or there is *home market effect*: a country tends to be an exporter of the good that its home country has large demand for.

The logic behind the Krugman (1980) results is that economies of scale make it cheaper to produce commodities of monopolistically-competitive sector at large economy. Even when production costs are the same in these two countries, firms are still likely to locate near large economy since they can minimize their transportation costs by locating near large market.

The market size and increasing returns have been widely used in the empirical trade studies. Yet, in empirical studies where there are more than two countries, the effect of market size is generally captured not only by home market demand but also by the other relevant neighboring markets as well. The standard method to capture effect of neighboring market sizes is the Harris (1954) market potential, which is defined as the sum of distance-weighted market sizes.

3.1.3 Conclusion

In summary, there are some unrealistic assumptions in traditional trade theories such as identical technology, constant returns to scale, perfect competition, no government intervention or no policies restricting the movement of goods between countries in the H-O theory. The recent theories such as in new trade theories thus have relaxed some of these assumptions by adding an active role for demand conditions, increasing returns or economies of scale, imperfect competition, and a time dimension in theoretical models to explain comparative advantage (Appleyard and Field, 2006).

Even though there are myriad theoretical models regarding factor endowments and

[2] Dixit-Stilitz-type monopolistically-competitive sector refers to a sector that consists of many differentiated products in that there is a constant elasticity of substitution between any two varieties.

increasing returns (the two principal theories of the basis for trade), the empirical studies still have not much to say about the relative importance of these two principal driving forces in explaining world trade (Davis and Weinstein, 1999). However, as these two approaches are not mutually exclusive, numerous empirical studies such as Davis and Weinstein (1999, 2003), Ellison and Glaser (1999), and Midelfart-Knarvik et al. (2000) argue along two approaches in studying comparative advantage and production location determinants.

3.2 Revealed Comparative Advantage Indexes

Despite an existence of numerous theoretical models concerning sources of comparative advantage, comparative advantage is not easy to measure in empirical research. In theory, comparative advantage is determined by relative lower costs at the relative autarky prices, which are unobservable in post-trade equilibria. Nevertheless, Balance et al. (1987), for instance, argues that economic conditions in various trading countries determine the international pattern of comparative advantage, which in turn governs the pattern of trade, production, and consumption among countries. Based on the close relationship between trade and pattern of comparative advantage, empirical literature customarily derives comparative advantage index from actual trade statistics, and calls the index *revealed* comparative advantage index[3] (RCA).

Among several RCA indexes, the Balassa index is the most popular measurement for comparative advantage. However, the Balassa index has no meaning in cardinal scale and has asymmetric distribution. It is, thus, difficult to employ the Balassa index in the regression analysis. [4] To be able to use the regression analysis, this study adopts the International Comparative Coefficient index defined below as our measurement for comparative advantage in this study.

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[3] Other than trade data, the comparative advantage can be also measured by using production data such as the Finger-Kreinin statistic (F-K) in Hine (1990) and Greenaway and Hine (1991), the Herfindhal index in Sapir (1996), and the Gini index to measure the intensity of specialization.

[4] The value of upper bound of the Balassa index, (x_r/x_c), varies across countries and time (Benedictis and Tamberi, 2004). This raises problem in making a comparison of specialization across countries and across time in cardinal measure even though the ordinal ranking of the Balassa index can be used for both cross-sector and cross-country comparison. In addition, the asymmetric distribution of the Balassa index can bring about a bias of coefficient estimates when using the Balassa index in regression analysis.

3.2.1 International Comparative Coefficient (ICC)[5]

The definition of the ICC Index can be expressed as follows:

$$ICC_{ci} = (X_{ci} - M_{ci})/(X_{ci} + M_{ci}) \quad [1]$$

;where X_{ci} and M_{ci} are exports and imports of industry *i* from country *c*

The ICC index is defined as net export over total trade. The ratio ranges from –1 to 1. A country is completely specialized in commodity *i* when the index equals 1 and de-specialized if the index is -1. The index equals 0 if there is balanced trade or the maximum intra-industry trade.

There are three merits behind the ICC index. First, the ICC index is computed from data on both imports and exports; therefore, the ICC index reveals competitiveness by having taken the degree of import dependence into account. Second, the properties of the ICC index, in that its value is symmetric around zero and it has finite value for its upper and lower bounds, make it convenient to use the ICC index in the framework of econometrics.

Third, net trade concept in the ICC index is suitable to be employed as comparative advantage measurement as asserted by Deardorff (1980). Deardorff (1980) asserts that international trade pattern is determined by comparative advantage and shows the validity of a weak form of the law of comparative advantage. According to the weak form, there exists a negative correlation between country's relative autarky prices and its net export pattern. On average, country will export goods whose autarky prices are lower and import goods whose autarky prices are higher than international prices. In other words, on average country's trade pattern will be shaped according to its comparative advantage.[6] This relation holds even in many-commodity with trade impediment model. In addition, Bowen (1983) also asserts that the net trade is a proper comparative advantage measurement. A more discussion about the role of net exports as a theory-based measurement of trade patterns in a Hecksher-Ohlin framework can be found in Deardorff (1984), Leamer and Levinsohn (1995) and Bowen et al. (1998).

Unlike the Balassa index, the ICC index does not provide the contrasting dimension

[5] There are several names for this index. Some authors call it as net trade index (e.g. Tung, 2003), or as trade specialization coefficient (Hiratsuka, 2006), or as normalized balance (Algieri, 2004).

[6] A country, in the Ricardian model, is said to have comparative advantage in commodity *i* if its relative autarky price of commodity *i* is lower than relative price of commodity *i* in the world markets. Under perfect competition and undistorted markets, countries tend to export goods in which they have comparative advantage. (http://www-personal.umich.edu/~alandear/glossary/).

between country and benchmark country group (region). However, it may define the comparative advantage of country *c* to region *r* by using the concept of the ICC as

$$ICC^{r}_{ci} = (X_{ci}-M_{ci})/(X_{ci}+M_{ci}) - (X_{ri}-M_{ri})/(X_{ri}+M_{ri}) \quad [2]$$

;where ICC^{r}_{ci} measures comparative advantage in industry *i* of country *c* relative to region *r*; X_{ci} and M_{ci} respectively denote country *c*' s exports and imports of commodities in industry *i*, and so do the X_{ri} and M_{ri} for the region.

The ICC^{r}_{ci} compares competitiveness of country *c* to that of region *r*. This index value varies between (-2, +2). The value of the index will approach to 2 when a country is completely specialized in commodity *i* while region has comparative disadvantage in the same commodity. On the contrary, the index value will approach to -2 when a country has comparative disadvantage in the commodity while the region is completely specialized in the industry *i*. When the index is zero, it implies that a country specializes in industry *i* in the same extent that region does. Similar to the ICC index, this ICC^{r} has favorable properties for using in regression analysis since it also has symmetric distribution around zero and has finite upper and lower bounds.

3.3 Preceding Empirical Studies

The patterns of trade and of the evolution of trade specialization have been extensively investigated. There are three major approaches for studying how trade specialization changes over time. In the first approach, a comparison of RCA index values between two or more points of time is used to explore the specialization improvement/disimprovement among countries or industries that have different factor intensities. This kind of study is widely conducted on a basis of descriptive analysis such as Yue and Hua (2002), Proudman and Redding (2000), and Hiratsuka (2006). Hiratsuka (2006), for example, used the ICC index computed from the 2-digit trade data from 1990-2001 to explain the stage of product development in Asia (Asean4, China, NIEs, Japan, and the US). He finds that there are coexistence of high values of the ICC index for Japan and the latecomers (the ASEAN4 and China) in the transportation machinery industry. He explains that Japan and the late comers both specialized in transportation machinery because they specialize in different sector of the industry (high and low quality).

The second approach mainly investigates dynamic trade specialization pattern. The stability of specialization pattern, whether it is “persistence” or “mobility” over time, is examined by using the Spearman’s rank correlations or by the *Galtonian* regression (see Dalum et al. (1998), Cantwell (1989), Brasili et al. (2000) for further detail). Two main ideas, which are path dependency and structural change, play an important role in explaining whether specialization pattern will be “persistence” or “mobility” over time. Under path dependence, technological and organizational changes are cumulative processes and depend on what they have done in the past; therefore, specialization pattern will not change abruptly. On the other hand, structural change concept propounds that technological change is a random process. Specialization pattern can be altered by features of catching-up economies (Beelen and Verspagen, 1994) or by technology based diversification (Teece, 1988). This kind of empirical studies on dynamic specialization pattern can be found in Dalum et al. (1998); Sharma and Dietrich (2004); and Uchida and Cook (2005).

In the third approach, studies attempt to explore the determinants of comparative advantage, and the study in this chapter can be classified into this category. Numerous preceding researches find significant evidence on relationships between factor endowments and pattern of trade specialization. The previous researches such as by Hufbauer (1970), Keesing (1971), Hirsch (1974), and Baldwin (1979) all shows that the pattern of specialization in manufacturing industry primarily comes from the interaction of inter-industry characteristic differences in technology intensity and inter-country differences in technology endowments (Aquino, 1981).

The evolution of comparative advantage has attracted the interest of researchers. The preceding studies that seek to explain the evolution pattern of comparative advantage are such as Aquino (1981), Balassa (1979), and Dudley and Moenius (2007). Aquino (1981) examines how the pattern of comparative advantage changes over time by considering factor endowments, factor intensities, and scale economies. Capital endowment, technology endowment (or skilled endowment), and home market size are employed as explanatory variables to describe the comparative advantage from 1962 to 1974 for 25 groups of products for 25 countries, such as US, Japan, and Brazil. Technology endowment is measured by a composite index, creating from data on past research and development (R&D) activities, the number of innovation per capita, and wage costs per hour. However, his results remain unchanged when using GDP per capita as an alternative measure for technology endowment. He found that home market size (a proxy for economies of scale in his study) has significantly positive relationships with the specialization improvement in passenger motor cars, parts for motor vehicles, organic chemical, and aircraft for almost all period of his study.

Balassa (1979) investigates the pattern of comparative advantage that changes in accordance with the process of physical and human capital accumulation. He examines cross-sectional data across countries and manufacturing industries and assumes that all countries have the same factor intensities as the U.S. has. Two-step procedure is used to examine comparative advantage. In the first step, Balassa (1979) runs the Balassa index of country *c* and sector *i* on factor intensities for each country. Then, the coefficients from the first-step are regressed on the country's factor endowments. The results confirm the effect of factor abundance as predicted by the H-O theorem.

Dudley and Moenius (2007) examine export pattern of 14 OECD countries of 13 industries and explain trade anomalies pattern of the US and Japan during 1970-1992 under the factor-biased innovation concept. The study adapts Balassa (1979)'s methodology. Similar to Balassa (1979), the revealed comparative advantage index is used as dependent variable while cross-terms between factor intensities and factor endowments are employed as independent variables. To correct for errors in measurement of factor stocks across countries, the ratios of factor intensities and endowments of each country to those of 14 OECD countries is used instead of using countries' factor endowments and intensities, as in Balassa (1979). The results based on factor-biased innovation concept suggest that the reason why Japan has improved comparative advantage in machinery industry (human-capital intensive) despite its low level of physical capital after the WWII was the human capital-augmenting technology that Japan had developed.

In summary, the patterns of trade and specialization and their determinants have been attracted the interest of many researchers. Although there are various approaches in dealing with this issue, there are common in using factor endowments and intensities, and scales of economies as factors in determining the level of comparative advantage. The role of supporting industries, however, has mostly been ignored in the empirical literature due to the difficulty in measurement. Another obstacle in doing empirical research in this field is the availability of data. Since there is a problem in regard to industry classification that differs across countries, few studies have examined the determinants of countries' comparative advantage in the automotive industry in detail. To fill the gap, this study has dealt with this problem by classifying the aggregated data on country and industry's characteristics into detailed data for six sectors in the automotive industry, according to the industry classification of Japan. Furthermore, the paper has also contributed in highlighting the role of supporting industries in determining countries' comparative advantage in automotive industry by computing its own supporting industry index. This index is employed to reveal country's competitiveness in supporting industries for each of six automotive sectors in the automotive industry.

4. Data and Methodology

The objective of this chapter is to examine determinants and explore the evolution of comparative advantage of ASEAN4, China, India, Korea, Australia, and New Zealand in the automotive industry by principally using trade data expanding over the period 1988-2006. In order to have a deeper understanding of countries' comparative advantage in the automotive industry, the automotive industry is subdivided into six sectors according to the classification in the *Japan Input-Output Tables*. The six sectors are Passenger motor cars (3511-01), Trucks, buses, and other cars (3521-01), Two-wheel motor cars (3531-01), Bodies (3541-01), Internal combustion engines for motor vehicles and parts (3541-02), and Motor vehicle parts and accessories (3541-03). For simplicity, hereafter we respectively denote these sectors as car, truck, two-wheel, body, engine, and parts. The definition of these six sectors according to the *Japan Input-Output Tables* classification is provided in Appendix A.

4.1 Basic Data Description

Based on the *Japan Input-Output Tables*' industry classification, (1) the characteristics of each automotive sector in terms of factor intensity and transportation costs per unit value and distance and (2) the change of the comparative advantage index ($ICC^{r}_{ci,t}$) over time are discussed. Table 1 presents factor intensities and transportation costs of each sub-sector in the automotive industry while Table 2 gives some idea regarding the evolution of comparative advantage by country and sector over time.

4.1.1 Factor-Intensity and Transportation Costs

The definitions for the data in Table 1 are as follows. First, labor-intensity and R&D-intensity are respectively computed as a ratio of wages and salaries to total value added and as a ratio of intra-firm R&D to total production value, based on data from the *Japan Input-Output Tables*. The average values of labor-intensity and R&D-intensity for each sub-sector in the automotive industry over the period 1985-2005 are shown in Table 1. Second, the white-collar ratio is computed as a ratio of white-collar employees to total employees, and it is regarded as a proxy for skilled labor ratio required in each sub-sector. Data on white-collar employees is compiled from the 1990 *Census of manufactures, Report by industry*. Third, transportation costs per unit value and distance of each automotive sector in 2001 is computed as a ratio of US-Japan import charges (all freight, insurance and other charges (excluding import duties) incurring in bringing the merchandise to the US) to its imported value (excluding import duties, freight, insurance and other charges incurring in bringing the merchandise to the US) and distance between US and Japan. Data on transportation costs is taken from *Feenstra et al. (2002)*.

Regarding the automotive industry characteristics on labor-intensity, Table 1 shows that among six sectors in the automotive industry, three sectors in the auto-parts industry;

that is, body, engines, and parts sectors, are the sectors that highly employ labor. The highest labor-intensive sector is parts sector, followed by body and engines sectors. The car and truck sectors are similar in their values of labor-intensity while two-wheel sector has the lowest value of labor-intensity among six automotive sectors.

Next, as for R&D-intensity, Table 1 indicates that two-wheel and engines are the sectors that have highest R&D-intensity at around 4 percent while body sector is the sector that has lowest level of intra-firm research and development. Concerning white-collar ratio, Table 1 shows that the values of while collar ratio are similar among assembly activity sectors (car, truck and two-wheel). Likewise, the values of white-collar ratio are also similar in the auto-parts sectors (bodies, engine and parts). According to Table 1, assembly activity sectors use more white-collar workers than auto-parts group. The highest value of white-collar ratio belongs to truck sector.

Next, transportation costs (freight and insurance fee) are a kind of trade impediments. Transportation costs play an important role in determining where parts and components should be produced. Producers will procure parts from abroad only if foreign products are cheaper than local products even when taking account of trade costs (transportation, tariffs, and other pertinent costs). In the automotive industry, the body sector is the sector that has highest transportation costs while the second highest one is truck sector. This means that commodities in body and truck sectors are costly-to-transport. Hence, there is high propensity that assemblers will procure commodities in these two sectors from local suppliers in order to rationalize their total production costs. Note that two-wheel sector is the sector with the lowest transportation costs.

Insert Table 1

4.1.2 Comparative Advantage Index over Time

To have a deeper understanding of the Asian automotive industry, Table 2 provides an averaged values of $ICC^{r}_{ci,t}$ index and of supporting industry index (definition shown in Appendix B) by country and sector in the following three periods: 1988-1997, 1998-2002, and 2003-2006. The time span is divided by crucial important events occurred in the automotive industry. The first period expands from 1988-1997. The outbreak of the 1997 Asian financial crisis accelerated vehicle manufacturers to shift their strategy to export-oriented. Before 1997 many countries in the study adopted protectionist policies, such as high tariff rates and local content policies. Several of these regulations were liberalized after the crisis. The second period, 1998-2002, is the crisis recovery period. The final period, 2003 afterward, is the period that situation of the automotive industry in countries that were adversely affected by the 1997 crisis generally returned to its normal situation. The recovery can be seen from Table 3. Vehicle sales in 2002 of all countries that adversely affected by the crisis (ASEAN4 and Korea) have already recovered or almost recovered to their pre-crisis level in 1996, except for the Philippines.

Insert Tables 2 and 3

We next describe the level of countries' comparative advantage in automotive sectors suggested by the values of the $ICC^{r}_{ci,t}$ index for each country over time. There are several interesting findings from Table 2. First, it should note that all countries that adversely affected by the crisis (ASEAN4 and Korea) have improved their competitiveness except for Malaysia, whose vehicle market is dominated by national car assemblers. For example, Thailand has improved its competitiveness in car, engine, and truck sectors and so has the Philippines in body and car sectors. The improvement in competitiveness of Indonesia between the second and third period can also be observed in car, engine, and parts sectors.

A possible explanation for the improvement in competitiveness of countries adversely affected by the 1997 financial crisis is that there was an influx of foreign capital into these countries after the crisis. This influx of investment brought not only capital but also technology, monitoring, and supervision via a dispatch of foreign technicians to local firms. As argued by Kohpaiboon (2005), the increasing in equity share made foreign partners bring more technology and dispatch of foreign technicians to provide close supervision.

Another reason for improvement in competitiveness is the complementary production network. Japanese assemblers shifted their strategy to export-oriented and used more complementary production networks after the 1997 crisis. For example, in 2002 Toyota assigned Thailand and Indonesia to be two of its four main production bases that are responsible for exporting the IMV vehicles worldwide. In addition, diesel engines for the IMV project are produced in Thailand while gasoline engines are produced in Indonesia. Techakanont and Terdudomtham (2004) also pointed out that the change in automobile assemblers' strategies to export-oriented heightens demand for suppliers with high technological capacity, and this prompted assemblers to alter the contents of technology transfer.

Second, we find that China and India have positive values of the $ICC^{r}_{ci,t}$ index in all three periods in two-wheel sector. This is not a surprising result as China and India are the two largest motorcycle markets in the world. Motorcycle is a cheap transportation vehicle and popular in the developing countries like China and India. As of 2003, motorcycle sales in China and India were 11.13 million units and 5.63 million units respectively (JETRO, 2005).

Third, Korea noticeably performed well particularly in the first period and has a slight drop in performance during the second and third period in body, car, and two-wheel sectors. However, its comparative advantage index has improved for engine and parts sectors and has no substantial change in truck sector, which implies that Korean firms have done well in sectors with high labor-and R&D-intensity. Lastly, note that according to Table 2, the positive values of the $ICC^{r}_{ci,t}$ and supporting industry indexes are mostly observed in China, India, Korea and Thailand, suggesting their high competitiveness over the other countries in the study.

4.2 Econometric Analysis

4.2.1 Description of Variables and Data Sources

The following section explains the variables used in the analysis. Let us denote *c* for country, *c** for trading partner country, *r* for region, *i* for automotive sector, *j* for upstream industries and *t* for time to describe variables and their formulas used in this chapter.

Regarding the dependent variable, the $ICC^{r}_{ci,t}$ index is used as a measurement of country *c*'s competitiveness in each automotive sector *i*. Data for constructing the index is retrieved from the *UN Comtrade*.[7] The formula and meaning of the index are shown below.

International Competitiveness Coefficient

$$ICC^{r}_{ci,t} = (X_{ci,t}-M_{ci,t})/(X_{ci,t}+M_{ci,t}) - (X_{ri,t}-M_{ri,t})/(X_{ri,t}+M_{ri,t}) \quad [3]$$

$$= ICC_{ci,t} - ICC_{ri,t} \quad [4]$$

;where $ICC^{r}_{ci,t}$ measures comparative advantage in automotive sector *i* of country *c* relative to region *r*; $X_{ci,t}$ and $M_{ci,t}$ respectively denote exports and imports of automotive sector *i* from country *c*, and so do the $X_{ri,t}$ and $M_{ri,t}$ for the region.

The value of the index ranges from (-2, +2). The positive value of the index indicates that country *c* is more specialized in sector *i* than region and vice versa. We can say that a country *c* specializes in the same degree as region does when the index equals 0. In other words, the $ICC^{r}_{ci,t}$ index shows comparative advantage of a country relative to the region. In addition, the value of this index is symmetric; thus, it is easy to interpret (in terms of both ordinal and cardinal measures) and to use the index in the econometric work.

Since the $ICC^{r}_{ci,t}$ ranges from -2 to 2 by construction, we cannot simply use linear

[7] United Nations Commodity Trade Statistics Database, online: http://comtrade.un.org/db/default.aspx (accessed on January 29th, 2009).

regression in our analysis as there is no guarantee that the predicted value of the $ICC^{r}_{ci,t}$ would range within (-2, 2) if linear regression were used. Another limitation comes when logistic function can only be applied to dependent variable taking values within unit interval, [0, 1]. To solve these problems, two-step procedure is used to adjust the $ICC^{r}_{ci,t}$ index to be able to use with logistic function. The procedure is shown in Appendix C.

Turning to explanatory variables, the explanatory variables used are selected based on theories and preceding studies as discussed in section 3. As argued in section 3, there are two major theories: the one based on traditional trade such as the H-O and Rybczynski theorems and new trade theories that adopts an assumption of economies of scale and an active role of demand on trade. This chapter selects and employs explanatory variables based on these two concepts.

Regarding the role of factor endowment and factor intensity, the H-O theory suggests that a country will export and have comparative advantage in the commodity that intensively uses its abundant factor. The Rybczynski theorem also postulates that an increase in a factor endowment will induce the output of industry that uses it intensively to increase and reduce the output of the other industry. This suggests that the interaction between factor endowments and factor intensity is required in examining trade pattern. Cross-terms between variables representing factor availability and factor intensity, hence, are embedded into our econometric model. Similar to preceding literature, three kinds of factors of production (labor, skilled labor and Research and Development (R&D)) are on focused.

Regarding measurement for factor availability, wage rates in manufacturing sector are used to reflect the labor availability and labor costs in each country whereas gross ratio of tertiary enrollment is used as a proxy for the availability of skilled labor in each country. Due to data constraint for R&D endowments, the study follows Aquino (1981) in using GDP per capita as a proxy for the availability of R&D endowments. The results of Aquino (1981) show that although there is no theoretical background, GDP per capita does not inferior to a complex index for technology endowment in using as a proxy for technological endowment. Aquino (1981) obtains similar results when using GDP per capita instead of his complex index for measuring technology endowments.

As for factor intensities, labor-intensity, white-collar ratio, and intra-firm R&D-intensity are used. Labor-intensity is defined as a ratio of wages and salaries to total value added while intra-firm R&D-intensity is a ratio of intra-firm R&D to output value. Data on labor-intensity and intra-firm R&D-intensity is collected from the 1985-2005 *Japan Input-Output Tables*. Since the *Japan Input-Output Tables* is published for every five years, the missing values are filled by using interpolation and extrapolation method. In addition, a ratio of white-collar employees to total employees is computed to provide an idea of how much skilled labor is required in each automotive sector. The data comes from the 1990 *Census of Manufactures, report by industries*.

Next, *supporting industry index* ($sup_{ci,t}$) is employed to gauge the strength of upstream industries of country *c* in each automotive sector *i*. The index is constructed as a weighted average of the values of the $ICC^{r}_{cj,t}$ index (the index that shows comparative advantage of country *c* in core supporting industries *j* of each automotive sector). The input coefficients of each core supporting industry *j* in the *Japan Input-Output Tables* are used as weights to reflect the importance that each core supporting industry *j* has on the competitiveness in the automotive sector *i*. Core supporting industries are selected from the upstream industries that have close linkage with each automotive sector. We regard the upstream industries (excluded service and public sector) whose input coefficients are larger than 0.009 as the core supporting industries.

To account for the effect from demand distribution in both home country and neighboring countries as suggested in the concepts of increasing returns and economies of scale, home market size and foreign market potential are adopted as explanatory variables. To capture the home market effect, *home market size* ($\ln hmkt_{ci,t}$), representing domestic demand for commodities in each automotive sector, is introduced into models.

Foreign market potential ($\ln fmktp_{ci,t}$) is calculated as the sum of neighboring market sizes while discounting for trade impediments, which are distance, transportation costs, and tariff. In other words, it measures the potential market size for exports by discounting for costs incurring from trade. Since Japan is a major destination for exports of products in automotive sectors of countries in the study, aside from countries in the scope of this study, Japan is included as a neighboring country in computing foreign market potential. Data on market size is collected from the CD-ROM of the *2008 Seikai Jidosha Tokei Nenkan* published by Fourin, transportation costs from *Feenstra et al. (2002)* while data on distance and tariff respectively comes from the *CEPII website,* and the *2008 Handbook of Statistics, UNCTAD.*

To capture the role of technology transfer and other spillovers that are assumed to be accompanied with investment by Japanese firms, the *Japanese employment ratio* ($fdi\_jp_{c,t}$) is computed by using data from the *RIETI* and from various issues of the *Statistical yearbook*, United Nations. The *Japanese employment ratio* is defined as a ratio of Japanese foreign affiliate employees to total employees in the transportation equipment industry.

Note that the $ICC^{r}_{ci,t}$, the dependent variable, is an index that represents the comparative advantage of a country compared to the competitiveness of region. To build a contrasting dimension with region for explanatory variables as appeared in the $ICC^{r}_{ci,t}$

index, an adjustment on explanatory variable is made by taking a logarithm on the ratio of each country's value to regional average value, which is similar to what have been done in Dudley and Moenius (2007). Specifically, the adjustment has been done to explanatory variables that represent country characteristics or that represent industry and country characteristics except for supporting industry index (that already has regional contrasting dimension); namely, wage rate, GDP per capita, gross enrollment ratio in tertiary education, Japanese employment ratio, home market size, and foreign market potential. Taking wage rate as an example, the formula of variables after the adjustment for the wage rate will be:

$$wage_{c,t} = \ln\left(w_{c,t} \Big/ \sum_{c \in r} w_{c,t} / n \right) = \ln(w_{c,t}) - \ln(w_{r,t}) \qquad [5]$$

;where $w_{c,t}$ is wage rate of country *c* in US dollars in year *t*, and *n* is the number of total countries in the study (region *r*), and $w_{r,t}$ is the average wage rate in year *t* of the region.

Other than continuous variables just described, there are following three dummy variables. The first dummy, *crisis,* takes a value of 1 in 1997 for the ASEAN 4 countries and Korea. The second dummy is national car dummy (*nat*). It captures the effect of national car policy and takes a value of 1 for Malaysia since the year 1988 and Indonesia during 1996 to 1998. The third dummy is the *heavy* dummy and refers to automotive sectors making costly-to-transport products. It takes a value of 1 in body and truck sectors and 0 otherwise.

The detailed definitions and data sources of continuous variables are explained in Appendix B. The definitions of all variables used are summarized in Table 4.

Insert Table 4

4.2.2 Model Specifications and Hypotheses

Six specifications are employed to examine determinants and explore the evolution of comparative advantage of ASEAN4 countries, China, India, Korea, Australia, and New Zealand in the automotive industry over the period 1988-2006. Three major issues are on focused: structural change, the role of Japanese firms, and industry characteristics concerning transportation costs. Specification 1 shows standard model while Specifications

2 and 3 examine structural change of a country's comparative advantage arising from economic integration and decline in government regulations by splitting sample data used in specification 1 into two periods: before 1997 and after 1997. Specifications 4 and 5 are augmented from Specifications 2 and 3 by adding the Japanese employment ratio ($fdi\_jp_{c,t}$) variable to examine the role of Japanese firms in helping enhance a country's comparative advantage in the automotive industry. Specification 6 investigates the role of characteristics of automotive sectors in regard to transportation costs. By using the six specifications, five hypotheses are tested. The details of the hypotheses and specifications are shown below.

Specification 1 examines basic factors that determine a country's comparative advantage, regarded as the benchmark model. Explanatory variables employed in Specification 1 are supporting industry index, home market size, foreign market potential, the cross-terms between the availability of factor endowments and factor intensities, and the *national car* and *crisis* dummies. Two hypotheses are tested under Specification 1. First, the study hypothesizes that strong supporting industry can help a country to increase its comparative advantage in the automotive industry. Thus, it is expected a positive sign of the supporting industry index. Second, regarding the cross-term variables, it is hypothesized that the cross-terms between intra-firm R&D-intensity and GDP per capita ($rd\_intensity_{i,t}*ln\ gdpc_{c,t}$), and between white-collar ratio and gross ratio of tertiary enrollment ($white\_intensity_{i,t}*ln\ edu_{c,t}$) will have positive estimates while the cross-term between labor-intensity and wage rates ($labor\_intensity_{i,t}*ln\ wage_{c,t}$) will have a negative estimate. In other words, the analysis hypothesizes that a country tends to upgrade itself to become more specialized in high R&D-and/or skilled labor-intensive sectors.

The reason behind the second hypothesis is that the pattern of comparative advantage can change and evolve along factor accumulation process and it is likely that a country will accumulate more knowledge and human capital along its path of development. According to the Rybczynski theorem, in two goods and two factors model, an increase in a factor endowment will increase the output of the industry that uses it intensively and reduce the output of the other industry. We thus assume that a relative expansion in R&D endowment and skilled labor along economic development will induce a country to increase its output in R&D- and skilled labor-intensive industries and reduce its output in the labor-intensive industries as suggested by the Rybczynski theorem. With the unchanged tastes and preferences or neutral consumption effect[8], the country will have higher net exports or increase its specialization in R&D- and skilled labor-intensive commodities while reducing its net exports or lowering its specialization in labor-intensive products, leading to positive

[8] Neutral consumption effect refers to a situation when an expansion/detraction of trade does not change relative consumption pattern among commodities (Appleyard and Field, 2006).

signs for (*rd_intensity*$_{i,t}$**ln gdpc*$_{c,t}$) and (*white_intensity*$_{i,t}$**ln edu*$_{c,t}$), and negative sign for (*labor_intensity*$_{i,t}$**ln wage*$_{c,t}$).

Next, the third hypothesis focuses on the influence of the expansion of government deregulation and economic integration in the late 1990s. It is hypothesized that the effects of country and industry characteristics on comparative advantage before and after 1997 are not the same. Constraints creating by governments' regulations (especially from local content regulations and high tariff rates) could prevent assemblers and automotive firms from taking advantages of differences in factor endowments and foreign market potential. We expect that deregulation and economic integration that have been increasingly implemented in the late 1990s will bring us a more obvious role of the cross-terms between factor endowments and intensities in determining a country's comparative advantage in the automotive industry as predicted by the H-O and Rybczynski theorems. To test this hypothesis, the period of study is subdivided into the period before and after 1997 (1988-1996 and 1997-2006). The results for the two split periods (Specifications 2 and 3) are compared.

Fourth, it is assumed that the larger operating scale of Japanese automotive firms in a country, the more likely that a country will attain a higher level of comparative advantage in the automotive industry. The basis for this hypothesis is that the presence of MNEs can play a role in increasing productivity of host country by raising the level of competition or by bringing new idea and technology transfer to the country (Ito, 2002). There are several channels of technology transmission that are associated with high involvement or large operating scale of foreign enterprises such as reverse engineering, skilled-labor turnover from foreign-investment related firms to local firms, demonstration effects, and supplier-customer relationships. A ratio of the number of Japanese MNEs employees to total employees in the transportation equipment industry is used to capture the operating scale of Japanese automotive firms in a country. Since the larger involvement of foreign firms implies a higher possibility to improve comparative advantage, the fourth hypothesis expects a positive sign of the *Japanese employment ratio* variable (*fdi_jp*$_{c,t}$). Similar to the third hypothesis, the sample data used to test the role of Japanese firms is also divided into two periods to compare results of Japanese operating scale in the period before and after 1997 that could differ from an effect of economic integration, deregulation, and economic crisis. The results for the first period are shown in Specification 4 while results for the second period in Specification 5.

Lastly, the fifth hypothesis concerns characteristics of automotive sectors in regard to transportation costs. We hypothesize that a country's comparative advantage in automotive sectors making costly-to-transport products principally comes from the home market effect.

Since high transportation costs might prevent automotive firms from taking advantage of cheap labor costs and make it necessary for automotive firms to produce costly-to-transport products where large demand exists, it is likely that a country with large home demand will have comparative advantage in costly-to-transport sector. The discussion on transportation costs per unit value and distance in section 4.1.1 tells us that body and truck sectors are costly in international trade. Since the sources of a country's comparative advantage in automotive sectors making costly-to-transport products could differ from the other automotive sectors, the cross-terms between the *heavy* dummy, taking a value of 1 for body and truck sectors, and 0 otherwise, and all continuous explanatory variables in Specification 1 are employed to test the hypothesis. It is expected a positive coefficient from the cross-terms between the *heavy* dummy and home market size ($ln\ hmkt_{ci,t} * heavy$). We test this hypothesis in Specification 6.

The equations of the six specifications can be summarized as follows:

Specification 1: The whole period (1988-2006)

$$ICC^{r}_{ci,t} = f^{1}(sup_{ci,t}, ln\ hmkt_{ci,t}, ln\ fmktp_{ci,t}, (labor\_intensity_{i,t}*ln\ wage_{c,t}), (rd\_intensity_{i,t}*ln\ gdpc_{c,t}), (white\_intensity_{i,t}*ln\ edu_{c,t}), crisis, nat) \quad [6]$$

Specification 2: Before 1997 (1988-1996)

$$ICC^{r}_{ci,t} = f^{2}(sup_{ci,t}, ln\ hmkt_{ci,t}, ln\ fmktp_{ci,t}, (labor\_intensity_{i,t}*ln\ wage_{c,t}), (rd\_intensity_{i,t}*ln\ gdpc_{c,t}), (white\_intensity_{i,t}*ln\ edu_{c,t}), nat) \quad [7]$$

Specification 3: Since 1997 (1997-2006)

$$ICC^{r}_{ci,t} = f^{3}(sup_{ci,t}, ln\ hmkt_{ci,t}, ln\ fmktp_{ci,t}, (labor\_intensity_{i,t}*ln\ wage_{c,t}), (rd\_intensity_{i,t}*ln\ gdpc_{c,t}), (white\_intensity_{i,t}*ln\ edu_{c,t}), crisis, nat) \quad [8]$$

Specification 4: FDI_JP before 1997 (1988-1996)

$$ICC^{r}_{ci,t} = f^{4}(sup_{ci,t}, ln\ hmkt_{ci,t}, ln\ fmktp_{ci,t}, (labor\_intensity_{i,t}*ln\ wage_{c,t}), (rd\_intensity_{i,t}*ln\ gdpc_{c,t}), (white\_intensity_{i,t}*ln\ edu_{c,t}), fdi\_jp_{c,t}, nat) \quad [9]$$

Specification 5: FDI_JP since 1997 (1997-2006)

$$ICC^{r}_{ci,t} = f^{5}(sup_{ci,t}, ln\ hmkt_{ci,t}, ln\ fmktp_{ci,t}, (labor\_intensity_{i,t}*ln\ wage_{c,t}), (rd\_intensity_{i,t}*ln\ gdpc_{c,t}), (white\_intensity_{i,t}*ln\ edu_{c,t}), fdi\_jp_{c,t}, crisis, nat) \quad [10]$$

Specification 6: Costly-to-transport (1988-2006)

$$ICC^{r}_{ci,t} = f^{6}(sup_{ci,t}, ln\ hmkt_{ci,t}, ln\ fmktp_{ci,t}, (labor\_intensity_{i,t}*ln\ wage_{c,t}), (rd\_intensity_{i,t}*ln\ gdpc_{c,t}), (white\_intensity_{i,t}*ln\ edu_{c,t}), crisis, nat, (sup_{ci,t}*heavy), (ln\ hmkt_{ci,t}*heavy), (ln\ fmktp_{ci,t}*heavy), ((labor\_intensity_{i,t}*ln\ wage_{c,t})*heavy)\ ((rd\_intensity_{i,t}*ln\ gdpc_{c,t})*heavy), ((white\_intensity_{i,t}*ln\ edu_{c,t})*heavy)) \quad [11]$$

5. Results[9],[10]

Table 5 provides results for six specifications. These specifications are estimated by fixed-effects estimator with heteroskedasticity robust covariance matrix.

Results for Specification 1 show positive significant effects of the supporting industry index, home market size, and the cross-term between intra-firm R&D-intensity and GDP per capita *($rd\_intensity_{i,t}$*$ln\ gdpc_{c,t}$)*, as hypothesized. The results reveal that the presence of strong supporting industries helps improve the comparative advantage of a particular country in the study in the automotive industry, highlighting the importance of vertical linkages between the automotive industry and supporting industries. The positive coefficient of the *($rd\_intensity_{i,t}$*$ln\ gdpc_{c,t}$)* also suggests that countries tend to have higher competitiveness in R&D-intensive automotive sector, which becomes more important in export-oriented strategy of assemblers, as GDP per capita grows. However, we cannot observe significant effects from the foreign market potential and the cross-terms between labor-intensity and wage rates (*$labor\_intensity_{i,t}$*$ln\ wage_{c,t}$*), and between white-collar ratio and gross ratio of tertiary enrollment (*$white\_intensity_{i,t}$*$ln\ edu_{c,t}$*) in Specification 1 where sample of the overall period is employed.

Insert Table 5

Next, Specifications 2 and 3 subdivide the study period into the period before and after 1997 to examine the effect of government deregulation and economic integration on the determinants of comparative advantage. Our empirical results again suggest a positive effect of the supporting industries. Regarding results for the cross-term variables, we find contrasting results for the estimated coefficients of the cross-terms that are statistically significant in these two specifications (Specifications 2 and 3). The coefficients for (*$labor\_intensity_{i,t}$*$ln\ wage_{c,t}$*) and (*$rd\_intensity_{i,t}$*$ln\ gdpc_{c,t}$*) in Specification 2 respectively show significantly positive and negative signs while the signs of the two cross-terms respectively become negative and positive in Specification 3, which are consistent with what we expected from the H-O and Rybczynski theorems. It is likely that government deregulation and economic integration help increase the importance of factor endowments in determining comparative advantage in period after 1997 since few trade barriers and

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[9] For reference, results of the same specifications in the text but estimated by random-effects estimator is provide Appendix D Table 5.7. Note that the results from the random-effects and fixed-effects estimator are similar.

[10] The basic statistics and correlation matrixes are provided in Table 5.6.

regulations from government are more in line with the assumptions in the H-O theory. However, we do not find a significant effect of the cross-term between white-collar ratio and gross ratio of tertiary enrollment ($white\_intensity_{i,t}$*$ln\ edu_{c,t}$). A possible reason is that *gross ratio of tertiary enrollment*, which we use to capture the availability of skilled labor in each country, primarily measures the availability of educated population and does not directly reflect the current situation of skilled labor supply in labor market.

In addition, it is not found that *foreign potential market* helps increase a country's comparative advantage in the automotive industry even when the economic integration and liberalization policies have been implemented. This result is rather difficult to interpret; however, some preceding studies also provide evidence for the negative effect of foreign market potential, which is consistent with our finding. Midelfart-Knarvik et al. (2000), for instance, finds a negative effect of variable (the interaction between industry transportation costs and the distribution of demand) that corresponds to our foreign market potential in his study for the EU. A likely reason for negative estimated coefficient for the foreign market potential in our study is that there was intense foreign competition that made some countries lose their competitiveness in the international markets and become worsened from the foreign market potential, while only few countries became better in gaining more market share via exports. As discussed in section 4.1.2, the positive values of the $ICC^{r}_{ci,t}$ index primarily belong to only four countries. The presence of losers seems to be larger than the presence of ones who gain advantages from international markets. This would lead us to have a negative sign of the foreign market potential.

Turning to the role of Japanese affiliated firms in Specifications 4 and 5, the estimated coefficient for the *Japanese employment ratio* ($fdi\_jp_{c,t}$) in Specification 4 is negative and statistically insignificant. On the contrary, the estimated coefficient for the $fdi\_jp_{c,t}$ (in Specification 5) is positive and significant in the period after liberalization and economic integration have been accelerated. Two plausible reasons for this contrasting result can be explained as follows.

First, it is likely that Japanese automotive firms' strategy to form complementary production networks and utilize location-specific advantages, promoted by the industry liberalization and lower tariffs especially in the ASEAN4, has led them to transfer more technology and know-how to local economies, resulting in an improvement of host countries' comparative advantage and a positive estimate of the $fdi\_jp_{c,t}$ in the second period. In the protectionist period, the Japanese vehicle manufacturers were demanded to use local parts by the local content regulations. Japanese suppliers were thus mainly invited to invest in local markets to complement low-quality indigenous suppliers. However, after the liberalization and economic integration, Japanese firms were allowed to take more advantage from using complementary production networks and had greater leeway to choose where to invest and procure parts. An attempt to form their production networks in the region would create an incentive to transfer more technology and train personnel. Toyota, for example, sent Thai staffs to receive training in Japan after setting up its IMV project (JETRO, 2005, p. 42). Since the objective of doing business has changed between these two periods (from local market access to production network formation), this led an amount of technology transferred to be altered. This interpretation is consistent with the survey results of Ivarsson and Alvstam (2005) who argue against the background of the liberalization of the industry that the main motive for technology transfer is assemblers' need to source high quality parts in an efficient manner.

Second, it is likely that the large operating scale of Japanese firms helped increase a country's comparative advantage in the automotive industry by raising the level of competition. This is especially the case when there are fewer government regulations. The reduction in government regulations exposed local firms to fiercer competition with foreign firms, meaning that uncompetitive firms were forced to raise their capabilities or exit from the market, leading to a rise in the competitiveness of the automotive industry as a whole and a positive estimate of $fdi\_jp_{c,t}$ in the period after 1997.

To sum up, the objective of doing business of Japanese firms has been changed between these two periods (from local market access to production network formation) and a higher exposure of local firms to competition with foreign firms as a result of a relaxation of protectionist measures are two plausible reasons for the insignificant estimate of the $fdi\_jp_{c,t}$ in the period before 1997 and a statistically positive sign in the period after 1997 of the $fdi\_jp_{c,t}$.

Moving to Specification 6, our last specification concerns characteristics of automotive sectors in regard to transportation costs. It is assumed that high transportation costs per unit value and distance of commodities in body and truck sectors might prevent them from taking advantage of cheap wage rates and necessitate automotive firms producing them where there is already large demand. The cross-terms of the *heavy* dummy are included to test the hypothesis. Note that the base category (the *heavy* dummy =0) is car, two-wheel, parts, and engine sectors. The coefficients for the variables in Specification 6 without cross-terms variables, therefore, can be interpreted as the effects of explanatory variables for these four sectors while the coefficients for the cross-term variables can be interpreted as differential effects of the explanatory variables for body and truck sectors compared to the base category.

A crucial result in this specification is that we find a positive significant coefficient for the cross-term between *home market size* and the *heavy* dummy *($\ln hmkt_{ci,t}$*heavy)* as expected. This result implies that large home demand helps to improve a country's comparative advantage in the automotive industry, and this effect is stronger for products that are costly to transport. In addition, we also find that wage rates and labor-intensity are not quite relevant to the determination of a country's comparative advantage in the automotive sectors making costly-to-transport products comparing to other automotive sectors in the base category. This interpretation is suggested by a significant negative coefficient for the ($labor\_intensity_{i,t}*\ln wage_{c,t}$) and a positive coefficient for the cross-term between ($labor\_intensity_{i,t}*\ln wage_{c,t}$) and the *heavy* dummy (($labor\_intensity_{i,t}*\ln wage_{c,t}$)*heavy). The positive sign of (($labor\_intensity_{i,t}*\ln wage_{c,t}$)*heavy) has lowered the importance of the role of wage rates and labor-intensity in the case of the costly-to-transport components, compared to the commodities in the base category. Accordingly, the results in Specification 6 suggest that it is likely that automotive products that are costly to transport will be produced where there is large home demand. In other words, the results suggested that transportation costs played a greater role than factor endowments and factor intensities in determining a country's comparative advantage in costly-to-transport components.

Concerning robustness of results, two modified specifications have been employed to check for robustness. First, we check robustness of our results to the reverse causation of the supporting industry index. There would be a two-way causality between the competitiveness of supporting industries and the level of a country's comparative advantage in the automotive industry. To do this, we incorporate a period lagged variable of the supporting industry index into Specification 1, the benchmark model. Second, we check robustness of our results to the high correlation between the availability of R&D and skilled labor endowment since it is likely that a country that has large availability of skilled labor will also have large amount of R&D resource. To test the robustness, we drop the cross-term between white-collar ratio and gross ratio of tertiary enrollment ($white\_intensity_{i,t}*\ln edu_{c,t}$) from Specification 1. The results for these two modified versions are same as those in Specification 1, and thus indicate the robustness of the results obtained in this analysis. For reference, the results of robustness test are shown in Appendix D Table 8.

Insert Appendix D Table 8.

6. Conclusions

This chapter analyzes how and what factors have influenced the vehicle manufacturers' complementary production networks in the long run by employing the concept of comparative advantage and examined the determinants of comparative advantage in six automotive sectors of the ASEAN4 countries, China, India, Korea, Australia and New Zealand over the period 1988-2006. The main contributions in this chapter are to use detailed data that is subdivided the automotive industry into six sectors, and to compute its own supporting industry index. Three major issues are on focused: structural change, the role of Japanese firms, and industry characteristics concerning transportation costs.

Four major results can be summarized from our analysis. First, this analysis has extended the literature in providing evidence for a robust and strong positive effect of the supporting industry index on improving a country's comparative advantage in the Asian automotive industry. Second, the role of factor endowment and intensity performs better when there is a decrease in government regulations since a lowering in trade barriers and intervention from governments are more in line with the assumptions in the H-O theory. Third, regarding the role of Japanese firms, a large presence of Japanese firms in a particular country raised that country's comparative advantage in the industry, particularly in the period after 1997. Two plausible reasons can be provided: (1) the higher incentive to transfer technology due to a shift in the motivation for doing business of Japanese firms from market-sourcing to production network formation and (2) an improvement in local productivity from a higher exposure of local firms to fiercer competition with foreign firms, arising from a relaxation of protectionist measures. Fourth, our analysis provides some new evidence that the sources of a country's comparative advantage in the different automotive sectors can vary depending on the characteristics of the sector concerned and that costly-to-transport products are more likely to be produced in countries where there exists large local demand.

From our empirical results, it can make a prediction that in long run, assemblers are likely to concentrate their production of costly-to-transport products where there is large local demand. For instance, one-ton pickup trucks, which are costly to transport, are likely to be produced in Thailand since Thailand is the world's second largest one-ton pickup truck market and has large demand for this sector. The scales of economies and high transportation costs of pickup trucks appear to play a large role in promoting Thailand to be a major producer of one-ton pick-ups in this region. Concerning relatively not costly-to-transport product group, it is likely that assemblers will produce the products in this category in countries where there are strong supporting industries for the sectors.

As for policy implications, our empirical results suggested that governments should develop the upstream industries in tandem with the automotive industry. However, it would be difficult to develop every upstream industry for the automotive industry. Thus, it is advisable for governments to set their target of which automotive sectors should be set as priorities of the industry development. In determining which niches in the automotive industry should to be promoted, governments should consider not only country conditions such as its strong supporting industries, the availability of factor endowments, and demand characteristics in vehicle market but also consider the characteristics of the sectors that will be promoted to make the policies more effective and to attain a successful development of the automotive industry in the long run.

However, the study in this chapter still has some limitations, mostly on the constraints from data. Let us take data constraint on factor intensity as an example. Due to data constraint on factor intensities, the study can subdivide the automotive industry into only six sectors despite the fact that there are 6-digit trade data for the automotive industry. A more detailed classification of the automotive industry could provide the more complex characteristics of the industry. It is interesting for future research to study on how a country has increased its comparative advantage or its competitiveness, either within the same product line (intra-sector) or across product lines (upgrade industry structure) by examining diverse characteristics of automotive subsectors. Another limitation of this research also lies on data constraint on factor-intensities. The study assumes that all countries have the same factor intensities as Japan has. Using real factor intensities data for each country will enable us to account for the real differences in production technology used in the automotive industry across countries. The further improvement of these issues is left to the future research.

Appendix A: Japan Input-Output Tables' Classification on the Automotive Industry

According to the classification of the *Japan Input-Output Tables*, the definition of six automotive sectors will be as follows.

First of all, Passenger motor cars sector (3511-01) includes light, small and normal passenger cars. The second sector is Trucks, buses and other cars sector (3521-01), which includes small and large buses, light, small, and normal trucks (gasoline and diesel trucks) and special purpose motor vehicles (mobile cranes, mobile drilling derricks, fire fighting, and mobile concrete mixers). Chassis or Knock down set whose value is more than 60 percent of passenger car and truck vehicle completely built unit (CBU) at Free on Board (FOB) price will classified in the category of passenger car and truck sectors respectively. The third sector, Two-wheel motor cars sector (3531-01), includes motor scooters, electric bicycles, sidecars, or motorcycle parts whose value is more than 60 percent of a motorcycle CBU at FOB price.

Fourth, Bodies sector (3541-01) includes bodies of trailers, passenger cars, trucks, and buses. Fifth, Internal combustion engines for motor vehicles and parts sector (3541-02) includes gasoline engines, diesel engines, internal combustion engines and parts related to internal combustion engine such as radiators, oil filters, pistons, exhaust valves, cylinders, carburetors, and fuel injectors. Sixth, Motor vehicle parts and accessories sector (3541-03) includes all automotive parts except those related to engines and internal combustion components. The examples of auto-parts in this category are bumpers, car heaters, seats, car air conditioners, brakes, clutches, drive axles, transmissions, and steering boxes and columns. A set of Knock Down parts (KD) whose FOB value is lower than 60 percent of finished vehicle will be classified in the Motor vehicle parts and accessories sector.

Appendix B: Definition of Variables and Data Sources

1. Dependent Variable

International competitiveness coefficient ($ICC^{r}_{ci,t}$)

The $ICC^{r}_{ci,t}$ index is constructed by using trade data (6-digit) taken from the *UN Comtrade*. In order to compute $ICC^{r}_{ci,t}$ index of each automotive sector classified by Japan Input-Output Tables, the correspondence code table between Japan Input-Output Tables and HS (Harmonized Commodity Description and Coding System), provided in the appendix of the Japan Input-Output Tables, is used to aggregate trade data in 6-digit level to trade data for 6 automotive sectors. Then, the $ICC^{r}_{ci,t}$ index is computed by the formula described in the text.

2. Explanatory Variables

There are three groups of explanatory variables, i.e., those representing country characteristics, industry characteristics, and those representing country and industry characteristics. First, variables that show country characteristics are wage rate, GDP per capita, gross enrollment ratio in tertiary education, and Japanese employment ratio. Second, variables that represent industry characteristics are labor-intensity, R&D-intensity, and white-collar ratio. All of which present factor intensity of each sector in the automotive industry. Third, the characteristics of countries and industries comprise supporting industry index, home market size, and foreign market potential.

2.1 Country Characteristics Variables

Wage rate

Wages is collected from wages in manufacturing of the *LABORSTA*, ILO[11]. Wage rates in local currencies are converted into US dollar for comparison. Linearly interpolation is adopted to fill in the missing data. A ratio of country's wage rate to the average wage of the region is used to reflect the contrasting dimension as we have done to the dependent variable, $ICC^{r}_{ci,t}$. The formula for the wage rate can be presented as:

Computed as $$\frac{w_{c,t}}{\frac{\sum_{c \in r} w_{c,t}}{n}}$$

; where $w_{c,t}$ is wage rate of country *c* in US dollars, and *n* is the number of total countries in the study (region *r*). Note that in quantitative analysis, the logarithm value has been used. Likewise, all variables representing country characteristics and country and industry characteristics in section 2.1 and 2.3 describe below is also adjusted in a similar way to create a region-contrasting dimension, corresponding to the adjustment in the $ICC^{r}_{ci,t}$ index.

GDP per capita

GDP per capita is constructed using data from the *International Financial Statistics (IFS)*, IMF. Data on gross domestic product (GDP) in local currency, foreign exchange rate and the number of population are also retrieved from the IFS. Then, GDP per capita (in billion US dollars per million people) is computed.

[11] Retrieved online at:< http://laborsta.ilo.org/> (accessed May 27th, 2009).

Gross enrollment ratio in tertiary level

Gross enrollment ratio in tertiary level is retrieved from the *EdStats*, World Bank. According to the EdStats, gross enrollment ratio in tertiary level is the number of pupils enrolled in tertiary, regardless of age, expressed as a percentage of the population of the five-year age group.

Japanese employment ratio

Data on Japanese foreign affiliates' employment in transportation equipment industry by country from 1988-2005 is collected from the *RIETI*[12] while data on total employment in transportation equipment industry comes from various issues of the *Statistical yearbook*, United Nations. The ratio of Japanese foreign affiliate employment to the total employment in the transportation industry is computed to use as a proxy for the involvement of Japanese automotive firms in each country.

2.2 Industry Characteristics Variables

Labor and R&D-intensity

The labor-intensity is defined as a ratio of input coefficient between wages and salaries in sector and total value added while intra-firm R&D intensity is the ratio of intra-firm R&D to output value. Data from the 1985, 1990, 1995, 2000 and 2005 *Japan Input-Output Tables*, published for every five years is collected and used as benchmarks while data for years between the benchmarks is estimated by linear interpolation and extrapolation.

White-collar ratio

To have a more precise idea of skilled labor required in each sector, we collect the number of white and blue-collar employees of establishments whose employees are more than 30 person from the 1990 *Census of Manufactures, report by industries*. Due to different industry classification between Census of Manufactures and the Japan Input-Output Tables, the industry codes have been reconciled by using the correspondence code table between the Japan Input-Output Tables and Census of Manufactures, provided in the appendix of the Japan Input-Output Tables. Then, the white-collar ratio, the number of white-collar employees over total employees, for each automotive sector as defined by the *Japan Input-Output Tables* is computed.

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[12] Access online at: <http://www.rieti.go.jp/en/database/d08.htm> (accessed May 27th, 2009).

2.3 Country and Industry Characteristics Variables

Supporting industry index

The supporting industry index ($sup_{ci,t}$) is constructed using data from the 2000 *Japan Input-Output Tables* and *UN Comtrade*. We regard the upstream industries (excluded service and public sector) whose input coefficients are more than 0.009 as the core supporting industries (*j*). The competitiveness of core supporting industries for each automotive sector is computed to gauge the strength of upstream industries in each country.

The $sup_{ci,t}$ index is defined as a weighted average of the $ICC^{r}_{cj,t}$ index (the comparative advantage indexes of the core supporting industries *j*) for each automotive sector *i*. Input coefficients of each core supporting industry *j* are used as weights to reflect the importance that each core supporting industry *j* has on the competitiveness in automotive sector *i*. The $sup_{ci,t}$ index summarizes the competitiveness of core upstream industries j in each country *c* on the automotive sector *i*. The methodology and data used to compute the $ICC^{r}_{cj,t}$ index for core supporting industries are the same as those used in computing dependent variable. The formula of $sup_{ci,t}$ can be presented as:

$$\text{Supporting industry index } (sup_{ci,t}) = \sum_j a_{ij,t} ICC^{r}_{cj,t} \Big/ \sum_j a_{ij,t}$$

; where a_{ij} is the input coefficient of core upstream industry *j* in the automotive sector *i* and $ICC^{r}_{cj,t}$ is the country *c*'s ICC^{r} index of core upstream industry *j*.

As industry classification for sectors under the automotive industry vary across countries, the study takes industry classification in the Japan Input-Output Tables as the benchmark and adopts the Japan input coefficients for all countries in the study. However, it should be noted that although we use the same input coefficient from the 2000 *Japan Input-Output Tables* for all countries in the study, we do not assume that there is identical technology or competitiveness in automotive sectors and in their supporting industries across countries and over time. The difference in technology/ competitiveness of core supporting industries *j* ($ICC^{r}_{cj,t}$) across countries and over time will allow for technology differences in supporting industries and in turn for the automotive industry across countries and time.

Home market size

Data on home market is compiled from the CD-ROM of the *2008 Seikai Jidosha Tokei Nenkan* published by Fourin. Data in the CD-ROM contains production and sales volume (in unit) mainly for passenger and commercial vehicle. Production and sales volume (in unit) is converted into production and sales value (in US dollars) to make production and sales of different types of vehicles become comparable. The value of sales and production is computed by using Japan export unit-value in the year 2000, attained from the *UN Comtrade*. In order to measure home market size for each sector as precisely as possible, the following method is adopted to capture market size of six automotive sectors in the study.

First, sales of passenger cars and commercial cars in each country are respectively used as a proxy for home market size of car and truck sector. Second, to capture demand for automotive components that increased along production level, the production volume of total vehicles in the economy is employed as a proxy for demand for body, engine, and parts sector. Third, due to the unavailability of motorcycle sales data, we assume that the motorcycle sales is proportional to total vehicle sales and uses total vehicle sales as a proxy for the size of motorcycle market.

Foreign market potential

Foreign market potential ($ln\ fmktp_{ci,t}$) is constructed by using data from the CD-ROM of the *2008 Seikai Jidosha Tokei Nenkan* published by Fourin, *Feenstra et al. (2002),* the *CEPII website,* and from the *2008 Handbook of Statistics, UNCTAD.* The most widely used method in capturing market potential belongs to the Harris (1954), which is computed as the distance weighted of market size $\sum_{c^*} \frac{M_{c^*,t}}{D_{c,c^*}}$. Following preceding work such as Head and Mayer (2004) that takes account of bilateral trade impediments for more than just considering on distance, we augment the Harris (1954) market potential to account not only for distance as in Harris (1954) but also for other kinds of trade impediments; i.e., transportation costs and tariffs.

Hence, the foreign market potential in this chapter is the sum of neighboring market sizes by discounting for trade impediments, which are distance, transportation costs, and tariff, and it can be interpreted as export market potential that belongs to a country *c*.

The formula of foreign market potential can be written as

$$ln\ fmktp_{ci,t} = \sum_{c^*} \frac{M_{c^*,t}}{(1 + \frac{D_{c,c^*}}{D_{us.jp}}(tc_i) + t_{c^*,t})}$$

; where $M_{c^*,t}$ is market size of trading partners countries c^*, tc_i is transportation costs for a unit value of commodity *i* incurring when transporting from Japan to the US in the year 2001, $D_{us.jp}$ is distance between US and Japan, D_{c,c^*} is distance between home country c and its trading partners c^*; and $t_{c^*,t}$ is tariff rate that imposed by trading partner countries c^*.

The sources of data used to construct the index are as follows. The data sources of market size ($M_{c^*,t}$) in the foreign market potential are same as those in home market size. Since Japan is a major destination for exports of products in automotive sectors of countries in the study, aside from countries in the scope of this study, Japan is included as a neighboring country in computing foreign market potential.

Next, data on transportation costs is taken from *Feenstra et al. (2002)*. The US import charges and customs import value from Japan in 2001 are collected to compute trade costs per import value. Feenstra et al. (2002) defines import charges as all freight, insurance, and other charges (excluding import duties) incurring in bringing the merchandise to the US and defines customs import value as the value of imported commodities appraised by the U.S. custom service, excluding import duties, freight, insurance and other charges incurring in bringing the commodities to the US. Trade costs per import value from US to Japan (tc_i) can be computed as import charges/customs value.

Basing on US-Japan trade costs (tc_i) in each automotive sector i, we compute transportation costs among countries in the study by dividing US-Japan trade costs by US-Japan distance ($D_{us.jp}$) and multiplied by distance between two countries in the study (D_{c,c^*}), or $\frac{D_{c,c^*}}{D_{us.jp}}(tc_i)$.

The data provided in Feenstra et al. (2002) are shown in HS 10-digit industries. Trade costs in the HS classification are converted into Japan Input-Output Tables' classification using concordance code table provided in appendix of the Japanese Input-Output Table. The Feenstra et al. (2002) data is made available at http://cid.econ.ucdavis.edu/usixd/wp5515d.html

As for distance, data on distance (D_{c,c^*} and $D_{us.jp}$) is collected from the geo_cepii.xls file in *the CEPII website*.[13] The distance calculation method in detail can be referred to http://www.cepii.fr/distance/noticedist_en.pdf.

The final trade impediment is import tariff. Tariff data ($t_{c^*,t}$) are obtained from the *2008 Handbook of Statistics*, UNCTAD[14], which provide effectively applied tariff rate[15]

13 Access online at: <http://www.cepii.fr/anglaisgraph/bdd/distances.htm> (accessed May 27th, 2009).

14 Retrieve online at: <http://stats.unctad.org/Handbook/ReportFolders/ReportFolders.aspx > (accessed on May 22th, 2009).

15 Effectively applied tariff refers to actual tariffs used. In contrast to MFN tariff (applied to all WTO members), it includes the preferential rates, which are available through regional trade agreement like

(from the world) in the SITC (Rev. 2) classification. Since the motor vehicle sector tends to have the highest tariff rate in the machinery and transportation equipment, the maximum import effectively applied tariff rate (from the world) in section 7 of the SITC (Rev. 2) (Machinery and transport equipment) is used as a proxy for tariffs on motor vehicle industry. The missing value of tariff is extended by assuming that the missing values have the same value as the data in previous year.

Note that home market size and foreign market potential is also divided by their own average region value in order that the variables will reflect the relative value as we did with dependent variables and country characteristics variables such as wage rate. Then, the logarithm is taken before using in econometric analysis.

Appendix C: Two-step Procedure in Adjusting Dependent Variable

Two-step procedure is used in order that the study can estimate and contain the predicted value of ICC^r index within the range of -2 to 2.

In the first step, we convert value of ICC^r index to lie inside the unit interval [0, 1] in order that the transformed value can follow the logistic distribution (by divided by 4 and added by 0.5) and define the adjusted index as ICC'. In the second step, we then apply the logistic distribution to estimate the ICC' distribution.

Step 1: Adjust the ICC^r to lies within the unit interval

$-2 < ICC^r < 2$

$-0.5 < ICC^r/4 < 0.5$

$0 < ICC^r/4 + 0.5 < 1$

Define ICC' equals to $ICC^r/4+0.5$, or $ICC^r = 4*ICC' - 2$.

Step 2: Apply the logistic function $\left(\frac{1}{1+e^{-x\beta}}\right)$ to explain ICC'. This will help us contain the predicted value of ICC within the range of -2 to 2.

$$ICC' = \left(\frac{1}{1+e^{-x\beta}}\right)$$

Regarding meaning of slope coefficients (β), the marginal effects in nonlinear regression vary depending on the values of X (explanatory variables) that used as a point of evaluation, and do not equal the relevant slope coefficients. By the transformation in step 1, the marginal effect (ME) of k^{th} of X, X_k, on ICC^r will equal to

AFTA. So, the effectively applied tariff will be less than or equal to the MFN applied rate.

$$\frac{dICC^r}{dX_k} = \frac{dICC^r}{dICC'} . \frac{dICC'}{dX_k}$$

$$= \frac{d(4ICC'-2)}{dICC'} . \frac{d(1+e^{-x\beta})^{-1}}{dX_k}$$

$$= 4*(\frac{1}{1+e^{-x\beta}})(\frac{e^{-x\beta}}{1+e^{-x\beta}}).\beta_k$$ where β_k is slope coefficient of X_k.

Since $e^{-x\beta}$ has positive value, the sign of $\frac{dICC^r}{dX_k}$ is same as the sign of β_k.

Besides, at any value of X, we have $\frac{ME_k}{ME_{k'}} = \frac{\beta_k}{\beta_{k'}}$ since $4*(\frac{1}{1+e^{-x\beta}})(\frac{e^{-x\beta}}{1+e^{-x\beta}})$ is always constant irrespective of k and k'.

From the above property, we can make simple interpretations of coefficients of independent variables by using β. The sign and ratio of coefficients (β) will give the same sign and same value of ratio of its marginal effect.

Appendix D: Results Tables Estimated by Random-Effects Estimator and Robustness Test

For reference, results of the same specifications in the text but estimated by random-effects estimator is provided in Appendix D Table 7 while Appendix D Table 8 presents results of robustness test. Note that the results from the random-effects estimator shown in Appendix D Table 7 are similar to our main results estimated from fixed-effects estimator.

Insert Appendix D Table 7 and Appendix D Table 8

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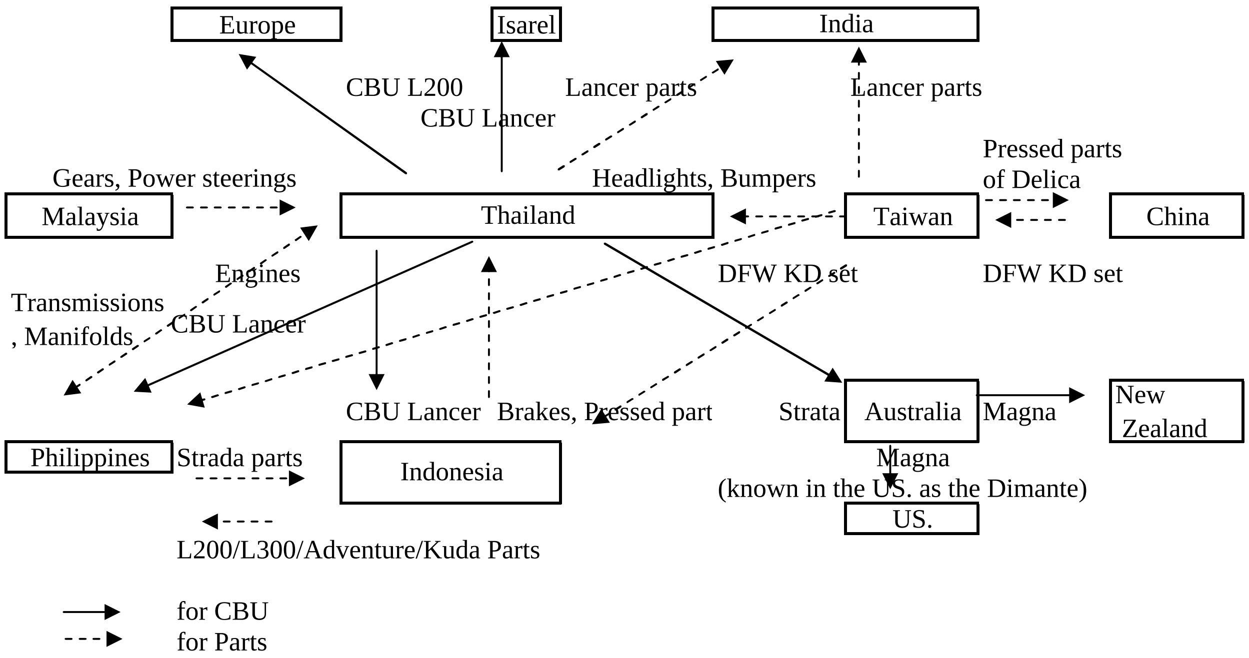
Figure 1: Complementary Production of Mitsubishi Motors in the East Asia



Source: Fourin (2003)

Table 1: Characteristics of Automotive Sectors

Japan's Input-Output industry classification	Labor-intensity	R&D-intensity	White collar /Total employees	Transport cost per unit value and distance
Passenger motor cars	0.5071	0.0323	0.3284	0.0231
Trucks, buses and other cars	0.5254	0.0359	0.3285	0.0585
Two-wheel motor vehicles	0.4337	0.0435	0.3254	0.0146
Motor vehicle bodies	0.6420	0.0174	0.2869	0.1075
Internal combustion engines for motor vehicles and parts	0.6008	0.0423	0.2801	0.0205
Motor vehicle parts	0.6477	0.0311	0.2820	0.0272

Source: 1. Labor intensity and R&D intensity are computed basing on data from Japan Input-Output Tables, average values of data from the period 1985-2005.
2. White-Collar ratio is collected from the 1990 Census of manufactures, Report by industry.
3. Transport costs per unit value and distance is computed, based on the data from Feenstra (2001)

Table 2: ICC Index by Country and Period

		Australia			China			India			Indonesia			Korea		
		1988-1997	1998-2002	2003-2006	1988-1997	1998-2002	2003-2006	1988-1997	1998-2002	2003-2006	1988-1997	1998-2002	2003-2006	1988-1997	1998-2002	2003-2006
body	$ICC^{r}_{ci,t}$	-0.4189	-1.0441	-1.1409	0.1398	0.4518	0.3446	0.5103	-0.0696	-0.5037	-0.5719	-0.5474	-0.7696	0.6131	0.1992	-0.1463
	supporting index	0.0707	-0.2452	-0.4893	-0.1785	-0.2344	-0.2015	0.1161	0.1322	0.1224	-0.3841	-0.4240	-0.3498	0.3643	0.5285	0.5426
car	$ICC^{r}_{ci,t}$	-0.6303	-0.7944	-0.8174	-0.8004	-1.1526	-1.0642	0.7921	0.4218	0.5525	-0.7026	-0.9057	-0.7011	1.0425	0.7542	0.6931
	supporting index	-0.0979	-0.3854	-0.4954	0.0239	0.0283	-0.0090	0.1299	-0.0192	-0.0946	-0.2614	-0.2969	-0.2683	0.2299	0.2589	0.2531
engine	$ICC^{r}_{ci,t}$	0.3819	0.0999	-0.0586	-0.0529	-0.0417	-0.0394	0.4301	0.1735	0.2179	-0.2685	-0.0723	-0.0221	-0.0556	0.0402	0.0609
	supporting index	0.1902	-0.0611	-0.1820	0.0072	0.0068	-0.0030	0.2594	0.1476	0.1924	-0.2732	-0.1530	-0.1395	0.0243	0.1139	0.1171
parts	$ICC^{r}_{ci,t}$	-0.0003	-0.3415	-0.4993	-0.0217	-0.0782	-0.1185	0.1457	0.0106	-0.0328	-0.3373	-0.4489	-0.3434	0.2413	0.3872	0.4643
	supporting index	-0.1002	-0.3931	-0.5047	0.0143	-0.0352	-0.0716	0.0796	-0.0078	-0.0385	-0.3633	-0.3778	-0.3008	0.2075	0.2941	0.3362
truck	$ICC^{r}_{ci,t}$	-0.2471	-0.8248	-0.8937	-0.1841	-0.4040	0.1631	1.5531	0.9249	0.8653	-0.3251	-0.6970	-0.8952	0.9285	0.9364	0.7602
	supporting index	-0.0785	-0.4216	-0.5624	0.0189	0.0247	-0.0138	0.2146	0.0141	-0.0595	-0.3038	-0.3208	-0.2788	0.2338	0.2734	0.2727
two-wheel	$ICC^{r}_{ci,t}$	-0.6713	-1.1880	-1.4587	0.1716	0.7042	0.4802	1.1263	0.7080	0.4683	1.1242	0.3296	-0.3838	0.8060	0.4657	-0.0871
	supporting index	0.0369	-0.2740	-0.4191	-0.0012	-0.0304	-0.0605	0.2190	0.0315	0.0091	-0.3078	-0.3189	-0.2486	0.1783	0.2770	0.3246

Source: Author's Calculation

Table 2: ICC Index by Country and Period(Con't)

		Malaysia			New Zealand			Philippines			Thailand		
		1988-1997	1998-2002	2003-2006	1988-1997	1998-2002	2003-2006	1988-1997	1998-2002	2003-2006	1988-1997	1998-2002	2003-2006
body	$ICC^{r}_{ci,t}$	-0.1091	-0.3038	-0.5217	-0.1713	-0.6152	-0.7877	-0.7052	-0.8810	-0.6999	-0.5173	-0.2017	-0.5109
	supporting index	-0.1773	-0.1298	-0.2482	0.0634	-0.1240	-0.2793	0.0680	0.0675	0.1111	-0.2282	-0.0511	-0.1760
car	$ICC^{r}_{ci,t}$	-0.6213	-0.9512	-1.0649	-0.8341	-1.1776	-1.1955	-1.0668	-1.1430	-0.5574	-0.7290	-0.1952	0.3856
	supporting index	-0.0371	-0.0966	-0.2656	-0.0004	-0.2031	-0.3559	0.0994	0.0978	0.1430	-0.0734	0.0330	-0.0887
engine	$ICC^{r}_{ci,t}$	-0.1962	-0.2838	-0.3541	-0.2215	-0.2741	-0.3645	-0.3306	-0.2914	-0.4429	-0.1376	0.0863	0.1663
	supporting index	-0.2089	-0.2866	-0.3560	-0.2299	-0.3280	-0.3920	-0.1987	-0.2146	-0.2328	-0.1264	0.0580	0.1182
parts	$ICC^{r}_{ci,t}$	0.0022	-0.0582	-0.2879	0.1245	-0.1298	-0.3341	0.4389	0.4765	0.4945	-0.0248	0.1041	-0.0589
	supporting index	-0.0475	-0.0969	-0.2691	-0.0103	-0.2012	-0.3893	0.2490	0.2940	0.3295	-0.0745	0.0298	-0.0544
truck	$ICC^{r}_{ci,t}$	-0.2991	-0.6191	-0.7789	-0.3222	-0.8420	-0.9420	-0.5930	-0.8809	-0.9463	-0.1760	0.7982	0.6948
	supporting index	-0.0716	-0.1492	-0.3384	-0.0684	-0.2894	-0.4595	0.0314	0.0602	0.0851	-0.0868	0.0730	-0.0497
two-wheel	$ICC^{r}_{ci,t}$	-0.7012	0.3259	-0.8526	-0.6801	-1.0538	-1.3975	-1.0361	-1.2056	-1.5132	1.1245	0.5871	0.1953
	supporting index	-0.0917	-0.1498	-0.3160	-0.0348	-0.2221	-0.3737	0.1057	0.1270	0.1269	-0.0706	0.0603	-0.0182

Source: Author's Calculation

Table 3: Total Vehicle Sales in Each Country

Country	1996	1997	1998	2002	2003	2004	2005	2006
Australia	650,049	722,674	807,669	824,309	909,811	955,205	988,269	962,666
China	1,458,666	1,564,862	1,600,080	3,271,488	4,390,748	5,071,648	5,766,679	7,215,525
India	746,176	752,113	651,563	877,445	1,084,739	1,344,297	1,440,455	1,750,873
Indonesia	332,035	386,691	58,303	317,780	354,355	483,168	533,917	318,904
Korea	1,644,132	1,512,935	779,905	1,622,268	1,318,312	1,094,652	1,142,562	1,164,254
Malaysia	364,788	404,837	163,851	434,954	405,010	487,605	551,042	490,768
New Zealand	79,146	71,492	65,667	83,621	91,591	98,455	103,231	99,645
Philippines	162,087	144,435	80,231	85,587	92,336	88,075	97,063	99,541
Thailand	589,126	363,156	144,065	409,242	533,176	626,026	703,432	682,161

Source: Fourin (2008)

Table 4: Variable Definition

Symbol	Variables	Definition
Dependent variable		
$ICC^r_{ci,t}$	International competitiveness coefficient	$ICC^r_{ci,t} = (X_{ci,t}-M_{ci,t})/(X_{ci,t}+M_{ci,t}) - (X_{ri,t}-M_{ri,t})/(X_{ri,t}+M_{ri,t})$
Explanatory variables		
Industry, country characteristics (*c,i*)		
$sup_{ci,t}$	Supporting industry index	Weighted average of the $ICC^r_{cj,t}$ index (the index that shows comparative advantage of country *c* in core supporting industries *j* of each automotive sector *i*)
ln $hmkt_{ci,t}$	Home market	ln (home market $size_{ci,t}$/ home market $size_{ri,t}$)+
ln $fmktp_{ci,t}$	Foreign market potential	ln (foreign market $potential_{ci,t}$/foreign market $potential_{ri,t}$) Foreign market potential = Σ_{c*}[neighboring vehicle market size $_{c*i,t}$/(1+transport $costs_i$ per km*$distance_{cc*}$+$tariff_{c*,t}$)]
Industry characteristics(*i*)		
$labor\_intensity_{i,t}$	Labor-intensity	The ratio of labor value added to total value added
$rd\_intensity_{i,t}$	R&D-intensity	The ratio of R&D expenditures to total output value
$white\_intensity_{i,t}$	White-collar ratio	The ratio white-collar employees to total employees
Country characteristics (*c*)		
ln $wage_{c,t}$	Wage rate	ln ($wage_{c,t}$ (in us dollars)/$wage_{r,t}$ (in us dollars))
ln $gdpc_{c,t}$	GDP per capita at 2000 price	ln (constant GDP per capita at 2000 $price_{c,t}$ (in us dollars)/ constant GDP per capita at 2000 $price_{r,t}$ (in us dollars))
ln $edu_{c,t}$	Gross enrollment ratio in tertiary education	ln (gross enrollment ratio in tertiary $education_{c,t}$/ gross enrollment ratio in tertiary $education_{r,t}$)
ln $fdi\_jp_{c,t}$	Japanese employment ratio	ln ($fdi\_jp_{c,t}$/$fdi\_jp_{r,t}$); where fdi_jp is the ratio of Japanese firms' employees to total employees in transportation equipment industry
Cross-term variables		
$labor\_intensity_{i,t}$*ln $wage_{c,t}$		Labor-$intensity_{i,t}$*ln ($wage_{c,t}$/$wage_{r,t}$)
$rd\_intensity_{i,t}$*ln $gdpc_{c,t}$		R&D-$intensity_{i,t}$*ln (GDP per $capita_{c,t}$/GDP per $capita_{r,t}$)
$white\_intensity_{i,t}$*ln $edu_{c,t}$		White-collar $ratio_{i,t}$*ln (gross tertiary enrollment $ratio_{c,t}$/gross tertiary enrollment $ratio_{r,t}$)
$sup_{ci,t}$*heavy		Supporting industry $index_{ci,t}$*heavy dummy
ln $hmkt_{ci,t}$*heavy		Home market $size_{ci,t}$ *heavy dummy
ln $fmktp_{ci,t}$*heavy		Foreign market $potential_{ci,t}$*heavy dummy
($labor\_intensity_{i,t}$*ln $wage_{c,t}$)*heavy		Labor-$intensity_{i,t}$*ln ($wage_{c,t}$/$wage_{r,t}$)*heavy dummy
($rd\_intensity_{i,t}$*ln $gdpc_{c,t}$)*heavy		R&D-$intensity_{i,t}$*ln($gdpc_{c,t}$/ $gdpc_{r,t}$)*heavy dummy
($white\_intensity_{i,t}$*ln $edu_{c,t}$)*heavy		White-collar $ratio_{i,t}$*ln(gross tertiary enrollment $ratio_{c,t}$/gross tertiary enrollment $ratio_{r,t}$)*heavy dummy
Dummies		
nat	The national car policy dummy	1 for Malaysia since 1988 and for Indonesia from 1996-1998; 0 otherwise
crisis	The 1997 financial crisis dummy	1 for Asean 4 and Korea in 1997; 0 otherwise
heavy	The heavy dummy	1 for body and truck sector; 0 otherwise

Note: $_r$ refers to the average value of all countries in the study; The subscripts of the variables refer to country c, automotive sector i, and time t. In case of foreign market potential, $_{c*}$ is trading partners include Japan and all countries in the study, except for home country.

+ Definition in detail and data sources are provided in Appendix B

Table 5: Fixed-Effects Results Tables

Variables	Specification 1			Specification 2			Specification 3		
	The whole period			Before 1997			Since 1997		
	coefficients	t	p-value	coefficients	t	p-value	coefficients	t	p-value
$sup_{ci,t}$(Supporting industry index)	1.2540 ***	16.70	0.0000	0.9521 ***	5.65	0.0000	1.0090 ***	9.65	0.0000
ln $hmkt_{ci,t}$ (Home Market)	0.0055 ***	2.88	0.0041	-0.0462	-0.97	0.3322	0.0059 ***	2.71	0.0070
ln $fmktp_{ci,t}$ (Foreign market potential)	-0.2908	-0.87	0.3872	-1.2580	-1.52	0.1294	-1.1030 ***	-2.86	0.0045
$labor\_intensity_{i,t}$*ln $wage_{c,t}$	0.1063	1.07	0.2828	0.8051 ***	5.06	0.0000	-0.3451 ***	-3.67	0.0003
$rd\_intensity_{i,t}$*ln $gdpc_{c,t}$	3.9110 ***	2.74	0.0062	-13.2900 ***	-3.44	0.0007	5.7210 ***	4.85	0.0000
$white\_intensity_{i,t}$*ln $edu_{c,t}$	0.1549	0.68	0.4959	-0.3438	-0.75	0.4554	-0.2096	-0.62	0.5391
nat	0.1246	1.47	0.1410	-0.1307 *	-1.75	0.0817	0.2143 *	1.83	0.0684
crisis	-0.0368	-0.79	0.4327				-0.0121	-0.19	0.8511
constant term	0.0829 *	1.94	0.0527	0.0764	0.90	0.3672	-0.2424 ***	-4.89	0.0000
Number of Observations	914			381			533		
F statistic	48.85			10.69			19.15		
Adjusted R-square	0.2308			0.1465			0.2114		
P-value	0.0000			0.0000			0.0000		

* p<.1, ** p<.05, *** p<.01

Table 5: Fixed-Effects Results Tables(Con't)

Variables	Specification 4			Specification 5			Specification 6		
	FDI_JP before 1997			FDI_JP since 1997			Costly-to-transport		
	coefficients	t	p-value	coefficients	t	p-value	coefficients	t	p-value
$sup_{ci,t}$(Supporting industry index)	0.9567 ***	5.38	0.0000	0.9034 ***	7.65	0.0000	1.2900 ***	12.00	0.0000
ln $hmkt_{ci,t}$ (Home market)	-0.0471	-1.01	0.3151	0.0013	0.42	0.6755	0.0018	1.26	0.2096
ln $fmktp_{ci,t}$ (Foreign market potential)	-1.2780	-1.50	0.1338	-0.7358 *	-1.78	0.0759	-0.7045	-1.46	0.1444
$labor\_intensity_{i,t}$*ln $wage_{c,t}$	0.8087 ***	5.14	0.0000	-0.3638 ***	-3.83	0.0001	-0.1577 *	-1.73	0.0836
$rd\_intensity_{i,t}$*ln $gdpc_{c,t}$	-13.3900 ***	-3.41	0.0007	6.0810 ***	5.04	0.0000	5.7000 ***	4.05	0.0001
$white\_intensity_{i,t}$*ln $edu_{c,t}$	-0.3447	-0.75	0.4549	-0.2039	-0.60	0.5510	0.0580	0.21	0.8378
nat	-0.1307 *	-1.75	0.0819	0.2247 *	1.93	0.0548	0.1369	1.56	0.1200
crisis				-0.0076	-0.12	0.9067	-0.0356	-0.77	0.4403
ln $fdi\_jp_{c,t}$	-0.0076	-0.12	0.9025	0.0890 **	2.19	0.0291			
$sup_{ci,t}$*heavy							-0.0779	-0.53	0.5989
ln $hmkt_{ci,t}$*heavy							0.0093 **	2.08	0.0377
ln $fmktp_{ci,t}$*heavy							1.0200	1.53	0.1269
($labor\_intensity_{i,t}$*ln $wage_{c,t}$)*heavy							0.8561 ***	4.77	0.0000
($rd\_intensity_{i,t}$*ln $gdpc_{c,t}$)*heavy							-9.1190 ***	-2.88	0.0041
($white\_intensity_{i,t}$*ln $edu_{c,t}$)*heavy							0.0755	0.16	0.8722
constant term	0.0701	0.69	0.4885	-0.1997 ***	-3.77	0.0002	0.0827 **	2.06	0.0398
Number of Observations	381			533			914		
F statistic	9.33			16.64			37.65		
Adjusted R-square	0.1443			0.2179			0.2548		
P-value	0.0000			0.0000			0.0000		

* p<.1, ** p<.05, *** p<.01

Table 6: Basic Data Description and Correlation Matrixes (Con't)
Overall Period Correlation Matrix
(observations =914)

	Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1)	$ICC^{r}_{ci,t}$	1										
(2)	$sup_{ci,t}$	0.4974	1									
(3)	$\ln hmkt_{ci,t}$	0.1963	0.2491	1								
(4)	$\ln fmktp_{ci,t}$	-0.241	-0.2826	-0.2844	1							
(5)	$labor\_intensity_{i,t}$	-0.1659	-0.0042	-0.1838	-0.1733	1						
(6)	$rd\_intensity_{i,t}$	-0.193	-0.1303	-0.1615	-0.1491	0.8666	1					
(7)	$white\_intensity_{i,t}$	-0.1377	0.0643	-0.1833	-0.1162	0.8783	0.7905	1				
(8)	heavy	-0.0221	-0.0165	-0.0104	-0.0045	-0.0225	0.0972	-0.0065	1			
(9)	$sup_{ci,t}$*heavy	0.3406	0.6426	0.1015	-0.155	0.062	-0.0505	0.0825	-0.1897	1		
(10)	$\ln hmkt_{ci,t}$*heavy	0.1639	0.1124	0.5721	-0.1358	-0.1259	-0.1061	-0.1251	-0.2599	0.2122	1	
(11)	$\ln fmktp_{ci,t}$*heavy	-0.1357	-0.1541	-0.1248	0.668	-0.0698	-0.0341	-0.0086	-0.03	-0.2274	-0.1971	1
(12)	$(labor\_intensity_{i,t} * \ln wage_{c,t})$*heavy	-0.0838	0.0647	-0.1175	-0.0694	0.56	0.289	0.479	-0.4087	0.1648	-0.0931	-0.0944
(13)	$(rd\_intensity_{i,t} * \ln gdpc_{c,t})$*heavy	-0.1204	-0.0401	-0.1039	-0.0438	0.4836	0.3524	0.443	-0.385	0.003	-0.0767	-0.0566
(14)	$(white\_intensity_{i,t} * \ln edu_{c,t})$*heavy	-0.0894	0.0932	-0.1247	-0.0084	0.5247	0.3053	0.5636	-0.2741	0.1857	-0.1375	-0.0062
(15)	nat	-0.1488	-0.2407	0.0115	0.1813	-0.0007	0.0155	-0.217	-0.0031	-0.1256	-0.002	0.0993
(16)	crisis	-0.007	-0.0073	0.0292	0.0255	-0.0035	0.0017	-0.0133	-0.0014	0.0014	0.0182	0.0264

	Variables	(12)	(13)	(14)	(15)	(16)
(12)	$(labor\_intensity_{i,t} * \ln wage_{c,t})$*heavy	1				
(13)	$(rd\_intensity_{i,t} * \ln gdpc_{c,t})$*heavy	0.8756	1			
(14)	$(white\_intensity_{i,t} * \ln edu_{c,t})$*heavy	0.8962	0.8308	1		
(15)	nat	0.0006	0.0078	-0.1178	1	
(16)	crisis	-0.0023	0.0012	-0.0063	0.1401	1

Appendix D Table 7: Random-Effects Results Tables

Variables	Specification 1				Specification 2				Specification 3			
	The whole period				Before 1997				Since 1997			
	coefficients		t	p-value	coefficients		t	p-value	coefficients		t	p-value
$sup_{ci,t}$(Supporting industry index)	1.2700	***	16.70	0.0000	0.9097	***	5.68	0.0000	1.0410	***	10.90	0.0000
ln $hmkt_{ci,t}$ (Home market)	0.0062	***	2.99	0.0028	-0.0104		-0.28	0.7805	0.0052	**	2.44	0.0146
ln $fmktp_{ci,t}$ (Foreign market potential)	-0.6963	**	-2.39	0.0168	-1.4320	*	-1.96	0.0501	-1.1710	***	-3.46	0.0005
$labor\_intensity_{i,t}$*ln $wage_{c,t}$	0.0148		0.16	0.8712	0.6562	***	4.47	0.0000	-0.3535	***	-4.46	0.0000
$rd\_intensity_{i,t}$*ln $gdpc_{c,t}$	3.7340	***	2.78	0.0054	-11.5000	***	-4.12	0.0000	5.3600	***	4.81	0.0000
$white\_intensity_{i,t}$*ln $edu_{c,t}$	-0.1738		-0.92	0.3588	-0.4677		-1.51	0.1316	-0.2287		-0.94	0.3488
nat	0.0935		1.14	0.2559	-0.1528	**	-2.29	0.0222	0.1984	*	1.75	0.0795
crisis	-0.0340		-0.70	0.4831					-0.0024		-0.04	0.9695
constant term	-0.0003		0.00	0.9975	-0.0239		-0.23	0.8191	-0.2523	***	-2.93	0.0034
Number of Observations	914				381				533			
Chi Square	383.06				64.20				196.13			
P-value	0.0000				0.0000				0.0000			

* p<.1, ** p<.05, *** p<.01

Appendix D Table 7: Random-Effects Results Tables(Con't)

Variables	Specification 4				Specification 5				Specification 6			
	FDI_JP before 1997				FDI_JP since 1997				Costly-to-transport			
	coefficients		t	p-value	coefficients		t	p-value	coefficients		t	p-value
$sup_{ci,t}$(Supporting industry index)	0.9162	***	5.72	0.0000	1.0180	***	10.40	0.0000	1.2960	***	12.10	0.0000
ln $hmkt_{ci,t}$ (Home market)	-0.0204		-0.55	0.5840	0.0037		1.39	0.1644	0.0018		1.21	0.2271
ln $fmktp_{ci,t}$ (Foreign market potential)	-1.5010	**	-2.03	0.0427	-1.1160	***	-3.31	0.0009	-0.9565	**	-2.20	0.0280
$labor\_intensity_{i,t}$*ln $wage_{c,t}$	0.6642	***	4.50	0.0000	-0.3544	***	-4.51	0.0000	-0.2060	**	-2.47	0.0136
$rd\_intensity_{i,t}$*ln $gdpc_{c,t}$	-11.6800	***	-4.16	0.0000	5.4720	***	4.77	0.0000	5.5700	***	4.24	0.0000
$white\_intensity_{i,t}$*ln $edu_{c,t}$	-0.4239		-1.36	0.1744	-0.2591		-1.04	0.2970	-0.1413		-0.59	0.5550
nat	-0.1455	**	-2.17	0.0297	0.1950	*	1.73	0.0837	0.1073		1.25	0.2123
crisis					-0.0026		-0.04	0.9676	-0.0318		-0.66	0.5084
ln $fdi\_jp_{c,t}$	-0.0394		-0.93	0.3522	0.0297		0.99	0.3214				
heavy									0.1162		0.57	0.5659
$sup_{ci,t}$*heavy									-0.0686		-0.46	0.6488
ln $hmkt_{ci,t}$*heavy									0.0112	**	2.42	0.0155
ln $fmktp_{ci,t}$*heavy									0.6722		1.11	0.2653
($labor\_intensity_{i,t}$*ln $wage_{c,t}$)*heavy									0.7469	***	3.89	0.0001
($rd\_intensity_{i,t}$*ln $gdpc_{c,t}$)*heavy									-9.7770	***	-2.94	0.0032
($white\_intensity_{i,t}$*ln $edu_{c,t}$)*heavy									-0.1619		-0.41	0.6818
constant term	-0.0502		-0.47	0.6365	-0.2359	***	-2.77	0.0055	-0.0381		-0.33	0.7434
Number of Observations	381				533				914			
Chi Square	63.96				195.33				506.77			
P-value	0.0000				0.0000				0.0000			

* p<.1, ** p<.05, *** p<.01

Appendix D Table 8: Robustness

Variables	Robust test 1				Robust test 2			
	Lagged supporting industry				Omitted white_intensityi,t*ln educ,t			
	coefficients		t	p-value	coefficients		t	p-value
$sup_{ci,t}$(Supporting industry index)	1.2540	***	10.50	0.0000	1.2560	***	16.70	0.0000
ln $hmkt_{ci,t}$ (Home market)	0.0047	**	2.40	0.0165	0.0056	***	2.92	0.0036
ln $fmktp_{ci,t}$ (Foreign market potential)	-0.4319		-1.22	0.2212	-0.4120		-1.51	0.1319
$labor\_intensity_{i,t}$*ln $wage_{c,t}$	0.0562		0.54	0.5914	0.1131		1.15	0.2509
$rd\_intensity_{i,t}$*ln $gdpc_{c,t}$	4.2260	***	2.94	0.0034	3.8510	***	2.71	0.0069
$white\_intensity_{i,t}$*ln $edu_{c,t}$	0.1970		0.81	0.4166				
$sup_{ci,t-1}$ (1 period lagged supporting industry index)	0.0693		0.49	0.6258				
nat	0.1283		1.50	0.1344	0.1218		1.44	0.1508
crisis	-0.0254		-0.53	0.5991	-0.0412		-0.88	0.3795
constant term	0.0630		1.39	0.1642	0.0713	*	1.84	0.0654
Number of Observations	859				914			
F statistic	44.00				55.24			
Adjusted R-square	0.2415				0.2311			
P-value	0.0000				0.0000			

* p<.1, ** p<.05, *** p<.01