Impact of Regional Economic Integration on Taiwan's Industrial Supply Chain of Vehicles

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Abstract

Regional economic integration can help to increase the welfare of participating members, but they can also cause redistribution of income. According to the international trade theory, opening up the market will help to increase the employment and income level of an industrial sector with advantages in one country; while the employees in those sectors with no advantage would negatively affected because the production resources would flow to the advantageous industries. However, from the perspective of the industrial supply chain, if an industry of a country is dominated by foreign investors and the country shows advantages in part of the supply chain, what will be the impact on industry under the situations of regional economic integration and MNEs' adjustment of global supply chain?

Participating regional economic integrations has been a certain policy in Taiwan. That is, Taiwan will actively establish closer trade and economic relations with international partners after the participation to WTO few decades ago. It could be then expected that those industries with advantages in Taiwan would definitely gain the benefit after Taiwan be a member of some regional partnership. However, the industries, such as automobile, which has always been dominated by Japanese brands in Taiwan, may be negatively affected when Taiwan open markets and the Japanese automobile producers adjust their distribution of supply chain. If that happen, the upstream of automobiles would also be negatively affected due the decreasing of demand for producing automobiles, even though Taiwan shows a relative advantage on the sectors of auto components. Therefore, by adopting the model proposed by Lewbel (2012), this paper would aim to estimate the price elasticity of imported vehicles, and the impact of tariff elimination toward imported vehicles on the sales of domestically produced automobiles and auto components, so as to figure out the policy implications for the development of the automobile industry in Taiwan.

Key words：Regional economic integration, demand and supply model, automobile industry, supply chain

JEL classification：F14, F15, L62

1. Introduction

Japan's automobile industry began to develop after World War II. After two oil crises in the 1970s, Japanese automobiles began to rapidly gain market share in Europe and America due to their lighter weight and fuel efficiency, and became a major competitor of European and American automobiles in the global market. However, many countries impose high tariffs on finished vehicles. Thus Japan's automobile manufacturers utilized ICT technologies to improve its management and production efficiency and invested in overseas production bases to satisfy the local and regional markets, so as to enhance its competitiveness in the international market.

On the other hand, Taiwan's government once adopted many protectionist policies to establish Taiwan's automobile industry, such as high tariffs, local content restrictions, and regulations on factory establishment. Those policies drove Japanese and American automobile manufacturers producing in Taiwan, and gradually completed the supply chain for Taiwan's automobile industry, in which some auto parts companies gained high competitiveness in aftermarket (AM). However, most automobiles manufactured in Taiwan are Japanese brands and sold domestically, so production arrangements and sales are mostly managed by the parent company in Japan. Due to the limited scale and gradually reduction of the tariff rates after joining the WTO, competition between domestically produced automobiles and imported automobiles in Taiwan has become severe in recent years.

Most industries in Taiwan are an integral part of the international supply chain. Facing the rapid development of regional economic integration after 2000, Taiwan cannot turn back and must actively take part in regional economic integration to maintain the importance of its industries in the international supply chain. Consequently, industries that mainly sell to the domestic market must face open competition. Based on the research of (Shih et al., 2016), Taiwan’s automobile industry will face severe impact when Taiwan participates in regional economic integration, while Japan will have the greatest impact on Taiwan's finished vehicle industry. The reason is not only because Taiwan's finished vehicles are mainly sold in the domestic

market, but also due to the production and marketing management of the parent company (mainly Japanese automobile manufacturers).

To determine the effect of opening Taiwan's automobile market, especially to Japan, on domestic automobile sales (number of vehicles registered) when Taiwan participates in regional economic integration, this study refers to the approaches of previous studies to estimate the price elasticity of domestically produced vehicles to imported ones. The effect of lower imported vehicles' prices due to the lower tariff rates on the sales of domestically produced vehicles is then inferred. Finally, the effect of this development on Taiwan's auto parts industry would be discussed from the supply chain perspective.

The rest of the paper is organized as follows. Besides the literature review in section 2, section 3 presents the development of Taiwan and Japan's automobile industries. The empirical model and regression results are described in section 4 and section 5, respectively, which are followed by the conclusions in section 6.

2. Literature Review

2.1 International Trade and Price Elasticity of Imports

Estimating the price elasticity or income elasticity to discuss the effect of trade policy is a common analysis method adopted in this series of studies. For example, Sharma (2002) estimated the Morishima elasticities of substitution (MES) between imported goods and domestic capital and labor, and found that imported goods were substitutes for capital and labor in the U.S., in which the degree of substitution is higher for labor. So imports would impose negative impact on U.S. employment. Aiello et al. (2015) estimated the price elasticity of China and OECD countries in 1990-2013 to investigate the effect of exchange rate policy, and found that globalization had reduced the effect of currency depreciation on export. Kayum et al. (2016) used the import demand function of Bangladesh in 1977-2015 to estimate the short-term and long-term import price and income elasticity of Bangladesh, and used it as a basis for making policies of domestic price, tax refund and subsidy, and tariff.

Other studies emphasized that industries in each country have different features and are affected by policies to different extents, so it would be more appropriate to separately estimate the elasticity of imports for different industries (Felettigh and Federico 2010; Cheng et al. 2015; Colak et al. 2014). After analyzing different industries, Colak et al. (2014) found that the industries such as basic metal, vehicle and scooter, electronic machinery, and textile industries not only had the highest price elasticity of imports, but also had the highest level of dependence on imported intermediate goods during production. Hence, improving the price advantage and stability of supply of domestic intermediate goods will help decreasing Turkey's trade deficit. Felettigh and Federico (2010) found that the price and income elasticity in its main export market was lower for the vehicles and transportation equipment imported from Italy than those from France and Germany; while there was no significant difference in other industries. Hence, Italy has higher export pricing power for vehicles and transportation equipment. Imbs and Mejean (2017) used the data of 28 developing countries to estimate the trade elasticity of different industries in different countries, and discussed the cause of different trade elasticities between countries with different degrees of development, as well as the correlation between trade elasticity and welfares.

Even though many studies focus on import and trade policy, and pointed out that different industries would be affected differently due to the different elasticity of import, only a few studies analyzed the effect of opening markets on the domestic production and sales of a specific industry. Within the limited examples, Cheng et al. (2015) estimated the price and expenditure elasticities of imported logs in China, and inferred the substitution and complementarity of imported logs and those produced in China.

2.2 Supply Chain of Automobile Industry

The concept of the Global Value Chain (GVC) began in the 1970s and rapidly developed following the globalization in the 1990s. Backer and Miroudot (2013) believe that due to liberalization on trade and investment, as well as the technology development of ICT, manufacturers have greater flexibility to choose the locations for

production or services with lower cost, which lead to the rise of the global supply chain.

Gereffi (1994, 1999) divided global commodity chains into "producer-driven" and "buyer-driven" based on the different roles of multinational companies and independent suppliers in supply chains of different industries. In a producer-driven global commodity chain, MNEs with core technologies in such industries have strong control power over their upstream suppliers and downstream dealerships. Those capital and technology intensive industries are usually in this kind of categories, such as automobile, aerospace, semiconductor, pharmaceuticals.

Then, Gereffi, et al. (2005) investigated the globalization process from the role of GVCs. The paper divided the governance of GVC into five types, namely market, modular, relational, captive, and hierarchy. According to the study, the automobile industry is representative of captive GVCs. When knowledge and information have high codifiability and product portfolios are complex, but suppliers have relatively weak ability, the governance of GVC would tend to the captive type. With this governance type, the leading enterprise has high level of controlling power over the entire value chain. As a result, captive suppliers are usually confined to limited tasks for a long period of time, while the leading enterprise controls the key business.

The automobile industry is a capital and technology intensive industry with a massive supply chain that covers multiple different industries. The leading enterprises of automobile industries not only control the core technologies, they also strictly monitor the quality of parts and components, so that parts and components suppliers and the assembly plant form a center-satellite system with a stable long-term partnership. Meanwhile, those satellite plants may be restricted to supply only to the assembly plant that they cooperate to.

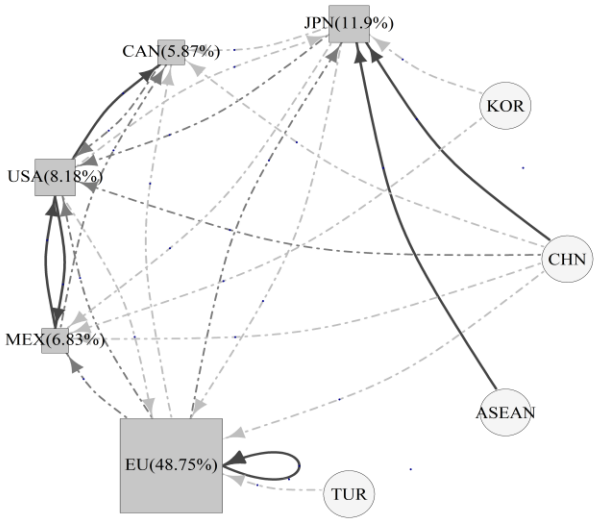
Furthermore, due to the complex production process, high transportation cost, and high tariffs on finished vehicles, automobile production is mostly near consumer markets, resulting in a relatively clear division between regions. Figure 1 illustrates the main sources of the top five finished vehicles exporters to import parts and components. The box in the figure is the world's top five exporters of finished vehicles,

and those countries in circles show the regions where the exporters mainly import auto parts and components from. It can be observed from the figure that cross-border automobile supply chains can be divided into three main regions. One is the regional supply chain between the E.U. and Turkey, in which the automobile manufacturers gain benefit from the EU's Customs Union with Turkey. It is also worth noting that 81.28% of auto parts and components imported by EU are supplied within the EU itself.

The second regional supply chain is in North America, which includes Canada, Mexico, and with the U.S. as the center. These three countries connect the supply chain of automobile by the North America Free Trade Area (NAFTA). Canada and Mexico are the main suppliers of finished vehicles for the U.S., while the U.S. is the main auto parts and components supplier for Canada and Mexico.

The third regional supply chain is in East Asia, which includes Japan, ASEAN, and China. Japanese companies have a strong presence in ASEAN countries (especially Thailand) to leverage the FTA network within the region, so that the ASEAN countries have secured an important role in the East Asia supply chain and become the main source of auto parts for Japan.

It is noteworthy that despite the global expansion of European, American, and Japanese automobile manufacturers, their presence is mostly found in their own continent, i.e., the production bases of European automobile manufacturers are mainly in European countries, while the U.S. and Japanese brands are mainly produced in America and Asia, respectively. Hence, regional economic integration may strengthen the automobile supply chain within the region, while the production base without economies of scale may be dismissed by its parent companies.



Notes：1.Countries in squares are the world's main finished vehicle exporters; countries in circles are main parts and components suppliers for the exporters.
2.Dark gray solid lines indicate that the source accounts for over 30% (inclusive) of imports; light gray solid lines indicate that the source accounts for 20% (inclusive) to 30% of imports; dark gray dotted lines indicate that the source accounts for 10% (inclusive) to 20% of imports; light gray dotted lines indicate that the source accounts for less than 10% of imports.
3.This figure is prepared by HS codes which corresponding to IO classifications, and the definition of consumer goods is HS8701-8705 finished vehicle products. Intermediate goods are defined as goods other than the finished vehicle products.
4.Import data for the E.U. is 2016 and 2017 for other countries.
Source：WTA Database.

Figure 1　Trade flow of automobile and auto parts

The situation above implies that even if multinational automobile manufacturers are expanding globally, the leading enterprises will still keep a part of its production line, especially the high value models, in its native country for export and differentiates from those produced overseas. More importantly, those vehicles produced overseas are mainly for satisfying the demands of regional market, thus the production and export of each production base is still controlled by the parent company.

That is, even though the automobile supply chain is complete in Taiwan, it is almost no connection with the main supply chains because Taiwan is lagging in participation in regional economic integration. Besides, the limited scale of market keeps the automobile plants in Taiwan from enjoying the economies of scale. With this background and the regional supply chains that have already established globally, Taiwan's assembly plants will very likely be forced to close and finished vehicles will

be imported from other countries in the East Asia supply chain (Japan and ASEAN countries) once Taiwan participate in regional economic integration, which will also negatively affect the auto parts suppliers working with Taiwan's assembly plants.

2.3 Effect of regional economic integration

There are many studies about different aspects of regional economic integration. For example, Thronton and Goglio (2002) and Clarete et al. (2003) used the gravity model to determine the effect of free trade agreements (FTA) on trade, and pointed out that exports between two countries would significantly increases by signing preferential trade agreement (PTA). Nguyen (2014) used the logit model to determine the effect of tariffs and Japan's foreign investments on the probability of counterparts' exports to Japan. Marmolejo (2011) used a Richardian general equilibrium model to show that the higher tariffs would give trading counterparts greater incentive to transfer the effects of currency depreciation to product prices, causing import prices to become more sensitive to exchange rate changes.

With regard to the effect of trade agreements on the automobile industry, Goldberg (1995) pointed out that the automobile industry is an oligopoly market which dominated by multinational automobile manufacturers, and thus used the oligopoly model to find the supply and demand curve of the U.S. automobile market, which was then used to determine the price elasticity of demand and the effect of exchange rates and quotas in the U.S..

Automobile plants in Taiwan are not oligopolists in the global market, but are OEMs with complete supply chains for multinational automobile manufacturers to meet the demand of Taiwan's finished vehicle market. When Taiwan participates in regional economic integration, the effect of opening Taiwan's market to countries of parent companies (especially Japan) on the automobile and auto parts industries will be different from the case in the U.S., which not only has a large domestic market but also its own automobile brands.

Therefore, this study refers to the ideas of previous studies and the concept of Goldberg (1995), and then uses the supply-demand model with GMM estimators proposed by Lewbel (2012) to estimate the price elasticity of finished vehicles in

Taiwan. Lewbel (2012) proposed a method which adopts the heteroscedastic covariance restriction to identify and estimate endogenous regressor models. In other words, there is no need of additional instruments when researchers adopt the heteroscedasticity-based identification approach (Huang et al. 2009).

This study also conducts a questionnaire survey and interviews to determine the effect on prices of automobiles resulting from lowering tariffs on finished vehicles in Taiwan. Then the effect of participation in the regional economic integration and tariff elimination on the industry of vehicles and auto parts will be implied based on regression analysis and the result of survey and interviews.

3. Overview of Taiwan's and Japan's Automobile Industry Development

3.1 Japan's and Taiwan's Automobile Industry

3.1.1 Japan's Automobile Industry and its Cross-Border Supply Chain

After the two oil crises in the 1970s, Japanese vehicles became smaller and more fuel efficient, and gradually increase their market shares in European and American markets. However, finished vehicles are usually protected by high tariff in many countries. Thus Japan's automobile manufacturers gradually invested in overseas production bases to satisfy the local and regional markets. And with the increase of overseas investments, the overseas production of finished vehicles increased by about 3 million between 2013 and 2017 with a growth rate of 17.81%, and was about twice the production of finished vehicles in Japan[1].

Meanwhile, the cross-border production model of Japan's automobile industry has resulted in the decline in Japan's finished vehicle production. Even though Japanese brands have maintained high market share in Japan's automobile market (94% and above), its production and market shares have been slightly decreasing while the market share of imported vehicles has slightly increased, which cause the reducing

[1].In 2017, finished vehicle production in Japan was 9.69 million vehicles, while overseas production was 19.741 million.

demand for auto parts in Japan as well.

Corresponding to the shrinking sales of domestic products, and for revitalizing Japan's domestic finished vehicle production and its supply chain, Japanese automobile manufacturers subsequently utilized automatic production and network technology to increase their production and supply chain management efficiency, and moved the production of some models back to Japan and then exported.

It is worth noting that vehicle production by the six major Japanese automobile manufacturers in Taiwan accounts for a low percentage of their global production, which shows that Taiwan is not an important production base of Japanese automobile manufacturers. In other words, even if Taiwan participates in the same regional economic integration with Japan, the number of vehicles assigned to produce in Taiwan and exported to meet Japan's demand will be very limited. But it is more likely that Japanese parent companies will dismiss the production bases in Taiwan and provide the demand in Taiwan from Japan.

3.1.2 Taiwan's Automobile Industry

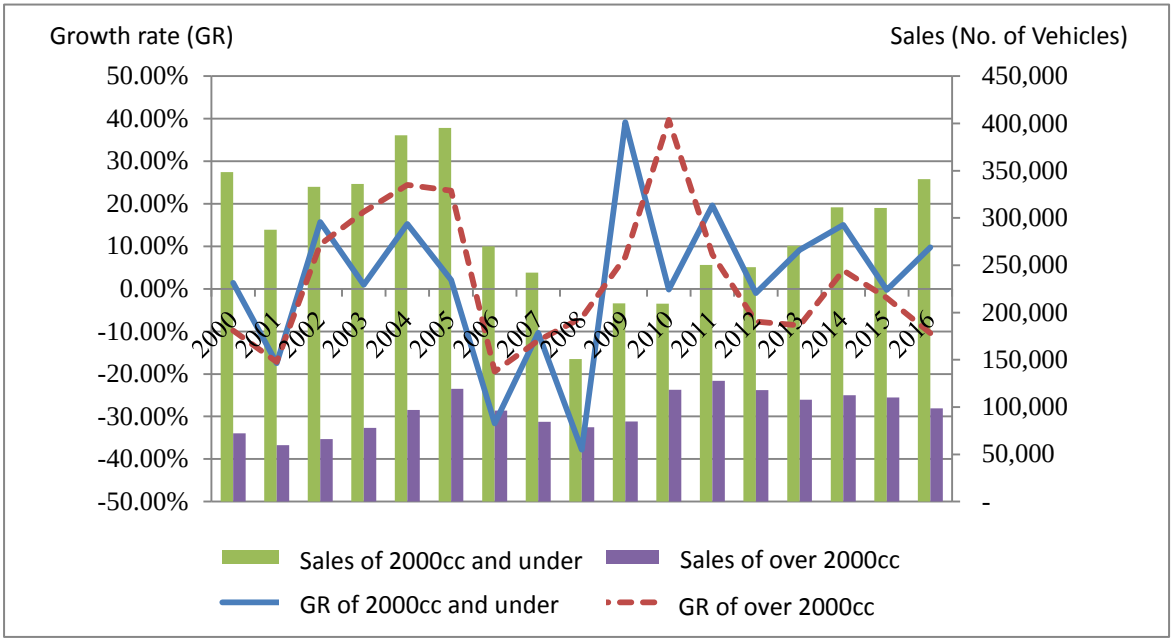
After joining the WTO in 2002, Taiwan sequentially lowered its tariffs, and gradually canceled local content restrictions and quotas. This resulted in severe competition between domestically produced vehicles and imported vehicles. And the market share of imported vehicles rapidly increased from 115 thousand vehicles sold in 2013 to 190 thousand vehicles sold in 2017. Despite the high tariff barriers of Taiwan against finished vehicles, imported vehicle sales and market share continued to rise each year, showing that Taiwanese consumers have a preference for imported vehicles. On the other hand, the market share of domestically produced vehicles has been dramatically shrinking from 69.61% in 2013 to 57.33% in 2017. Therefore, the auto parts industry in Taiwan needed to expand the overseas market due to the decline in output value of finished vehicles in Taiwan, and the output value of Taiwan's auto parts industry has continued to rise from NT$180.8 billion in 2013 to NT$197 billion in 2017 with the ratio of exports continued to climb to about 50% in 2017.

Of the vehicles sold in Taiwan in 2014-2016, models of Japanese brands on

average accounted for 68.9% of the total number of vehicles registered. Among the Japanese brand vehicles that were registered, approximately 74% was produced in Taiwan and 23% was produced in Japan and then exported to Taiwan. If we further divide the data by engine displacement, about 78% of the 2,000 cc and under registered vehicles was domestically produced. The ratios for 2000-3000cc vehicles were about 64.6% and 34.5% for over 3000cc. The situation above clearly presents the strategy of parent companies in Japan to produce most 2,000 cc and under vehicles in Taiwan for the local demand.

With the facts that Taiwan is not one of Japan's main overseas production bases, and the automobile manufacturers established factories in Taiwan in response to the relatively high tariffs to meet Taiwan's market demand. This sales distribution may change when Taiwan participates in regional economic integration and eliminates tariffs. If Taiwan participates in regional economic integration and opens its market to Japan or other important overseas production bases of Japanese automobile manufacturers (such as Southeast Asian countries), it is very likely that the Japanese automobile manufacturers will export from Japan or other production bases to replace the production in Taiwan after considering their global production and management efficiency, which will further reduce the market share of domestically produced vehicles in Taiwan. In that case, Japanese companies will benefit the most but Taiwan's automobile plants and auto parts manufacturers will be negatively affected.

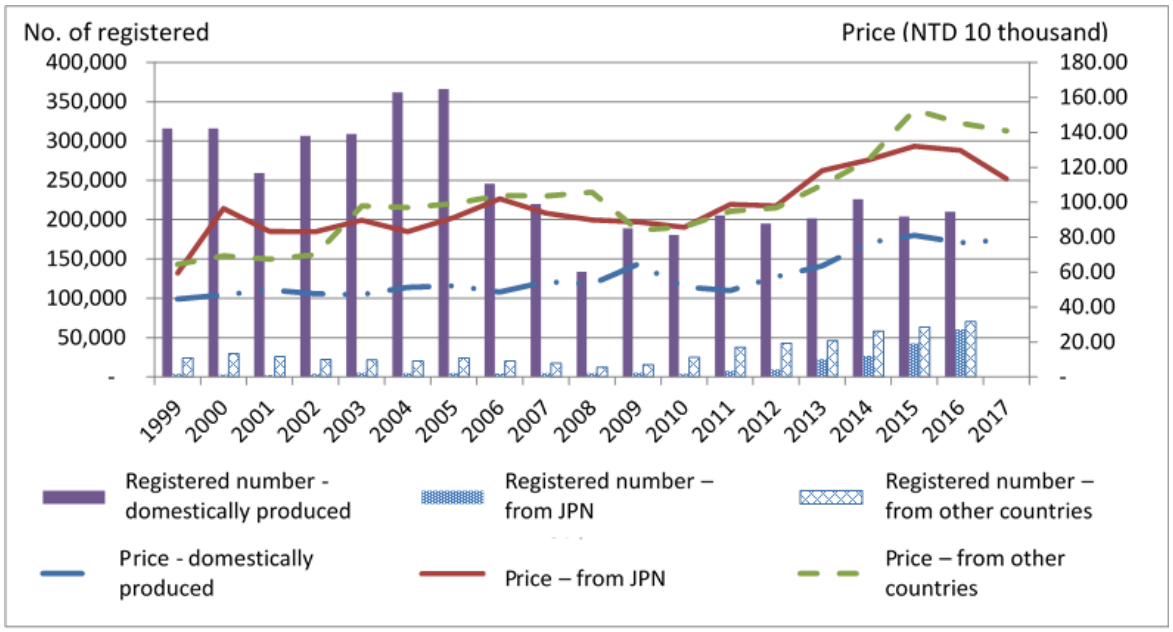
It is worth noting that, the vehicles that in the category of 2,000 cc and under are not only with the highest ratio of domestically production, but also shows the greatest growth potential. Figure 2 summarized the sales volume and growth rate of the two types of vehicles between 2000 and 2016. The figure shows that a significant number of 2,000 cc and under vehicles is sold in Taiwan, and its annual growth rate was greater than that of over 2,000 cc vehicles after 2011.



Source：Statistics on vehicles registered by Chunghwa Telecom compiled by this study.

Figure 2　Number and grow rate of 2,000 cc and under vehicles and over 2,000 cc vehicles registered

Meanwhile, the vehicles of 2,000 cc and under face the most severe competition with imported vehicles in Taiwan. Figure 3 shows the number of 2,000 cc and under domestically produced vehicles, vehicles imported from Japan, and vehicles imported from other countries that were registered and their price trends. The figure shows that the price of domestically produced vehicles for 2,000 cc and under has remained around NT$800 thousand since 2015, but the price of imported vehicles has declined, especially vehicles imported from Japan. This significant price decline may be due to the higher production efficiency and lower cost achieved by Japanese vehicles from globalization, as well as the depreciation of Japanese Yen. These trends have already reduced the price difference with domestically produced vehicles. If Taiwan further lowers tariffs on Japanese vehicles, it will create even greater pressure on domestically produced vehicles for 2,000 cc and under.



Source：Statistics on vehicles registered by Chunghwa Telecom compiled by this study.

Figure 3　Changes in prices of domestically produced vehicles and imported vehicles (2,000 cc and under)

3.2 Trade between the automobile industries of Taiwan and Japan

3.2.1 Foreign trade of Taiwan's and Japan's automobiles and auto parts

Overall, Taiwan's automobile industry enjoyed a trade surplus in the amount of US$307 million in 2015-2017, but those sectors with trade surplus are auto parts for aftermarkets in the EU and the US. The subsectors of finished vehicle, automobile engine, and chassis and transmission parts had a trade deficit.

The average amount of imports in Taiwan's automobile industry in 2015-2017 was US$8.47 billion, with the finished vehicles rank the first among the 7 subsectors (average import amount of US$4.60 billion), followed by chassis and transmission parts (average import amount of US$1.11 billion). Besides tires and inner tubes, the top five sources of the other 6 subsectors already take over 80% of total market, which shows the sources of imports in Taiwan's automobile industry are highly concentrated.

Regarding the individual sources of imports, Japan plays an extremely important role as the import source of Taiwan's automobile industry, and is among the top three sources of imports in all of the subsectors. Japan is the largest source of imported

chassis and transmission parts (43.8% of the import market). Other subsectors in which Japan takes at least 20% market share include finished vehicles (34.2%), other parts and components (25.4%), and automobile engines (23.8%). Furthermore, Thailand is the largest source of automobile engines in Taiwan, and is also the third largest source of car body and parts, electromechanical and electronic components, and other parts and components. Since Thailand is an important overseas production base for Japanese automobile manufacturers, and Taiwan's finished vehicle production is mainly Japanese brands, the situation above presents the supply chain arrangements of the Japanese parent companies.

It is noteworthy that finished vehicle exports of Taiwan are highly concentrated in West Asia, and over 50% of exports are exported to Saudi Arabia, followed by United Arab Emirates, which accounts for 14.7% of Taiwan's exports. This also presents the export strategies of Japanese parent companies. Hence, it is likely that Japanese parent companies will remove the production in Taiwan back to Japan to gain the economies of scale and thus affect the relative industries of finished vehicles as well.

On the other hands, Japan shows high competitiveness on finished vehicles and key component. The average export amount of Japan’s automobile industry was US$156.90 billion in 2015-2017, in which the average export amount of finished vehicles was the highest at US$97.53 billion, followed by chassis and transmission parts (US$26.95 billion in average) and automobile engines (US$10.84 billion). The amount of Japan’s automobile industry exports to the top 5 destinations accounted for about 52%-65%. Among the main markets, the U.S. is the most important which accounts for over 23% of exports for all subsectors, and accounts for almost 40% of Japan’s finished vehicle exports. Besides, China is also an important export market to Japan’s automobile industry.

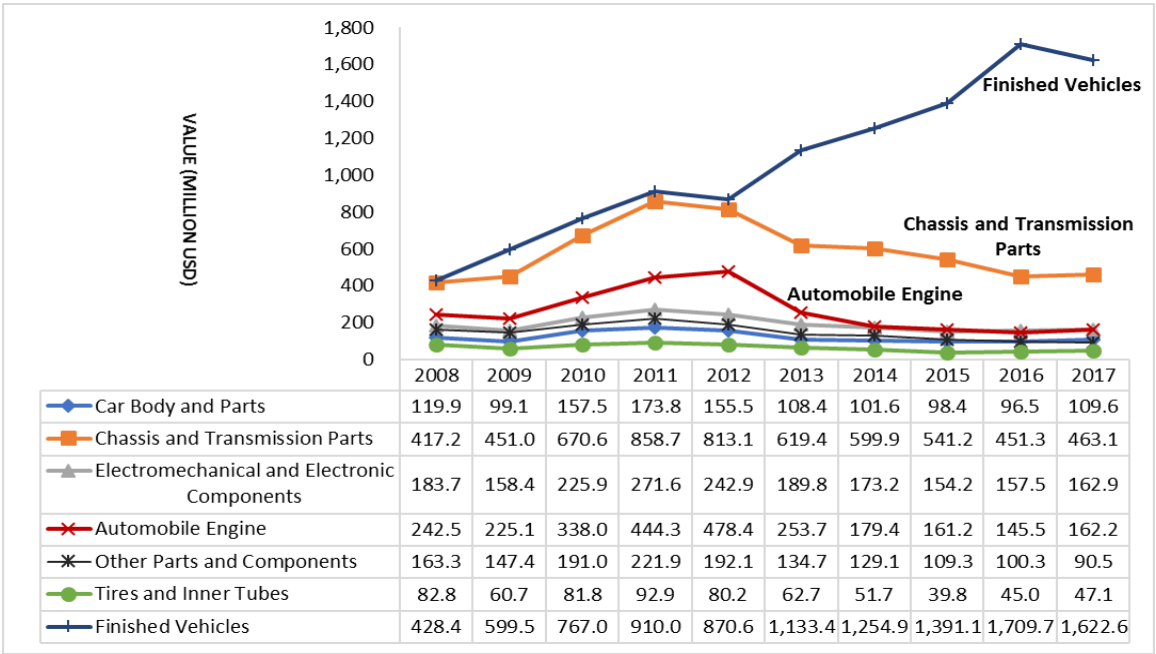
Regarding the import side, the average import amount of Japan’s automobile industry in 2015-2017 was US$32.69 billion, in which finished vehicles accounted for the highest amount of imports (US$10.07 billion in average), followed by electromechanical and electronic components (US$8.06 billion) and chassis and transmission parts (US$4.99 billion). The top 5 sources of imports in all subsectors of Japan take about 66%-78% of

import market, in which China is the main source of imports.

Taiwan is also a supplier of auto parts for Japan, and is the fourth largest source of tires and inner tubes (account for 7.8% of imports), and the sixth to ninth largest source of body and parts, chassis and transmission parts, electromechanical and electronic components, automobile engine, other parts and components, accounting for 2-4% of imports in each subsectors.

3.2.2 Bilateral trade of automobiles and auto parts between Taiwan and Japan

In terms of trade between the automobile industries of Taiwan and Japan (Figure 4), Taiwan mainly imported finished vehicles from Japan with a continuously increasing amount from US$428 million in 2008 to US$1.623 billion in 2017. Meanwhile, chassis and transmission parts and automobile engines were ranked the 2nd and 3rd in Taiwan's import from Japan within the 7 subsectors. But relatively, there was no such significant increase in their import amounts, the growth rate of these two subsectors are 11% and -33% in 2017 compared with 2008, respectively.



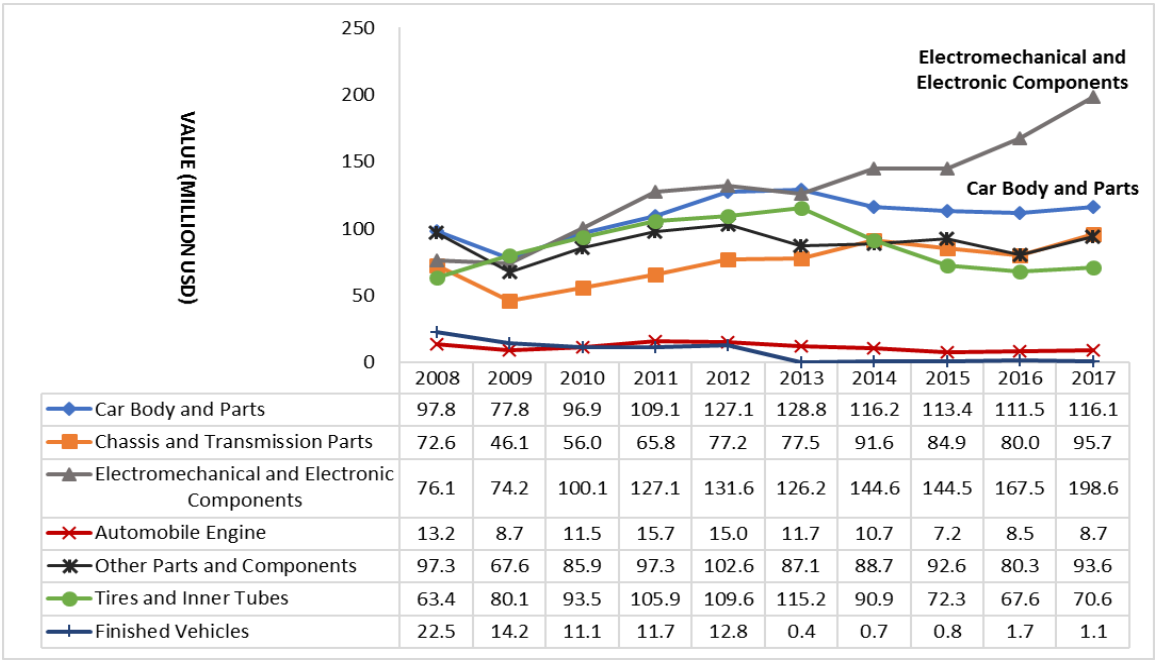
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Car Body and Parts	119.9	99.1	157.5	173.8	155.5	108.4	101.6	98.4	96.5	109.6
Chassis and Transmission Parts	417.2	451.0	670.6	858.7	813.1	619.4	599.9	541.2	451.3	463.1
Electromechanical and Electronic Components	183.7	158.4	225.9	271.6	242.9	189.8	173.2	154.2	157.5	162.9
Automobile Engine	242.5	225.1	338.0	444.3	478.4	253.7	179.4	161.2	145.5	162.2
Other Parts and Components	163.3	147.4	191.0	221.9	192.1	134.7	129.1	109.3	100.3	90.5
Tires and Inner Tubes	82.8	60.7	81.8	92.9	80.2	62.7	51.7	39.8	45.0	47.1
Finished Vehicles	428.4	599.5	767.0	910.0	870.6	1,133.4	1,254.9	1,391.1	1,709.7	1,622.6

Source：Compiled by this study from the Taiwan customs statistics of World Trade Atlas.

Figure 4 Changes in imports of Taiwan's automobile industry from Japan in 2008-2017

The import amount of auto parts subsectors has declined after peaking in 2011-2012. This presents the change of Japanese automobile manufacturers' strategies for Taiwan. For example, Mazda and Subaru import the vehicles from Japan to replace those products which were originally assembled in Taiwan.

Figure 5 shows that Taiwan mainly exports electromechanical and electronic components and car body and parts to Japan, and the export amount increased in 2008-2017. The increase of export of electromechanical and electronic components may due to the development of electric vehicles, which induced greater demand on electromechanical and electronic equipment. On the other hand, Taiwan barely exported finished vehicles and automobile engines to Japan, which indicated the weak competitiveness of Taiwan in these two subsectors.



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Car Body and Parts	97.8	77.8	96.9	109.1	127.1	128.8	116.2	113.4	111.5	116.1
Chassis and Transmission Parts	72.6	46.1	56.0	65.8	77.2	77.5	91.6	84.9	80.0	95.7
Electromechanical and Electronic Components	76.1	74.2	100.1	127.1	131.6	126.2	144.6	144.5	167.5	198.6
Automobile Engine	13.2	8.7	11.5	15.7	15.0	11.7	10.7	7.2	8.5	8.7
Other Parts and Components	97.3	67.6	85.9	97.3	102.6	87.1	88.7	92.6	80.3	93.6
Tires and Inner Tubes	63.4	80.1	93.5	105.9	109.6	115.2	90.9	72.3	67.6	70.6
Finished Vehicles	22.5	14.2	11.1	11.7	12.8	0.4	0.7	0.8	1.7	1.1

Source：Compiled by this study from the Taiwan customs statistics of World Trade Atlas.

Figure 5 Changes in exports of Taiwan's automobile industry to Japan in 2008-2017

From the figures above, it can be observed that Taiwan's automobile industry has a trade deficit with Japan, especially in the finished vehicles, chassis and transmission parts, and automobile engine. Despite the significant appreciation of Japanese Yen in 2008, Taiwan's trade deficit with Japan from finished vehicles still reached US$406 million. This amount sequentially grew each year to US$1.621 billion in 2017 due to the depreciation of Japanese Yen led by the easy money policy in Japan. The trade

deficit of chassis and transmission parts and automobile engines with Japan slightly increased during the observation period, while the trade deficit of automobile engines even decreased. The above shows that Taiwanese consumers prefer the finished vehicles imported from Japan than those produced domestically. And even though Japanese parent companies have invested and established complete automobile industry supply chain in Taiwan, the key technologies of auto parts and the production plan of new vehicle models are still controlled by the parent companies. So that the Taiwan's imports of key components would decrease as the domestically produced vehicles were replaced by the imported ones.

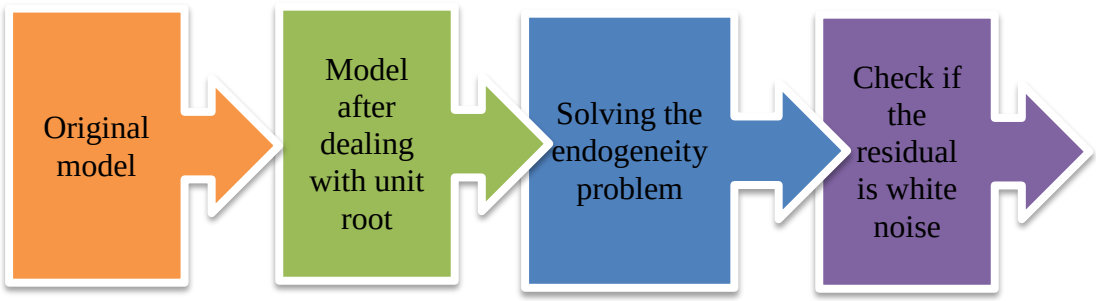
In summary, even though Japan imposes zero tariffs while Taiwan imposes an average tariff of 19.66% on finished vehicles, and most assembly plants in Taiwan are OEMs for Japanese automobile manufacturers to supply the domestic market, the amount of finished vehicles produced in Japan and then exported to Taiwan is still growing rapidly. Besides the changing operation strategies for Japanese automobile manufacturers in Taiwan, this also shows the competitiveness of Japanese finished vehicles in Taiwan's market. Therefore, under the management of Japanese parent companies, if Taiwan participates in regional economic integration in the future or signed bilateral FTAs with countries such as Japan, and opens its market to Japan, it is possible that parent companies in Japan will move finished vehicle production back to Japan, where they enjoy economies of scale, and then export the finished vehicles to Taiwan. On the other hand, it could be expected that there would be limited opportunities for the finished vehicles produced in Taiwan to export to Japan. This development will have an even greater impact on Taiwan's finished vehicle industry, and will severely affect the development of Taiwan's automobile industry.

In order to understand the impact of Taiwan's participation in the regional economic integration and eliminating the tariff imposed on finished vehicles, this study uses regression analysis to determine how changes in the price of vehicles imported (especially from Japan) will affect the registered number of domestically produced vehicles. And then the interviews and a questionnaire survey are conducted to determine how this impact on assembly plants will affect Taiwan's auto parts industry and its implications.

4. Empirical Model

To determine the effect of lowering tariffs on imported vehicles when Taiwan participates in regional economic integration, this study first uses the demand-supply regression model for estimating the price elasticity of domestically produced vehicles to imported vehicles. Then the implication for the effect on the sales of domestically produced vehicles and the auto parts will be determined based on the regression results and the opinions from industries.

With regard to specification of the regression model, either a single equation or simultaneous equations of supply and demand functions can be used. Thus the following would start the explanation of single equation approach, and then extended the introduction to simultaneous equations. Furthermore, since the price of domestically produced vehicles will become an important explanatory variable in the demand-supply model, the endogeneity problem must be solved to obtain consistent coefficient estimates. Besides, the problems of unit root and whether the residual is white noise are taken into consideration. Hence, the procedures for model specification and regression analysis are described below.



4.1 Original regression model

This study focuses on the effect of changes in the price of vehicles imported from Japan on the number of domestically produced vehicles registered. Hence, the explanatory variables that matter most is the price of vehicles imported from Japan (P_{JP}). Other independent variables include the price of domestically produced vehicles (P_{dom}), price of vehicles imported from other countries (P_{other}), exchange rates between TWD and USD, JPY and EUR (EX_{US}, EX_{JP} and EX_{EU}, respectively), national income

(Y), and dummy variables for months ($dummy_2$-$dummy_{12}$). The dependent variable is number of domestically produced vehicles registered (Q_{dom}).

The market demand formula for domestically produced vehicles is shown below：

$$\ln Q_{dom,t} = \beta_0 + \beta_1 \ln P_{dom,t} + \beta_2 \ln P_{JP,t} + \beta_3 \ln P_{other,t} + \beta_4 \ln EX_{US,t} + \beta_5 \ln EX_{JP,t} + \beta_6 \ln EX_{EU,t} + \beta_7 Y_t + f(dummy_m) + \varepsilon_t \quad (1)$$

Where ε_t denotes the error term. The natural logarithm is found for all variables except for monthly dummy variables. Thus the coefficient estimates would represent "elasticity". For example, the β_2 in equation (1) is the effect of a 1% change in the price of vehicles imported from Japan on the number of domestically produced vehicles registered, which is the first partial derivative of $ln\, P_{JP,t}$ of equation (1) (refer equation (2)).

$$\frac{\partial \ln Q_{dom,t}}{\partial \ln P_{JP,t}} = \frac{\partial Q_{dom,t} / Q_{dom,t}}{\partial P_{JP,t} / P_{JP,t}} = \beta_2 \quad (2)$$

4.2 Handling the non-stationary issue

Since this study uses time-series data, it is necessary to determine if variables have a unit root and are non-stationary. If a variable has a unit root, then directly using equation (1) for estimation may result in the problem of spurious regression. This means that the regression provides statistical evidence of correlation between two unrelated variables with a unit root. When the data has a unit root[2], researchers usually use the first order difference approach to transform the data into a stationary time series, and use the data after eliminating the unit root for regression analysis. Therefore, the first order difference for all variables other than the monthly dummy variables in equation (1) is used to obtain equation (3).

[2]. This study refers to the unit root test recommended by Dolado et al. (1990) and tests all variables in the regression model for unit roots, and found that all variables had a unit root. Therefore, all variables are converted using the first order differential equation during empirical analysis to become a stationary time series, preventing spurious regression caused by variables with a unit root.

$$d\ln Q_{dom,t} = \beta_0 + \beta_1 d\ln P_{dom,t} + \beta_2 d\ln P_{JP,t} + \beta_3 d\ln P_{other,t} + \beta_4 d\ln EX_{US,t} + \beta_5 d\ln EX_{JP,t} + \beta_6 d\ln EX_{EU,t} + \beta_7 dY_t + f(dummy_m) + u_t \quad (3)$$

Even though equation (3) went through first difference transformation, the meaning of regression coefficients is still the same as equation (2).

4.3 Solving the endogeneity problem

The independent variable P_{dom} in equations (1) and (3) should have the endogeneity problem because the price and the number of domestically produced vehicles registered are usually decided by both suppliers and consumers at the same time. If only a single regression equation is estimated, the independent variable P_{dom} will be correlated to random disturbance, which is known as the simultaneous equation problem. If this problem is not properly dealt with, it will prevent consistent estimates to be obtained, even when there is a large sample.

In other words, besides the demand equation, the market's supply equation must also be estimated and expressed as：

$$d\ln Q_{dom,t} = \beta_0 + \beta_1 d\ln P_{dom,t} + \beta_2 d\ln P_{JP,t} + \beta_3 d\ln P_{other,t} + \beta_4 d\ln EX_{US,t} + \beta_5 d\ln EX_{JP,t} + \beta_6 d\ln EX_{EU,t} + \beta_7 dY_t + f(dummy_m) + v_t \quad (4)$$

The error term u_t and v_t are mutually independent and have an average of zero; variance is an unknown constant for both. (3) and (4) for the simultaneous equation regression model, in which $Q_{dom,t}$ and $P_{dom,t}$ are endogenous variables, causing $P_{dom,t}$ in equation (3) to be correlated to random disturbance u_t.

This study uses the following three methods to solve the endogeneity problem：

4.3.1 Two-Stage Least Squares Method

The first stage in the two-stage least squares method is to carry out regression analysis of domestically produced vehicle prices and other exogenous variables with instrumental variables using the least squares method to obtain the fitted value of domestically produced vehicle prices. The second stage uses the fitted value to replace the endogenous variable in equation (3), and then use the least squares method again to estimate equation (3).

This study attempted to use lag-period price of domestically produced vehicles as an instrumental variable, and found that all the R^2 in first stage regression results were low, showing that lag-period price of domestically produced vehicles is not a good instrumental variable, and that results obtained from the two-stage least squares method have lower reference value.

4.3.2 Using lag-period of endogenous variable to replace the current period variables

Besides using the method of 2SLS, the endogenous variables were replaced by their lag-period values in this study. Since lag-period endogenous variables are predetermined, they usually are not correlated to the regression model's random disturbance. Hence, the endogeneity problem could be expected to be solved by this method.

4.3.3 Simultaneous equations model

The data of volumes and prices of registered vehicles in this study are simultaneously determined by both supply and demand in the market. Hence, this study adopted the simultaneous equations model to consider both supply and demand functions. Under the assumption of market clearing, the simultaneous equations of the supply and demand function are shown in equation (5)：

Supply Function：

$$d\ln Q_{dom,t} = \beta_0 + \beta_1 d\ln P_{dom,t} + \beta_2 d\ln P_{JP,t} + \beta_3 d\ln P_{other,t} + \beta_4 d\ln EX_{US,t} + \beta_5 d\ln EX_{JP,t} + \beta_6 d\ln EX_{EU,t} + \beta_7 dY_t + \beta_8 t + f(dummy_m) + u_{1t}$$

Demand Function：

$$d\ln Q_{dom,t} = \gamma_0 + \gamma_1 d\ln P_{dom,t} + \gamma_2 d\ln P_{JP,t} + \gamma_3 d\ln P_{other,t} + \gamma_4 d\ln EX_{US,t} + \gamma_5 d\ln EX_{JP,t} + \gamma_6 d\ln EX_{EU,t} + \gamma_7 dY_t + f(dummy_m) + u_{2t} \quad (5)$$

The generalized method of moments (GMM) proposed by Lewbel (2012) is then adopted to estimate the values of coefficients in equation (3) and (4). The advantage of this model is that it can use the heteroscedasticity of the supply-demand equation's error term to identify the regression coefficient's estimates. And there is no need for additional instrumental variables or the rank or order condition to determine if the

regression coefficient can be identified. Furthermore, a time-trend is added to the demand function.

4.4 Check if the residual has autocorrelation

After the estimation, the Ljung-Box Q test is adopted to check if the residual has autocorrelation. If it still has autocorrelation, it may indicate that the regression model omitted important explanatory variables or a specification error. So that the lag-period of dependent variable may be added for regression estimates, and then the Ljung-Box Q test can be applied again until the residual has no autocorrelation.

4.5 Data Source and Description

The data of the number of domestically produced vehicles, Japanese imported vehicles, and vehicles imported from other countries registered in Taiwan between January 1999 and May 2017 is obtained from the automobile registration statistics of Chunghwa Telecom. Data of the sales and monthly average prices of automobiles in Taiwan was obtained from Taiwan Insurance Institute.

Furthermore, the vehicle price is deflated by CPI. And because the data of GDP per capita can only obtained quarterly, this study refer to Cuche and Hess (1999) and Fulop and Gyomai (2012) and use the industrial production index announced monthly by the Directorate-General of Budget as a proxy variable for the data of personal income. The sources of data for the variables above are summarized in Table 1 below, while the statistical data of main variables are shown in Tables 2-7.

Table 1　Model variables and their source of data

Variable	Source：
Number of vehicles registered	Statistics of vehicles registered
Replacement price	Taiwan Insurance Institute
Exchange rate	Statistics of the Central Bank
Industrial production index	Directorate-General of Budget, Accounting and Statistics
CPI	Directorate-General of Budget, Accounting and Statistics

In terms of the registered number of vehicles, Table 2 shows that about 25,000 domestically produced vehicles are registered each month, in which about 70% are

small passenger vehicles; while over 90% of imported vehicles registered each month are small passenger vehicles. If vehicles are further divided by engine displacement, about 75% of small passenger vehicles registered in Taiwan are 2,000 cc and under, corresponding to the description in the previous section that the vehicles in the group of 2,000 cc and under are the main product in Taiwan, and engage in the most severe competition with imported vehicles. This shows that if Taiwan reduces tariffs on automobiles will bring a relatively significant effect on domestically produced passenger vehicles with an engine displacement of 2,000 cc and under. Therefore, in order to specifically capture the effect of reducing tariffs on automobile industries in Taiwan, the regression analysis in the following section will focus on this category of products

Table 2　Vehicles registered in Taiwan from Jan. 1999 to May 2018

(monthly average)

	Produced in TW		Imported from JP		Imported from other countries	
	No. of registered	%	No. of registered	%	No. of registered	%
Total	**25,264.52**	**100.00**	**2,522.09**	**100.00**	**4,421.68**	**100.00**
2000 cc and under	20,461.46	80.99	1,089.34	43.19	2,754.44	62.29
Over 2000 cc	4,803.06	19.01	1,432.75	56.81	1,667.24	37.71
small passenger vehicles	**17,382.81**	**68.80**	**2,422.55**	**96.05**	**4,124.38**	**93.28**
2000 cc and under	16,523.28	65.40	1,088.28	43.15	2,667.72	60.33
Over 2000 cc	859.54	3.40	1,334.27	52.90	1,456.65	32.94
Non-small passenger vehicles	**7,881.71**	**31.20**	**99.54**	**3.95**	**297.31**	**6.72**
2000 cc and under	3,938.19	15.59	1.06	0.04	86.72	1.96
Over 2000 cc	3,943.52	15.61	98.48	3.90	210.59	4.76

Notes：Other types of vehicles, such as small passenger-cargo vehicles, that are not small passenger vehicles are all classified as small passenger vehicles.
Source：Compiled by this study.

With regard to unit price, Table 3 shows that the average price of domestically produced small passenger vehicles in the group of 2,000 cc and under is around NT$715,700, while the price of vehicles imported from Japan is around NT$959,200; the difference is about NT$240,000. The unit price of small passenger vehicles

imported from other countries is about NT$1,518,900, roughly double and 1.6 times the value of vehicles produced in Taiwan and imported from Japan, respectively. Despite the high tariff rate of Taiwan on finished vehicles, the price difference between vehicles produced in Taiwan and imported from Japan is still relatively limited, which implies that the domestically produced vehicles will be more severely impacted by the imported vehicles from Japan once Taiwan participated in the regional economic integration. Therefore, the effect of prices reducing for vehicles, especially imported from Japan, on the number of domestically produced vehicles registered in Taiwan is emphasized in this study.

Table 3　Prices of vehicles in Taiwan' market from Jan. 1999 to May 2018 (monthly average)

Unit：NT$10,000

	Produced in TW	Imported from JP	Imported from other countries
small passenger vehicles	72.90	131.87	223.53
2000 cc and under	71.57	95.92	151.89
Over 2000 cc	100.52	159.47	343.92

Source：Compiled by this study.

Tables 4 and 5 show the descriptive statistics of variables in the regression model for the groups of 2000 cc and under and those over 2000 cc, respectively. Tables 6 and 7 show the correlation coefficient of the variables above for the two categories of vehicles.

Table 4 Descriptive statistics of variables in the regression model

(2,000 cc and under small passenger vehicles)

Variables	Description	unit	Average	Std.	Min.	Max.
Q_{dom}	Registered vehicles produced in Taiwan	vehicle	16,523.28	6,103.00	4,577.00	43,750.00
P_{dom}	Price of registered vehicles produced in Taiwan	NT$10,000	71.57	4.92	59.64	83.72
Q_{jp}	Registered vehicles imported from JP	vehicle	1,088.28	1,445.00	55.00	6,694.00
P_{jp}	Price of registered vehicles imported from JP	NT$10,000	95.92	23.05	66.95	160.83
Q_{other}	Registered vehicles imported from other countries	vehicle	2,667.72	1,546.00	618.00	7,191.00
P_{other}	Price of registered vehicles imported from other countries	NT$10,000	151.89	26.90	107.33	203.12
EX_{us}	Exchange rate between NTD and USD (NTD/USD)		32.03	1.62	28.81	35.07
EX_{jp}	Exchange rate between NTD and JP yen (NTD/JP yen)		0.30	0.04	0.25	0.39
EX_{eu}	Exchange rate between NTD and EUR (NTD/EUR)		38.53	5.11	27.20	48.23
industry	Industrial production index		83.27	18.49	46.01	113.37

Notes：Prices are deflated by CPI (2011 = 100).

Source：Compiled by this study.

Table 5 Descriptive statistics of variables in the regression model

(over 2,000 cc small passenger vehicles)

Variables	Description	unit	Average	Std.	Min.	Max.
Q_{dom}	Registered vehicles produced in Taiwan	vehicle	859.54	602.07	87.00	5,206.00
P_{dom}	Price of registered vehicles produced in Taiwan	NT$10,000	100.52	7.86	80.42	115.75
Q_{jp}	Registered vehicles imported from JP	vehicle	1,334.27	765.50	217.00	5,240.00
P_{jp}	Price of registered vehicles imported from JP	NT$10,000	159.47	23.34	104.82	227.99
Q_{other}	Registered vehicles imported from other countries	vehicle	1,456.65	426.72	488.00	3,297.00
P_{other}	Price of registered vehicles imported from other countries	NT$10,000	343.92	70.74	192.70	487.09
EX_{us}	Exchange rate between NTD and USD (NTD/USD)		32.03	1.62	28.81	35.07
EX_{jp}	Exchange rate between NTD and JP yen (NTD/JP yen)		0.30	0.04	0.25	0.39
EX_{eu}	Exchange rate between NTD and EUR (NTD/EUR)		38.53	5.11	27.20	48.23
industry	Industrial production index		83.27	18.49	46.01	113.37

Notes：Prices are deflated by CPI (2011 = 100).

Source：Compiled by this study.

Table 6　Coefficient of correlation between variables in the regression model

(2,000 cc and under small passenger vehicles)

	△*ln* Q_{dom}	△*ln* P_{dom}	△*ln* P_{JP}	△*ln* P_{other}	△*ln* EX_{US}	△*ln* EX_{JP}	△*ln* EX_{EU}	△*ln* industry
△*ln* Q_{dom}	1.000							
△*ln* P_{dom}	0.045	1.000						
△*ln* P_{jp}	0.132*	0.041	1.000					
△*ln* P_{other}	0.170**	0.227***	0.204***	1.000				
△*ln* EX_{us}	-0.062	0.002	-0.005	0.024	1.000			
△*ln* EX_{jp}	-0.026	-0.007	-0.022	-0.051	0.182***	1.000		
△*ln* EX_{eu}	0.019	0.076	0.036	0.205***	0.037	0.106	1.000	
△*ln* industry	0.451***	0.030	0.053	0.047	-0.054	-0.033	0.035	1.000

Table 7　Coefficient of correlation between variables in the regression model

(over 2,000 cc small passenger vehicles)

	△*ln*Q_{dom}	△*ln*P_{dom}	△*ln*P_{JP}	△*ln*P_{other}	△*ln*EX_{US}	△*ln*EX_{JP}	△*ln*EX_{EU}	△*ln*industry
△*ln* Q_{dom}	1.000							
△*ln* P_{dom}	0.172**	1.000						
△*ln* P_{jp}	0.152**	0.015	1.000					
△*ln* P_{other}	0.134**	0.027	0.130*	1.000				
△*ln* EX_{us}	-0.089	-0.096	-0.074	0.033	1.000			
△*ln* EX_{jp}	-0.083	0.013	-0.137**	-0.081	0.182***	1.000		
△*ln* EX_{eu}	0.146**	0.114*	0.037	0.026	0.037	0.106	1.000	
△*ln* industry	0.423***	0.024	0.057	0.073	-0.054	-0.033	0.035	1.000

Notes：*** indicates a significance level of 0.01, ** indicates a significance level of 0.05, * indicates a significance level of 0.1.

Source：Compiled by this study.

5. Regression results and implications

5.1 Regression results

Different regression specifications were adopted in this study, and the estimated results were similar in different specifications, indicating that the research results are relatively stable. The regression specifications are shown in Table 8. Furthermore, since specification 1 and 2 are estimated by the single equation, the Variant Expansion Factor (VIF) and conditional indicators are also used for analyzing whether there is collinearity between independent variables. In general, if the VIF is less than 10 and the conditional index is less than 30, it can be inferred that there is no collinearity problem in the regression model. For specification 1 and 2, the VIF are both lower than 8.6, while the maximum condition index of the two models is 12.77; which shows that these two specifications have no collinearity problem.

For the specification of simultaneous equations, since the supply and demand functions were simultaneously estimated, it would be appropriate to keep less explanatory variables. Besides, the regressing results of specification 2 show that the effect of lag period price is insignificant. Hence, only the current price is adopted to determine the effect on the number of registered vehicles which were domestically produced. The R^2 and adjusted R^2 of the specifications are between 0.7-0.9 (Table 8).

Table 8　Regression model specification

	Single equation		Simultaneous equations (demand function)	
	Specification 1	Specification 2	Specification 3	Specification 4
Prices of registered vehicles produced in Taiwan, imported from JP and other countries	Current period	Current period Lagging 1-12 periods	Current period	Current period
Number of periods the dependent variable is lagging	Lagging 1-3 periods		Lagging 1-6 periods	Lagging 1-10 periods
Other control variables	Exchange rate, industrial production index. Add time-trend to the demand function			
Monthly dummy variables	February-December			
R^2	0.831	0.874	0.745	0.749
Adjusted R^2	0.813	0.826	0.711	0.723

Notes：The log difference is obtained for all data except for monthly dummy variables.
Source：Compiled by this study.

Regression results of this study are listed in Table 9, the effect of each variable on the number of domestically produced vehicles registered is described below.

5.1.1 Effect of the price of imported vehicles

In specification 3 and specification 4 in Table 9, the level of significance for the estimators of Japanese vehicle prices are at least 5%, indicating that the registered number of domestically produced vehicles are indeed affected by the prices of vehicles imported from Japan. In specification 1 and specification 2, even though the coefficient values do not have statistical significance, the direction is the same as the specification 1 and 2. On the other hand, prices of imported vehicles from other countries show no significant effect on the registered number of domestically produced vehicles. The result once again proves that it is the vehicles imported from Japan that bring the more severe competition to the automobile manufacturers in Taiwan than those from other countries.

More specifically, the elasticity of domestically produced vehicles on the price of vehicles imported from Japan showed in specification 3 and 4 represents that when the price of vehicles imported from Japan changes 1%, it will cause the registered number of domestically produced vehicles to change about 0.457% and 0.569% in the same direction, respectively. In summary, when the price of vehicles imported from Japan decreases 1%, it will cause the registered number of domestically produced vehicles to decrease about 0.4-0.6%.

5.1.2 Effect of the price of domestically produced vehicles

In terms of the price of domestically produced vehicles, specification 1-4 all show that the current period was significantly negatively correlated to the registered number of domestically produced vehicles, i.e., when the price of domestically produced vehicles declines, it will increase the registered number of this kind of vehicles.

It is noteworthy that even though estimates from these four specifications met the expectations of economic theory, estimates obtained in specification 1 and 2 showed relatively weak effect; when the price of domestically produced vehicles decreased by 1%, it will cause demand on domestically produced vehicles to increase 0.98-1.32%.

The results of the simultaneous equation model were relatively high; when the price of domestically produced vehicles decreased by 1%, it will cause demand on domestically produced vehicles to increase 12.71-12.38%. Since there are obviously many substitutes for domestically produced vehicles in Taiwan's market, and it can be observed that price changes have a considerable effect on sales for domestically produced vehicles. Thus the estimates from the simultaneous equations regression model may match the actual situation better.

5.1.3 Effect of exchange rate

Exchange rates between USD, JPY, and EUR with TWD are adopted to analyze the effect of exchange rate on the registered number of domestically produced vehicles, while a rise in exchange rate indicates TWD depreciation.

Results in Table 9 show that the effect of USD exchange rate did not have a significant effect on the registered number of domestically produced vehicles for all of the model specifications; JPY exchange rate was significantly positively correlated in specification 4; EUR exchange rate was significantly positively correlated in specification 3 and 4. Based on the results of specification 4 for the simultaneous equation regression model, if JPY and EUR exchange rates rise by 1% (i.e., TWD depreciates 1%), it will increase demand on domestically produced vehicles and increase registration by 1.247% and 0.721%, respectively; showing that changes of exchange rate will affect the demand for domestically produced vehicles to a certain extent.

5.1.4 Effect of industrial production index

This study uses the industrial production index announced by the Directorate-General of Budget, Accounting and Statistics each month as a proxy variable for per capita income and the estimates represents the income elasticity. As shown in Table 9, only specification 2 does not reach the level of significance, while estimates of the industrial production index in other specifications are in the range 0.77-2.01, showing that domestically produced vehicle is normal goods, which meets expectations of theory.

5.1.5 Effect of monthly dummy variables

Dummy variables for February-December are added to capture the seasonal factor of vehicles, and regression results clearly show seasonal changes in the domestic market. The positive and negative sign of estimates for these dummy variables represent the difference in registered number of domestically produced vehicles compared with January. Because in Taiwan, January is usually when employees receive their year-end bonuses thus increase the demand on buying vehicles before Chinese New Year, so there is usually more domestically produced vehicles registered in January, resulting in the estimates for other dummy variables mostly being negative. Besides, there are fewer work days in February due to Chinese New Year. August is the seventh month of the lunar calendar, which is so called as a “month of ghost”, so the absolute value of their regression coefficients are much higher than other months, which also meets expectations.

Table 9 Regression Results

$\triangle ln\ Q_{dom}$	Single equation		Simultaneous equations	
	Specification 1	Specification 2	Specification 3	Specification 4
Intercept	0.457*** (0.048)	0.392*** (0.055)	0.617*** (0.129)	0.538*** (0.127)
$\triangle ln\ P_{dom}$	-0.981** (0.451)	-1.32** (0.507)	-12.706*** (1.25)	-12.381*** (1.177)
$\triangle ln\ P_{JP}$	0.247 (0.154)	0.218 (0.176)	0.457* (0.233)	0.569*** (0.189)
$\triangle ln\ P_{other}$	-0.246 (0.282)	-0.021 (0.359)	0.544 (0.505)	0.367 (0.506)
$\triangle ln\ EX_{US}$	-0.25 (1.1)	-0.893 (1.236)	0.978 (1.732)	1.846 (1.588)
$\triangle ln\ EX_{JP}$	0.412 (0.562)	0.616 (0.634)	0.326 (0.832)	1.247* (0.742)
$\triangle ln\ EX_{EU}$	0.021 (0.291)	0.069 (0.314)	0.703* (0.416)	0.721** (0.339)
$\triangle ln$ industry	0.774*** (0.264)	0.433 (0.301)	1.238*** (0.477)	2.008*** (0.435)
dummy2	-0.967*** (0.068)	-0.983*** (0.078)	-1.123*** (0.167)	-0.974*** (0.166)
dummy3	-0.537*** (0.104)	-0.352*** (0.12)	-0.459*** (0.158)	-0.584*** (0.136)
dummy4	-0.461*** (0.085)	-0.457*** (0.098)	-0.831*** (0.163)	-0.794*** (0.167)
dummy5	-0.626*** (0.084)	-0.513*** (0.102)	-0.633*** (0.15)	-0.508*** (0.139)
dummy6	-0.205*** (0.065)	-0.112 (0.081)	-0.396*** (0.127)	-0.42*** (0.145)
dummy7	-0.198*** (0.065)	-0.133 (0.08)	-0.338** (0.14)	-0.339** (0.134)
dummy8	-0.929*** (0.067)	-0.913*** (0.081)	-1.041*** (0.139)	-1.007*** (0.132)
dummy9	-0.503*** (0.077)	-0.4*** (0.093)	-0.415*** (0.149)	-0.42*** (0.142)
dummy10	-0.47*** (0.082)	-0.414*** (0.095)	-0.807*** (0.146)	-0.84*** (0.156)
dummy11	-0.461*** (0.075)	-0.393*** (0.087)	-0.414*** (0.152)	-0.178 (0.155)
dummy12	-0.253*** (0.063)	-0.151** (0.071)	-0.333*** (0.125)	-0.417*** (0.148)
Lag-period variables, time trend	-	-	-	-
p-value of Ljung-Box Q(12) test	0.3162	0.6413	0.9978	0.9980
R^2	0.831	0.874	0.745	0.749
Adjusted R^2	0.813	0.826	0.711	0.708

Note 1：The log difference is obtained for all data except for monthly dummy variables.

Note 2：Figures in parentheses denote the standard error of estimate.

Note 3：*** indicates a significance level of 0.01, ** indicates a significance level of 0.05, * indicates a significance level of 0.1.

Note 4：Prices in previous periods were not significant in specification 2 and was not listed.

Source：Compiled by this study.

Summarizing regression results of specification 1-4, the current prices of vehicles imported from Japan and domestically produced vehicles both have significant effects on the number of domestically produced vehicles registered, while prices of previous periods did not have significant effects. This shows that the sales of domestically produced vehicles in Taiwan are mainly affected by current prices, and analyses should focus on models with only the current price (specification 1, 3, and 4). Furthermore, if the single equation (specification 1 and 2) is compared with the simultaneous equation (specification 3 and 4), estimates from the simultaneous equations, which estimate both supply and demand functions, better meet economic expectations, i.e., results of the simultaneous equations show that domestically produced vehicles are highly elastic products (due to the large number of substitutes) with income elasticity greater than 1.

5.2 Implications to industrial development

Based on the results of regression analysis, when the price of vehicles imported from Japan decreases 1%, it will reduce the number of domestically produced vehicles registered in Taiwan by 0.4-0.6%. Importers estimated based on their experience that once Taiwan eliminates tariffs on imported vehicles, importers will reduce the price of vehicles imported from Japan by up to 10%, and some will even choose to use imported vehicles instead of domestically produced vehicles. In other words, if Taiwan completely eliminates tariffs on vehicles, it will reduce the number of domestically produced vehicles registered in Taiwan by up to 4-6%. And when Taiwan opens its market to Japan, it is indeed possible that some Japanese automobile manufacturers will withdraw their production lines in Taiwan, which will have a negative impact on the development of Taiwan's automobile industry.

Regarding the effect of exchange rate, in terms of actual operations of dealerships, the losses and gains from changes of exchange rates are mostly absorbed by dealerships. If there is a profit, then dealerships will hold promotional events, provide gifts, or upgrade specifications to gain greater market share. In other words, the benefits of exchange rate changes are mainly gained by dealership and will not directly affect prices, but the increase in promotional events will still affect market share. Since Taiwan mainly imports finished vehicles from Japan and Germany, when the EUR and

JPY show a long-term downward trend, it will still have a significantly negative effect on the number domestically produced vehicles registered in Taiwan.

From the perspective of the supply chain, when domestically produced vehicles are impacted by Taiwan opening its market, it will also impact the auto parts manufacturers that work together with those manufactures of finished vehicles. Even if Taiwanese companies have a technological advantage in auto parts production, they will still be impacted by the decline in finished vehicle production, and may even affect the technologies development of auto parts. With the 70% local content of domestically produced vehicles in Taiwan, the output value of auto parts that will be impacted by opening market cannot be ignored as well.

On the other hand, highly competitive auto parts manufacturers of Taiwan, including rear view mirror, bumper, headlights, and electronic components for new types of vehicles, will have a greater opportunity to participate in international supply chains once Taiwan participates in regional economic integration, as they already have plans to do so and have invested in R&D to increase their chances. Such companies look favorably on Taiwan's participation in regional economic integration.

6. Conclusion and Directions for Future Research

Even though there are already many studies about the effect of import and trade policy which pointed out that the elasticity of import demand in different industries will cause the industries to be affected differently when exchange rates or tariffs are adjusted, only a few studies analyzed the effect of opening the market on the domestic production and sales of a specific industry. Studies that did focus on the automobile industry mainly focused on major European and American automobile brands, and did not look into a small market aiming to participate in regional economic integration, which has established complete automobile industry supply chain but is dominated by parent companies from other countries, like Taiwan.

This study focuses on Taiwan's finished vehicle and auto parts industries, and determines the impact of Taiwan participating in regional economic integration and opening its market of finished vehicles, especially to Japan, which Taiwan is highly

dependent on for imports and has control power over assembly plants in Taiwan. Interviews and a questionnaire survey were conducted as well to gain insight into the supply chain's perspective of the impact of policies and trends on Taiwan's highly competitive auto parts.

6.1 Effect of opening automobile market

6.1.1 Effect on finished vehicles

With the vehicle registration statistics of Chunghwa Telecom and data on automobile prices from Taiwan Insurance Institute, this study intended to determine the effect of opening the vehicles market in Taiwan on the domestically produced automobile with the engine displacement 2000cc and under, which domestically produced vehicles and vehicles imported from Japan engage in the most severe competition, by regression analysis, interviews, and a questionnaire.

According to statistics of vehicle registration from Chunghwa Telecom, 2,000 cc and under vehicles (including small passenger vehicles, small cargo trucks, and small passenger-cargo vehicles) are the main products of domestically produced vehicles in Taiwan, which have shown the most significant growth in recent years but also engage in the most severe competition with imported vehicles. If Taiwan participate in the regional economic integration and open its vehicle market, especially to Japan, it will significantly affect vehicle sales in this category of engine displacement. Hence, the regression analysis focuses on the effects of changes in the prices of imported vehicles in this bracket (especially adjustments to prices of Japanese vehicles) on the sales of domestically produced vehicles.

The regression results show that when the price of vehicles imported from Japan decreases 1%, it will cause the number of domestically produced vehicles registered to decrease about 0.4-0.6%, while the price of vehicles imported from other countries presents no significant effect on the domestically produced vehicles registered. Meanwhile, when TWD appreciates against JPY or EUR in a long term trend, it will increase citizens’ tendency to purchase imported vehicles, but USD exchange rate changes have no significant effect on sales of domestically produced vehicles in

Taiwan. Based on information obtained from the questionnaire, when tariffs on automobiles is eliminated (15.0%-20.0%), respondents will decrease the price of vehicles imported from Japan by up to 10%, and about 2/3 of the respondents will be likely to replace the domestically produced vehicles by imported ones. Therefore, based on the regression analysis results, if Taiwan completely eliminates tariffs on vehicles imported from Japan, it will reduce the number of domestically produced vehicles registered in Taiwan by up to 4-6%.

6.1.2 Effect on auto parts

Taiwan's auto parts, such as collision parts (e.g. bumper, rear view mirror, etc.) and headlights have enjoyed advantages in the aftermarket in European and American markets where the tariff rates are relatively low. Furthermore, facing the rapid development of new types of vehicles, Taiwan's highly competitive auto parts manufacturers, as well as certain electronics companies have successfully connected to the international automobile supply chains, and are working with the multinational enterprises for electric vehicles. Companies like this will profit from lower tariff rates in the countries of trade partners if Taiwan successfully participate in the regional economic integration with them.

On the other hand, auto parts manufacturers that work with Taiwan's assembly plants will be indirectly impacted by Taiwan opening its market, especially to Japan, for participating in regional economic integration. In the worst case, if the parent company in Japan decided to shift its finished vehicle production from Taiwan to Japan or other production bases, then the auto parts manufacturers will also be replaced due to the consideration of production efficiency. Under that circumstance, even highly competitiveness auto parts manufacturers will be affected and gradually lost their advantage, because finished vehicles are needed for the auto parts manufacturers to develop new products for different models of vehicles.

It is also worth noting that the structure of auto parts supply system will be significantly changed by the development of new types of vehicles. Engines will be replaced by batteries and motors, and vehicles originally assembled from over 30,000 parts and components will now be assembled from system parts that consist of several

major subsystems. In other words, the international division of labor for automobiles will involve the assembly of subsystems in different regions based on the comparative advantages of each country, and then the subsystems will be assembled into a vehicle. In light of this development trend, Taiwan should be able to utilize its superior auto parts and electronic and information technologies to participate in or even become the integrator of a certain subsystem.

However, with countries around the world actively developing new types of vehicles, and the rapid development of regional economic integration, Taiwan must not only utilize its superior technologies, but also need to participate in regional economic integration and strengthen its connection with industrial supply chain in the region. In other words, participating in regional economic integration may become an important force driving the development of Taiwan's new automobile industry.

6.2 Implications of industrial development trends and regional economic integration

In terms of the current production of conventional vehicles in Taiwan, empirical results have shown that if Taiwan participates in regional economic integration and opens its market, especially to Japan, it will significantly impact the production of domestically produced vehicles, and will further impact auto parts manufacturers working together with the assembly plants. Meanwhile, with the rising awareness of environmental protection, the automobile faces the urgent need for transformation around the world, which will also significantly change the structure of the domestic automobile industry. Taiwan should take this challenge of opening its market when participating in regional economic integration as a chance to accelerate the transformation of the domestic automobile industry. Opportunities and challenges of Taiwan’s automobile industry are described below based on the industrial development trends.

6.2.1 Opportunities of Taiwan’s Automobile Industry

The automobile industry is facing a massive transformation. One reason is the rising awareness of environmental protection, which has led many countries to set a

timetable to phase-out fossil fuel vehicles. Norway and the Netherlands were the fastest and announced that the sale of fossil fuel vehicles will be banned in 2025; Germany and India will ban the sale of fossil fuel vehicles in 2030; The United Kingdom, France, and China will all ban the sale of fossil fuel vehicles in 2040.

Major automobile manufacturers around the world are all investing in the development of hardware and software systems for electric vehicles or self-driving vehicles in response to this trend. Technologies of the new types of vehicles will also drive adjustments to the automobile industry's supply chain. Harald Rudolph, Director Daimler Strategy at Mercedes-Benz, pointed out during the 2016 Mobile World Congress that future development of the automobile industry will be in four directions, namely electrified, autonomous, car sharing, and digital ecosystem (e.g. Internet of Vehicles)[3]. Under this trend, automobile manufacturers will no longer be able to independently produce vehicles with its own closed supply chain, because the different fields of technologies are involved for producing a new type of vehicle. Meanwhile, the entering of Tesla, Amazon, and Google in the automobile industry have also changed the automobile supply chain, giving Taiwanese companies the opportunity to become part of the GVC of international automobile manufacturers.

Even though Taiwan's finished vehicles market does not enjoy the economies of scale, it has established a complete industrial supply chain, and has gained the trust of international parent companies for its excellent production efficiency and stable product quality. Furthermore, the number of electronic components by the new types of vehicles has significantly increased, which is an area that Taiwan shows high potential. For example, Delta Electronics has become a supplier of key auto parts for European and American manufacturers of electric vehicles, and some electronic companies have gained automobile certifications and successfully entered the supply chain of European automobile manufacturers, becoming Tier 1 suppliers and gradually developing automobile CPUs. A battery manufacturer that originally produced 3C products is also developing electric vehicles batteries. It is not only electronics companies developing automobile electronics; conventional auto parts manufacturers that already had a

[3] Automobile Industry Development in the IoT Era： https://read01.com/R4MQAO.html. Date last browsed： 2016.06.17.

competitive advantage are also developing parts needed by new types of vehicles.

As a matter of fact, with the support of government policy and R&D investments by related companies, Taiwan's local content of electric vehicles can reach approximately 80%. Some Taiwanese auto parts manufacturers have successfully begun working closely with Tesla, such as TPK, Chroma, and Kaori Heat Treatment.

6.2.2 Challenges of Taiwan's Automobile Industry

Many countries want to develop their own brand of new types of vehicles. Automobile manufacturers in Taiwan, however, lack the ability to free themselves from the control and global plans of parent companies, especially Japanese automobile manufacturers, and therefore have little incentive to invest in R&D. Furthermore, Taiwan's participation in regional economic integration is lagging and has had difficulty exporting finished vehicles, so the products of assembly plants in Taiwan were mainly for satisfying the local demand and are difficult to become part of regional supply chains.

It is not only the "hardware" of finished vehicles as a carrier of various parts and components, but also the integration of "software" for electronic components will be required to complete the integration platform for producing and assembling the modulized subsystems. Under this development, even though Taiwan has finished vehicle manufacturers with excellent production efficiency, auto parts manufacturers with a competitive advantage, and highly competitive electronics companies, and there is opportunity for Taiwan to become part of the GVC of multinational automobile manufacturers, how these companies work together to integrate electronics and automobiles to develop new type of vehicles and integrated systems is a challenge for Taiwan's automobile industry.

Infrastructure, including the number of electric vehicle parking spaces with charging devices, power cables in new apartment buildings reserved for charging electric vehicles, and parking spaces with charging devices in smart green buildings for electric vehicles, is also necessary in the development of new types of vehicles. The development of self-driving vehicles requires road planning and legislation, as well as a

testing site. This is another challenge for Taiwan in the development of a new automobile industry.

Furthermore, a sufficient large market is also crucial to successfully developed new types of vehicles. A large market with economies of scale will lower the cost and prices of vehicles and increase consumers' purchase intention, which will accelerate the popularization of new types of vehicles. On this basis, it would be necessary for Taiwan, which is a small market, to participates in regional economic integration and give the international enterprises incentive to invest their R&D centers as well as the production bases in Taiwan to leverage Taiwan's talent and industrial advantages.

6.3 Directions for Future Research

Under the rising awareness of environmental protection, the U.S., some European countries, China, and India have all set a timetable for banning the sale of fossil fuel vehicles. Taiwan's Bureau of Energy will also begin implementing the next phase of automobile fuel consumption policy in 2022. Hence, major manufacturers of convention fossil fuel vehicles in Taiwan are under immense pressure to develop new energy vehicles such as electric vehicles. With the development of new types of vehicles and restructuring of supply chains, the effect of regional economic integration on the automobile industry's cross-border supply chain is a topic worth looking into.

Some auto parts and electronics companies in Taiwan have shown high competitiveness, and are already a part of the production system of international electric vehicle manufacturers, but the most crucial part of technologies, such as battery production and integrated systems is still limited in Taiwan. In light of the pressure on Taiwan for transformation, and those major Japanese automobile manufacturers are now actively developing new types of vehicles, how Taiwan's automobile industry will strengthen its connection with cross-border supply chains by participating in regional economic integration, and work with the international automobile manufacturers to boost the mutual development of new types of vehicles is also worth further research.

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