

# Supply Chain Offshoring of Japanese Car Industries in China and Evaluation of Its Driving Factors by Logit Analysis

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**Abstract:** Standing on the recent globalising industrial activity over the world, this paper deals with direct investment of Japanese car manufacturers, especially focusing on their offshore site settlement in China. And using this information obtained through statistics literature survey, their driving factors (or major incentives) are intended to extract for understanding the mobilised mechanisms of global car industries. For this purpose, Logit model is utilised to identify gravity mechanisms of their direct investment. Obtained results indicate that car assembles are pulled by population, GDP and actual production volume produced in each area, whereas parts suppliers are pulled mainly by assemblers actual production volume, not by established contract-base network.

**Keywords:** Car Manufacturing, Assembler, Supplier, Supply Chain, Global Operation, Japan-China, Factor Analysis, Logit Model

## 1. Introduction

In 1984, New United Motor Manufacturing Inc. (NUMMI) was settled as a joint car manufacturing company owned by GM and Toyota, which started from a renewed factory of GM's Fremont Factory located in San Francisco and was a major attempt of Toyota's overseas manufacturing. After the big success of this trial, Toyota and other car manufacturers accelerated their global operations. As a result, Toyota, for example, continued to attain their volume increase about 200,000 vehicles annually till 1990. Also, from 2001, global manufacturing was encouraged moreover and increased 600,000 vehicles in annual volume, although due to long industrial stagflation happened in Japan during early 1991 and 2001, which was caused by the burst of bubble economy. In, 2007, their overseas production volume exceeded the level of domestic production (Uchiyamada, 2008). This trend is no longer of this world leading car assembler, but of other global car manufacturers. Figure 1 illustrates the trend of offshore manufacturing of Japanese general passenger car assemblers outside of Japan, excluding trucks, buses, automatic motorcycles and special cars. This indicates almost linear growth in terms of production volume has been accomplished by offshore sites during the past decade. For this reason, amount of academic as well as industrial professional articles were published to argue about merit and demerit of global manufacturing, how to mobilise it, way to establish and transfer competitive global operations (Hirano, 1987), (Tomozawa, 1991), (Katayama and Shibuya, 1999), (Katayama and

Deguchi, 2001), (Katayama and Hiraki, 2003),.

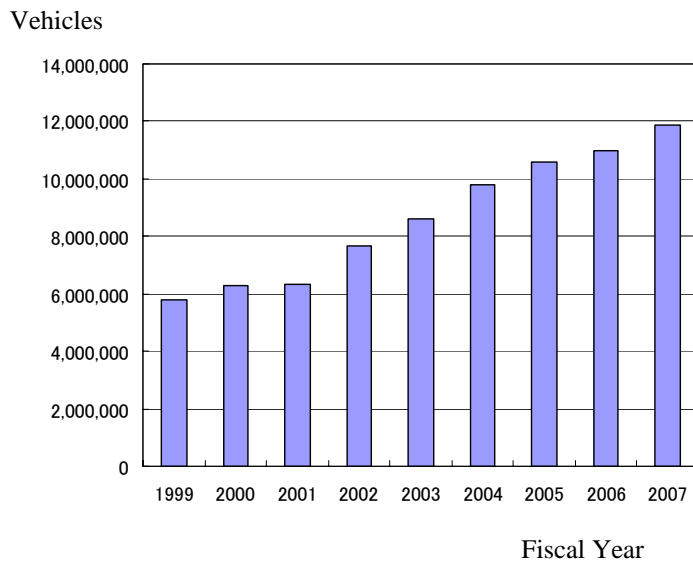


Figure 1. Trend of offshore manufacturing of Japanese car industries outside of Japan (JAMA, 2009)

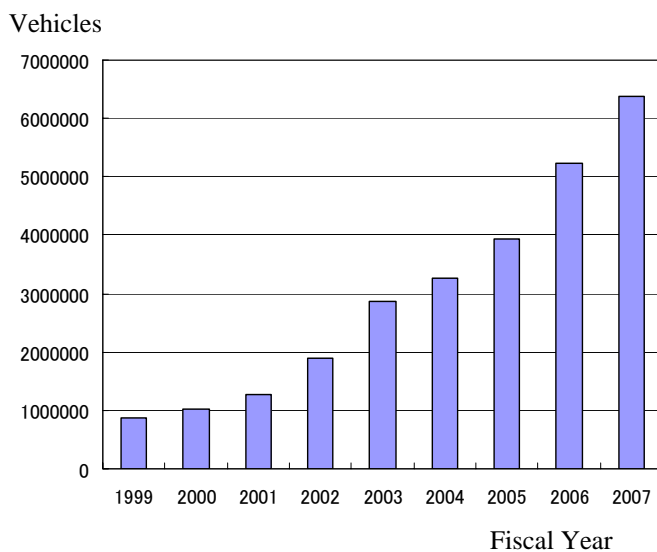


Figure 2. Trend of car manufacturing volume in China (Fourin, 2008)

Based on this understanding and focusing on Japanese car industries in China, their direct investment, especially their offshore site settlement activities is investigated as the first subject in this paper. The reason that China is the target is, of course, its power of manufacturing as the factory of the world. Figure 2 shows their trend of car manufacturing by the same category of car manufacturers in Figure 2 over this decade and it can be noticed that the volume is almost exponentially growing. Statistics literature survey is performed by tackling with huge amount of documents and reports published by associated organisations such as JAMA (Japan Automobile Manufacturers Association Inc.), JAPIA (Japan Auto Parts Industries Association etc. Using these corrected information and data, this study also focuses on investigating the driving factors or major incentives of global operations in China for understanding the mobilised mechanisms of global car industries. This second subject is tackled by application of Logit model, which is extended version of regression analysis for un-deterministic or stochastic environment.

## 2. China Offshoring Model of Car Manufacturing Supply Chain

First of all, the outline of a way to understand the situation of global operations of car industries must be considered. Elements of our scope to investigate consist of car assembler and parts suppliers operated in China. The former includes Toyota, Renault/Nissan, Honda, Ford/Mazda, Mitsubishi and Suzuki. The latter consists of various categories of industries being classified by their parts, i.e. engine components/parts suppliers, steering parts suppliers, transmission suppliers, electric/electronic parts

suppliers, body parts suppliers etc as high value added component/parts suppliers. Also, due to one of the biggest country in the world in terms of land and current dispersed operations in this country, it is necessary to define manufacturing regions in this country. These can be Tianjin Area, Guangzhou Area, Wuhan Area, Sichuan Area, Coastal Area, Changchu Area and Taiwan Area. Figure 3 illustrates current distribution of car industries in China including Japanese and due to logistics infrastructural assets among these regions, these are still a bit isolated and this situation supports a rationality of proposed classification.

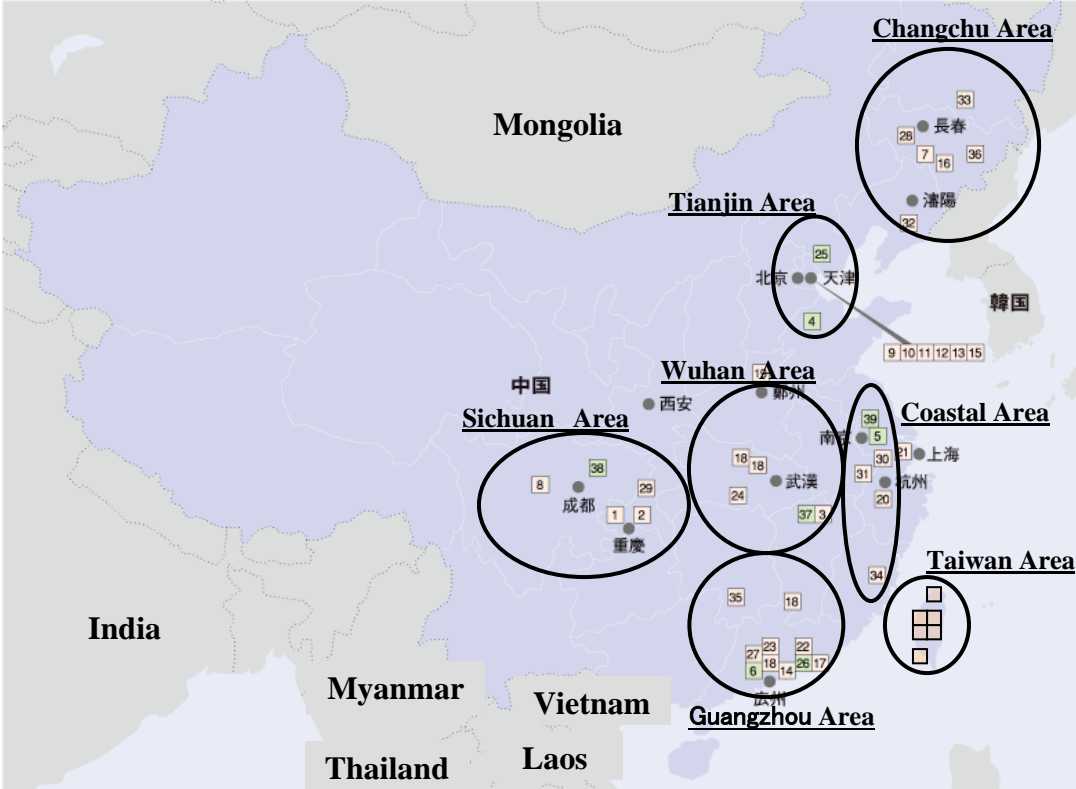


Figure 3. Distribution of car manufacturers in China (JAMA, 2009)

Figure 4 illustrates a general idea to recognise offshore operations of car industries by a gravity model which consists of assemblers and components/parts suppliers. Phase 1 tries to explain the reason to move to some area and it is supposed assemblers are pulled by the gravity of market that is created by some driving factors. In turn, Phase 2 attempts to explain the reason to move to some area by a similar idea but mainly supposed that assemblers are pulled by gravity of assemblers that is created by some other driving factors. This way of recognition enables to analyse some aspects of the reason why Japanese car industries move to certain area in China with suppliers in certain parts manufacturing businesses. These interesting problems are attempted to cope with by using Logit model formulated in the field of medical science and extended in marketing research field (Truett et al, 1967). Detail model is described in Chapter 3.

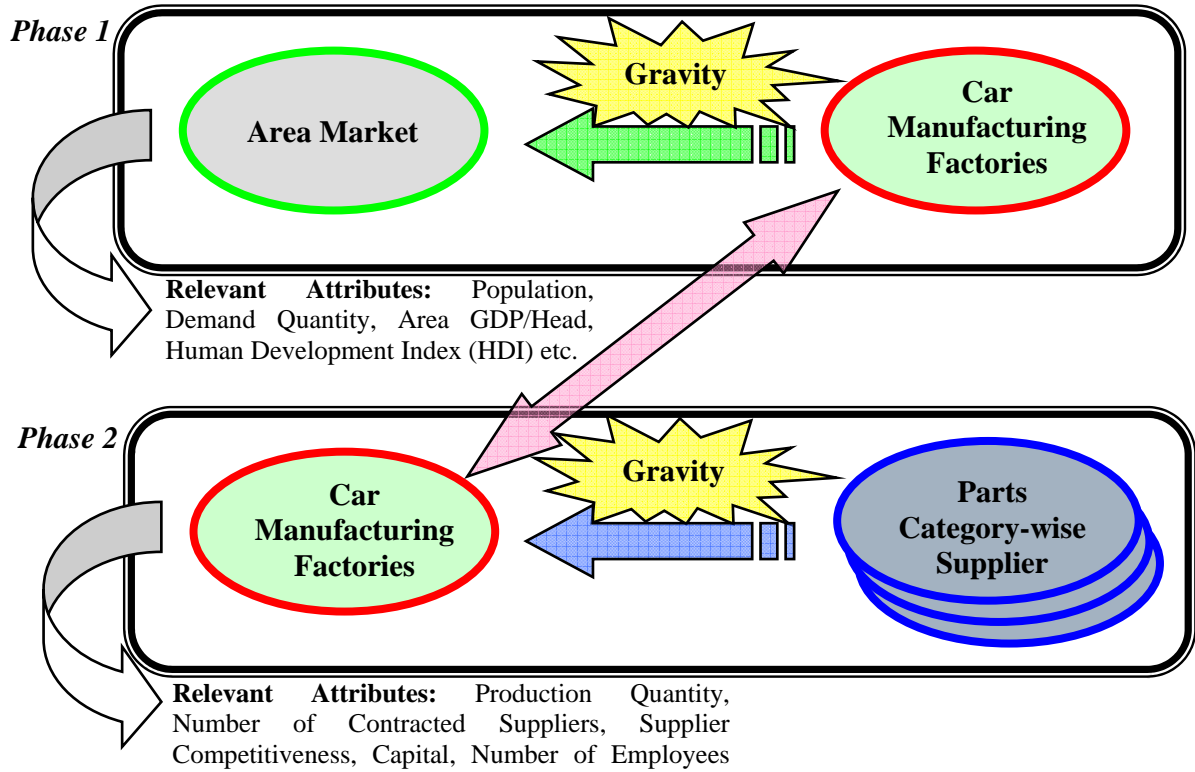


Figure 4. An offshoring model of car manufacturing supply chain in China

### 3. Factor Analysis

In this chapter, the offshoring trend was analyzed by using Logit model.

#### 3.2 Model Analysis

The logistic regression analysis used widely in plague research today, originated in the 1948 cohort study on coronary artery disease taking place in the United States. This research introduced a new concept called the "multiple risk factors (multiple risk factor)". The results of the logistic regression analysis have been widely recognised for its usefulness. As the dependent variable is a probability value, logistic functions is often used in the regression analysis. The Logit model is a model which explains the occurrence probability of an event with the value in sections 0 and 1 by logistic function and a linear function. The following mathematical model is used in this study. Where,  $F(Z)$  is a dependent variable to estimate the probability that event  $Z$  occurs and is supposed to subject to a logistic function as shown in expression (1). Event  $Z$ , which is the indirect variable used in Logit model, is supposed to be determined by some relevant independent variables by a linear relation as shown in expression (2).

$$F(Z) = \frac{\exp(Z)}{1 + \exp(Z)} = \frac{1}{1 + \exp(-Z)} \quad (1)$$

$$Z = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_r x_r \quad (2)$$

<Notation>

$F(Z)$  : Dependent variable with a probability value

$Z$  : Dependent variable

$x_1, \dots, x_r$  : Independent variables

$\beta_0$  : Constant term

$\beta_1, \dots, \beta_r$  : Parameter indicating significance

#### 4. Offshoring Activity of Car Assemblers and Its Factor Analysis

In this chapter, the Phase 1 research problem is described with some analytical results.

##### 4.1 Dependent and Independent Variables

In this section, useful dependent and independent variables obtained through statistical book investigation is described. Table 1 summarises Car Manufacturing Area wise values of major attributes such as area size, population, GDP and Human Development Index (HDI) together with Japanese parent companies currently operating in the corresponding areas and production volumes of offshore companies.

Table 1. Classification of offshoring area of Japanese car assemblers in China (FOURIN, 2008)

Car Manufacturing Area	Size (km <sup>2</sup> )	Population (10 <sup>4</sup> Heads)	Area GDP per Head (Yuan)	Human Development Index (HDI)	Japanese Car Assembler	Production Volume (10 <sup>3</sup> Vehicles/Year)
Tianjin Area (Tianjin City)	11,760	1,115	55,473	0.855	Toyota	208,359
Guangzhou Area (Guangdong Province, Hunan province)	391,675	16,312	25,997	0.790	Toyota	61,281
					Renault/Nissan	160,000
					Honda	286,611
					Mitsubishi	24,688
Wuhan Area (Hubei Province, Henan province, Jiangxi province)	519,800	20,203	16,453	0.752	Renault/Nissan	68,212
					Suzuki	65,096
Sichuan Area (Sichuan Province, Chongqing City)	567,400	11,960	16,702	0.737	Toyota	10,949
					Ford/Mazda	2,000
					Suzuki	110,164
Coastal Area (Jiangsu Province, Fujian province)	224,000	11,206	32,594	0.795	Mitsubishi	50,362
					Ford/Mazda	1,541
Changchu Area (Jilin Province)	187,400	2,709	23,514	0.795	Toyota	5,054
					Ford/Mazda	47,265
Taiwan Area (Taiwan)	36,190	2,305	103,273	0.916	Toyota	97,031
					Renault/Nissan	36,513
					Honda	20,559
					Mitsubishi	56,953
					Ford/Mazda	53,174

It is recognised that depending on the car manufacturing industrial area, each assembler shares their volume capability with others.

For analysis of driving factors that contributes to create gravity to absorb and to be absorbed in certain area, dependent variable and independent variables for Logit model are defined and clarified in terms of data as follows.

Dependent Variable: Probability of the area  $i$  to be chosen as an offshore site  $P_i$

$$P_i = \frac{\text{Number of Car Assembly Factories in the Area } i}{\text{Total Number of Car Assembly Factories in China}} \quad (3)$$

Table 2. Attributes of offshoring area of Japanese car assemblers

Independent Variable	Unit	Note
Size	Km <sup>2</sup>	Source: Home Page of Embassy of The People's Republic of China in Japan
Population	10 <sup>4</sup> Heads	Total local population in the area Source: Home Page of Embassy of The People's Republic of China in Japan
Area GDP per Head	Yuan	Gross Domestic (Area) Product in the area per head Source: Home Page of Japan-China Economic Association
Human Development Index (HDI)	Index	Formulation is described below of this table. Source: Human Development Report 2007/2008, United Nations Development Programme
Production Volume	10 <sup>3</sup> Vehicles/Year	Total production volume produced by Japanese offshore assemblers operated in the area

The Human Development Index (HDI) then represents the average of the following three general indices.

- Life Expectancy Index =  $\frac{LE - 25}{85 - 25}$  (4)

$LE$ : Average Expected Life Time

- Education Index =  $\frac{2}{3} \times ALI + \frac{1}{3} \times GEI$  (5)

- Adult Literacy Index (ALI) =  $\frac{ALR - 0}{100 - 0}$  (6)

$ALR$ : Adult Literacy Rate

- Gross Enrollment Index (GEI) =  $\frac{CGER - 0}{100 - 0}$  (7)

$CGER$ : Combined Gross Enrollment Rate

- GDP =  $\frac{\log(GDP_{pc}) - \log(100)}{\log(40000) - \log(100)}$  (8)

$GDP_{pc}$ : GDP per Capital

## 4.2 Result of Analysis

Table 3 summarises the result of Logit analysis and gravity is suggested to be estimated by the expression (9).

Table 3. Coefficients of Logit model (Japanese car assemblers)

Area Population	Area GDP/Head	Production Volume	Multiple Correlation Coefficient
0.305	0.339	0.276	0.939

$$P_i = -1.885 + 0.305x_1 + 0.339x_2 + 0.276x_3 \quad (9)$$

<Notation>

- $P_i$  : Probability of assembler to be absorbed in the area  $i$   
 $x_1$  : Area Population  
 $x_2$  : Area GDP/Head  
 $x_3$  : Production Volume

## 4.3 Some Considerations

- 1) In general, Japanese car assemblers have incentives on population, GDP/head and current car production volume in the candidate area to move, but the most significant factor can be area population. This interpretation is based on normalisation of all of the data items which have different units, averages and ranges.
- 2) Multiple correlation coefficient in this case is strangely big and this is caused by small size of sample data for the analysis. Therefore, this result does not mean the analysis is accurate. For further study work, it is necessary to increase sample data by extending the scope, i.e. involving other countries' global car manufacturers such as German, French, Italian, Korean, American and China Domestic.

## 5. Offshoring Activity of Car Parts Suppliers and Its Factor Analysis

In this chapter, the Phase 2 research problem is described with some analytical results.

### 5.1 Japanese Car Parts Suppliers in China

First of all, focusing on the first tier suppliers for Japanese car assemblers, list of influential suppliers are created through investigating of their offshore businesses in China. Table 4 summarises major components/parts suppliers which is up to 61 parent Japanese companies. Where, name of parent companies in Japan, name of offshore companies in China, their main products, capital and number of employees are described as major attributes of the companies in scope. For the driving force analysis, engine and steering components/parts businesses are focused to present in this paper as example studies.

Table 4. List of supplier companies (ordered by capital)(FOURIN, 2008), (JIRC, 2008)

No.	Supplier Company	Offshore Companies	Main Products	Capital (Yuan)	No. of Employee
1	DENSO	天津電装電子 etc 12 Companies	Engine components/part, Electric/electronic parts etc.	4 Bil. etc	801 etc

Table 4. List of supplier companies (ordered by capital) *Continued*

No.	Supplier Company	Offshore Companies	Main Products	Capital (Yuan)	No. of Employee
2	AISIN SEIKI	唐山愛信齒輪 etc 8 Companies	Oil Pump, Cylinder, MT etc.	6 Bil. etc	1,964 etc
3	JTEKT	無錫光洋軸承 etc 11 Companies	Bearing, Steering etc.	2.4 Bil. etc	730 etc
4	TOYOTA BOSHOKU	天津英泰汽車飾件 etc 11 Companies	Sheet, Filter etc.	2.2 Bil. etc	388 etc
5	CALSONIC KANSEI	康奈可汽車電子 etc 5 Companies	Car Airconditioner, Exhaust Systems etc.	2.7 Bil. etc	500 etc
6	NSK	昆山恩斯克 etc 5 Companies	Bearing, Steering etc.	7.5 Bil. etc	1,072 etc
7	TOYODA GOSEI	天津豐田合成 etc 7 Companies	Body Sealing Parts etc.	2.7 Bil. etc	1,051 etc
8	NTN	Shanghai NTN Corp. etc 4 Companies	Differential Gear Component, Bearing etc.	1.8 Bil. etc	1,020 etc
54	T.RAD	東洋熱交換器 (中山) etc 3 Companies	Radiator, Oil Cooler etc.	1.4 Bil. etc	229 etc
55	TAIHO KOGYO	大豐工業 (煙台)	Engine Bearing	1.1 Bil.	312
56	MIKUNI	上海三國精密機械	Carburetor, Throttle Body etc.	1.1 Bil.	850
57	IMASEN ELECTRIC INDUSTRIAL	廣州今仙電機有限公司	Free Wheel, Break etc.	0.3 Bil.	630
58	RIKEN	XIAMEN RIKEN IND. Etc 2 Companies	Piston Ring, Cam Shaft etc.	1.2 Bil. etc	573 etc
59	PACIFIC INDUSTRIAL	天津太平洋汽車部件 etc 2 Companies	Press Parts, Coil etc.	2.3 Bil. etc	100 etc
60	NIHON PLAST	中山富拉司特工業	Steering Wheel	0.6 Bil.	28
61	DAIDO METAL	大同精密金屬	Free Engine Bearing	1.6 Bil.	50

**(1) Engine Parts**

Table 5. List of engine parts supplier companies (order by capital)

No.	Supplier Company	Offshore Companies	Main Products	Capital (Yuan)	No. of Employee
1	AISAN ELECTRIC	愛三 (天津) 汽車部件 etc 2 Companies	Engine Bulb	2.7 Bil. etc	296 etc
2	AHRETTY	廣州阿雷斯提汽車配件	Locker Cover	2.3 Bil.	210
3	AISHIN SEIKI	唐山愛信齒輪 etc 5 Companies	Cylinder Head Cover	6 Bil. etc	1,964 etc
4	AISHIN TAKAOKA	高丘六和[天津]工業 etc 2 Companies	Free Wheel	2.5 Bil. etc	686 etc
5	NOK	無錫恩福油封有限公司	Torsion Dumper	2 Bil.	703
6	CALSONIC KANSEI	康奈可汽車電子 etc 3 Companies	Exhaust Systems	2.7 Bil. etc	500 etc
7	JTEKT	大連光洋瓦軸汽車軸承	Dumper Pulley	2.4 Bil.	730
8	DAIDO METAL	大同精密金屬	Free Engine Bearing	1.6 Bil.	50
9	TAIHO KOGYO	大豐工業 (煙台)	Engine Bearing	1.1 Bil.	31
10	TEIKOKU PISTON RING	安慶帝伯格茨活塞環 etc 3 Companies	Piston Ring	2.1 Bil. etc	1,547 etc
11	TSUBAKIMOTO CHAIN	椿本汽車發動機	Timing Belt	0.2 Bil.	40
12	DENSO	天津電裝電子 etc 8 Companies	ECU for Engine, Radiator	4 Bil. etc	801 etc
13	TOYODA GOSEI	天津豐田合成	Fuel Hose and Pipe	2.7 Bil.	1,051
14	TOYOTA INDUSTRIES	豐田工業汽車(昆山) etc 2 Companies	Engine Block	3.5 Bil. etc	398 etc

Table 5. List of engine parts supplier companies (order by capital) *Continued*

No.	Supplier Company	Offshore Companies	Main Products	Capital (Yuan)	No. of Employee
15	TOYOTA BOSHOKU	佛山豐田紡織汽車 etc 2 Companies	Oil Filter	0.9 Bil. etc	500 etc
16	HITACHI	日立汽車部件 etc 2 Companies	ECU for Engine	0.6 Bil. etc	60 etc
17	FUTABA INDUSTRIAL	協祥機械工業股 etc 4 Companies	Mufler	3 Bil. etc	480 etc
18	MIKUNI	上海三國精密機械	Carburetor, Throttle Body	1.1 Bil.	850
19	YACHIYO INDUSTRY	八千代工業 (中山) etc 2 Companies	Fuel Tank	1.4 Bil. etc	47 etc
20	YUTAKA GIKEN	武漢金豐汽配有限公司 etc 3 Companies	Catalytic Converter	0.5 Bil. etc	380 etc
21	T.RAD	東洋熱交換器 (中山) etc 3 Companies	Radiator, Oil Cooler	1.4 Bil. etc	229 etc
22	RIKEN	XIAMEN RIKEN IND. etc 2 Companies	Piston Ring, Cam Shaft	1.2 Bil. etc	573 etc

Table 6. Membership Table of Engine Parts Suppliers for Each Car Assembler's Collaborative Company Group (Ordered by Capital)

	Toyota	Renault/Nissan	Honda	Mitsubishi	Ford/Mazda	Suzuki
AISAN ELECTRIC	1	1	-	1	1	1
AHRETTY	1	1	1	-	-	1
AISHIN SEIKI	1	1	1	1	-	1
AISHIN TAKAOKA	1	-	-	-	-	1
NOK	1	1	1	1	1	1
CALSONIC KANSEI	-	1	-	1	1	-
JTEKT	1	1	1	1	1	1
DAIDO METAL	1	1	1	-	1	1
TAIHO KOGYO	1	-	-	-	-	1
TEIKOKU PISTON RING	1	-	1	1	1	1
TSUBAKIMOTO CHAIN	1	-	1	1	-	1
DENSO	1	-	1	1	1	1
TOYODA GOSEI	1	1	1	1	1	1
TOYOTA INDUSTRIES	1	1	1	-	1	1
TOYOTA BOSHOKU	1	-	-	-	-	1
HITACHI	1	-	-	-	-	1
FUTABA INDUSTRIAL	1	1	1	1	1	1
MIKUNI	1	-	1	1		1
YACHIYO INDUSTRY	-	-	1	1	1	1
YUTAKA GIKEN	-	-	1	-	-	1
T.RAD	-	-	1	-	-	-
RIKEN	1	1	1	-	1	1
Total	16	9	15	11	10	18

\*"1" means membership contract was established between parents companies in Japan

\*"-." meand no relationship established

## (2) Steering Parts

Table 7. List of steering parts supplier companies (order by capital)

No.	Supplier Company	Offshore Companies	Main Products	Capital (Yuan)	No. of Employee
1	AISHIN SEIKI	AISHIN 精機佛山自動車部品	Tilt Steering Column	1 Bil.	212

Table 7. List of steering parts supplier companies (order by capital) *Continued*

No.	Supplier Company	Offshore Companies	Main Products	Capital (Yuan)	No. of Employee
2	AISHIN TAKAOKA	高丘六和[天津]工業 etc 2 Companies	Nackle	2.5 Bil. etc	686 etc
3	JTEKT	大連光洋瓦軸汽車軸承 etc 5 Companies	Power Steering	2.4 Bil. etc	302 etc
4	SHOWA	上海昭和汽車配件 etc 3 Companies	Power Steering	0.7 Bil. etc	291 etc
5	TAKATA	高田（上海）汽車製造	Steering Wheel	0.9 Bil.	300
6	TOKAI RIKA	天津東海理化汽車部件	Steering Handle Lock	0.9 Bil.	776
7	TOYODA GOSEI	天津豐田合成	Steering Wheel	2.6 Bil.	1051
8	NSK	東莞恩斯克轉向器	Steering Column	0.7 Bil.	175
9	NIHON PLAST	中山富拉司特工業	Steering Wheel	0.7 Bil.	280
10	HITACHI	上海台厚汽車	Power Steering Pump	0.1 Bil.	41
11	FUTABA INDUSTRIAL	協展機械工業股份有限公司 etc 2 Companies	Steering Column	3 Bil. etc	480 etc
12	FUJI KIKO	協富光洋	Steering Column	0.6 Bil.	120
13	FTECH	偉福科技工業(中山) etc 2 Companies	Lower Arm	2 Bil. etc	652 etc
14	MITSUBA	三葉電機（青島）	Steering Motor	0.7 Bil.	143
15	YOROZU	廣州萬寶井汽車部件	Suspension Member	2.5 Bil.	295

Table 8. Membership Table of Steering Parts Suppliers for Each Car Assembler's Collaborative Company Group (Ordered by Capital)

	Toyota	Renault/Nissan	Honda	Mitsubishi	Ford/Mazda	Suzuki
AISHIN SEIKI	1	1	1	1	-	1
AISHIN TAKAOKA	1	-	-	-	-	1
JTEKT	-	-	1	-	-	1
SHOWA	1	1	1	1	1	1
TAKATA	-	-	1	1	1	1
TOKAI RIKA	1	1	1	1	1	1
TOYODA GOSEI	1	1	-	1	1	1
NSK	1	1	1	-	1	1
NIHON PLAST	1	1	1	1	1	1
HITACHI	-	1	1	-	-	1
FUTABA INDUSTRIAL	1	1	1	1	1	1
FUJI KIKO	-	1	1	-	-	1
FTECH	1	-	1	1	-	1
MITSUBA	-	1	1	1	1	1
YOROZU	-	1	1	-	1	-
Total	9	11	13	9	9	14

\*"1" means membership contract was established between parents companies in Japan

\*"- " meand no relationship established

## 5.2 Dependent and Independent Variable

For analysis of driving factors that contributes to create gravity to absorb and to be absorbed to the umbrella of assemblers, dependent variable and independent variables for Logit model are defined and clarified in terms of data items as follows.

Dependent Variable:  $P_{jr}$ , which denotes the probability that the supplier company belonging to business category  $r$  moves to customer assembler site  $j$

$$P_{jr} = \frac{\text{Number of Supplier Factories of Category } r \text{ move to Assembler } j}{\text{Total Number of Supplier Factories of Category } r \text{ in China}} \quad (10)$$

Table 9. Major attributes of Japanese car assemblers

Independent Variable	Unit	Definition
Capital	10 <sup>3</sup> Mil. Yen	Reference: (IRC, 2008)
No. of Employees	Head	Reference: (FOURIN, 2008)
Production Volume	10 <sup>3</sup> 台/年	Total production volume produced by Japanese offshore assemblers in China
No. of Collaborative Supplier Companies	Company	Number of suppliers collaborating with assemblers in the area
Dominance Index*	Index	Average suppliers' capital rate of each supplier against total capital of suppliers for considered assembler, which is considered as a dominance index in a assembler group

\* Dominance Index is defined as follows.

$$\text{Dominant Index} = \text{Ave} \left( \frac{\text{Capital of Considered Suppliers}}{\text{Total Capital of Suppliers considering to move specific Assembler}} \right) \quad (11)$$

### 5.3 Result of Analysis

#### (1) Engine Parts

Table 10 summarises the result of Logit analysis and gravity is suggested to be estimated by the expression (12).

Table 10. Coefficients of Logit model (Engine Suppliers)

Production Volume of Assembler	No. of Collaborative Supplier Companies	Dominance Index	Multiple Correlation Coefficient
0.300	0.109	0.135	0.861

$$P_{jr} = -1.633 + 0.300x_1 + 0.109x_2 + 0.135x_3 \quad (12)$$

<Notation>

$P_{jr}$  : Probability of supplier in business category  $r$  that supplies their parts to assembler  $j$

$x_1$  : Production Volume of Assembler

$x_2$  : Number of Collaborative Supplier Companies

$x_3$  : Dominance Index

#### (2) Steering Parts

Table 11 summarises the result of Logit analysis and gravity is suggested to be estimated by the

expression (13).

Table 11. Coefficients of Logit model (Steering Suppliers)

Production Volume of Assembler	No. of Collaborative Supplier Companies	Dominance Index	Multiple Correlation Coefficient
0.309	-0.055	-0.013	0.959

$$P_{jr} = -1.656 + 0.308x_1 - 0.055x_2 - 0.013x_3 \quad (13)$$

<Notation>

- $P_{jr}$  : Probability of supplier in business category  $r$  that supplies their parts to assembler  $j$
- $x_1$  : Production Volume of Assembler
- $x_2$  : Number of Collaborative Supplier Companies
- $x_3$  : Dominance Index

#### 5.4 Some Considerations

- 1) In general, Japanese car parts suppliers have incentives on production volume of assembler, and not very much affected by number of collaborative supplier companies for the target assemblers as well as suppliers' own dominance index. This interpretation is relatively known by offshore suppliers but not precisely identified so far.
- 2) Multiple correlation coefficients in both results are extremely big and again this is caused by small size of sample data for the analysis. Therefore, the same suggestion as described in section 4.3 in phase 1 analysis must be suggested.

#### 6. Concluding Remarks

In this study, investigating statistical data related to car industries including assemblers as well as parts suppliers and understanding current scene of Japanese offshore car manufacturers in China, driving factors were extracted through Logit analysis and examined their validity. Obtained results indicate that car assembles are pulled by population, GDP and actual production volume produced in each area, whereas parts suppliers are pulled mainly by assemblers actual production volume, not by established contract-base network.

This study could be developed further by involving other countries' global car manufacturers such as German, French, Italian, Korean, American and China Domestic. Furthermore the factors analysed in this study could contribute to estimate/forecast the future trends on relocation of automotive manufacturing function.

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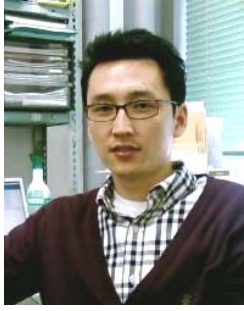
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