Titre: Title:	The characteristics of Chinese automobile industry
Auteur: Author:	Ningbing Wang
Date:	2011
Type:	Mémoire ou thèse / Dissertation or Thesis
Référence: Citation:	Wang, N. (2011). The characteristics of Chinese automobile industry [Mémoire de maîtrise, École Polytechnique de Montréal]. PolyPublie. https://publications.polymtl.ca/698/

UNIVERSITÉ DE MONTRÉAL

THE CHARACTERISTICS OF CHINESE AUTOMOBILE INDUSTRY

NINGBING WANG

DÉPARTEMENT DE MATHÉMATIQUES ET DE GÉNIE INDUSTRIEL

ÉCOLE POLYTECHNIQUE DE MONTRÉAL

MÉMOIRE PRÉSENTÉ EN VUE DE L'OBTENTION

DU DIPLÔME DE MAÎTRISE ÈS SCIENCES APPLIQUÉES

(GÉNIE INDUSTRIEL)

OCTOBER 2011

UNIVERSITÉ DE MONTRÉAL

ÉCOLE POLYTECHNIQUE DE MONTRÉAL

Ce mémoire intitulé:

THE CHARACTERISTICS OF CHINESE AUTOMOBILE INDUSTRY

présenté par : WANG Ningbing

en vue de l'obtention du diplôme de : Maîtrise ès sciences appliquées

a été dûment accepté par le jury d'examen constitué de :

M. BASSETTO Samuel, Doct., président

M. BAPTISTE Pierre, ing., Doct., membre et directeur de recherche

M. MASCLE Christian, Ph.D., membre

ACKNOWLEDGEMENTS

First of all, I would like to express my deep gratitude to Professor Pierre Baptiste for his guidance and support in my Master's studies. With his wonderful and continuous assistance, my study and research have always been progressed smoothly.

Many thanks to all my friends and relatives who contributed to my research work. Special thanks are expressed to Professor Chen at Shanghai University of Engineering Science, and Mr. Ma in Baosteel who was my classmate in Chongqing University.

I am grateful to my husband, Zhenfeng Li. He always gave me encouragement and helped me in my writing. Many thanks to my daughters. Their smiles are always my motivation.

I would like to thanks Aide Financière aux études du Quebec for the financial support, with which I can continue and finish my study.

RÉSUMÉ

Dans le livre «The Machine that Changed the World », Womack et son équipe du MIT ont réalisé une étude portant sur le phénomène japonais dans l'industrie automobile au début des années 90. Les membres concluent que le Japon avait utilisé une arme secrète pour ainsi dépasser les États-Unis et devenir le pays le plus puissant dans la fabrication des automobiles. Cette arme est connue comme Lean production. Depuis, Lean production s'est étendu dans les industries partout dans le monde.

Depuis deux ans, la Chine est devenue simultanément le premier marché et producteur des automobiles. Une question fondamentale reste à savoir s'il s'agit seulement d'un déplacement d'entreprises, ou si l'on vit l'émergence d'un nouveau modèle de production.

Cette étude examine d'abord l'histoire de l'industrie automobile dans le monde, où celle de la Chine doit être prise en considération sérieuse. La visite des quatre entreprises automobiles chinoises, tant locale qu'européenne et japonaise montre qu'il existe une grande variabilité de modèles qui coexistent en Chine et qu'il serait sans doute prématuré de parler de nouveau modèle de production. La mise en œuvre de Lean production et l'application de la nouvelle gestion et des méthodes de production sera ainsi étudiée. Il est remarqué que différentes méthodes sont utilisées en Chine. Par exemple, les entreprises étrangères en Chine possèdent des usines à très haut taux d'automatisation, assez conventionnelles par rapport aux modèles classiques, alors que les entreprises locales restent beaucoup plus utilisatrices en main-d'œuvre. Il est également constaté que Modular production se pratique très bien, même mieux que Lean production. Par ailleurs, l'imitation est aussi une approche importante au cours du processus de développement, bien que certains problèmes de droits et de brevets existent.

Ce projet de recherche permettra aux lecteurs de comprendre le nouveau développement de l'industrie automobile chinoise. Il sera également question de la gestion et du développement de la production en Chine, son passé historique, l'état actuel et un avenir glorieux.

ABSTRACT

In the book «The Machine that Changed the World », Womack and his colleagues studied the Japanese automobile industry in the 1990s and concluded that Japanese used a secret weapon to surpass the U.S. and became the biggest automobile manufacturing country. This secret weapon is known as Lean production. From then on, Lean production has been expanding in all industries around the world.

Two years ago, China became the biggest automobile producer and the largest automobile market in the world. This situation stimulates a fundamental question whether it is just an economic change or there is an emergence of a new production model?

This study first reviews the history of automobile industry in the world, where Chinese history is focused on. Four representative automobile companies are investigated in details, within which three are joint venture companies and one is a domestic company. The implement of Lean production and the application of new management and production methods are studied. It is found that different methods are applied in China, where joint venture companies usually have high executive levels and the domestic ones only use a cheap labor approach. It is also found that Modular production is well practiced in China, which is even better than the Lean production. Imitation is also an important approach during the development process, although some law and patent problems exist.

This research will allow us to understand the new development of automobile industry in China better. It will also deliver some important information for the management and production development in China, its past history, the current status and the glorious future.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS iii
RÉSUMÉ iv
ABSTRACT v
TABLE OF CONTENTS vi
LIST OF TABLES viii
LIST OF FIGURES ix
LIST OF APPENDICES x
NOMENCLATURE xi
INTRODUCTION 1
CHAPTER 1: LITERATURE REVIEW 3
1.1 The history of automobile industry in the world 3
1.1.1 The United States automobile industry 4
1.1.2 Europe automobile industry 8
1.1.3 Japan automobile industry 11
1.1.4 Korea automobile industry 16
1.2 The history of Chinese automobile industry 18
1.2.1 Independent manufacturing 18
1.2.2 Joint venture companies 20
1.2.3 Imitation and innovation 23
1.3 Chinese automobile industry map 28
1.4 Chinese government policies 30
1.5 Outcome of the literature review 34
CHAPTER 2: METHODOLOGY 36
2.1 Research methods 36
2.2 Questionnaire development 37
2.3 Data collection 37

CHAPTER 3: CASE STUDY 38
3.1Shanghai Volkswagen 38
3.1.1 Assembly shop 40
3.1.2 Department of procurement 41
3.1.3 Department of sales 42
3.2 Shanghai GM 45
3.2.1 GMS system 46
3.2.2 Supply chain optimization 48
3.2.3 CRM system 50
3.2.4 Green strategy 51
3.3 Chongqing Changan Suzuki 52
3.4 BYD Auto Company 54
CHAPTER 4: RESULTS AND DISCUSSION 59
4.1 Data display and analysis 59
4.1.1 Assembly shop 59
4.1.2 Department of procurement 63
4.1.3 Department of sales 66
4.2 What's more 67
4.3 Discussion 68
4.3.1 Lean production in China 69
4.3.2 Modular production in China 70
4.3.3 New direction in China 71
CONCLUSION 74
REFERENCE 75
APPENDICES 80

LIST OF TABLES

Table 1.1: The imported cars in China between 1981-1985 21

Table 4.1: Survey data from the assembly shop 61

Table 4.2: Survey data from the department of procurement 64

Table 4.3: Survey data from the department of sales 67

LIST OF FIGURES

Figure 1.1: Vehicle productions in different countries in certain years..... 4

Figure 1.2: 1900-1940 vehicle output in the U.S., Japan and five countries in Europe. 14

Figure 1.3: 1946-1987 vehicle output in the U.S., Japan and five countries in Europe. 14

Figure 1.4: 1997-2009 vehicle output in the U.S., Japan and five countries in Europe. 15

Figure 1.5: Transition diagram of global automobile industry..... 15

Figure 1.6: 1953-1982 vehicle and car production in China 20

Figure 1.7: Vehicle output of China in 1953-2009..... 27

Figure 1.8: Market shares of national brands passenger cars in China 27

Figure 1.9: China vehicle manufacturing map 29

Figure 3.1: Shanghai Volkswagen total car sales 39

Figure 3.2: Car production of Shanghai Volkswagen in different years 39

Figure 4.1: Number of components suppliers in 2010 for four representative companies.... 65

Figure 4.2: Engineering carried out by suppliers in 2010 for four representative companies66

LIST OF APPENDICES

APPENDICES A: MAJOR QUESTIONNAIRE ITEMS……...80

APPENDICES B: CAR BRANDS IN CHINA……..83

NOMENCLATURE

AMC	American Motor Corporation
BYD	Build Your Dreams
CDC	Customer Development Center
CKD	Complete Knock-Down kit
CRM	Customer Relationship Management
DKD	Direct Knock-Down kit
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
FAW	First Automobile Works
FDI	Foreign Direct Investment
GM	General Motors Corporation
GMS	General Manufacture System
JIT	Just-In-Time
KD	Knock-Down kit
LLM	Leading Logistics Management
MBTI	Modularity-Based Technology Innovation
MID	Modularity In Design
MIP	Modularity In Production
MIU	Modularity In Use
MIT	Massachusetts Institute of Technology
MITI	Ministry of International Trade and Industry
OEM	Original Equipment Manufacturer
OTD	Order To Deliver
RDC	Re-Distribution Center

SGM	Shanghai General Motors
SKD	Semi Knock-Down kit
SMS	Short Messaging Service
SOA	Service-Oriented Architecture
SPC	Statistical Process Control
SVW	Shanghai Volkswagen Corporation
TQC	Total Quality Control
UK	United Kingdom
USSR	Union of Soviet Socialist Republics
VA	Value Analysis
VE	Value Engineering
WEC	World Environment Center
WTO	World Trade Organization

INTRODUCTION

The automobile industry is growing rapidly in emerging countries. Overall, 40% vehicles in the world are produced in China, India or Brazil today. Among them, China holds the leading position and produces more than 25% vehicles in the world. Meanwhile, China had become the world's largest market since 2009 (Center & Association, 2009).

Automobile industry has existed for more than a century. During this period, the manufacturing center is changing continuously. Womack's team (Womack, Jones, & Roos, 1990) investigated many automobile companies in different countries to understand the mechanisms leading to this transformation. He concluded that the appearance of new management was the reason for the transformation. Following this thought, it is easy to bring a question if there is any new practice or method accomplished with the massive growth in China?

Looking back the history, the automobile industry started from western countries. It was mostly concentrated in Europe and the U.S. In the late nineteenth century, German engineer Karl Benz and American Henry Ford built four-wheel cars almost at the same time. Soon Henry Ford and his colleagues brought the U.S. into car era dependent on his T-model cars and assembly line (Wild, 1975). This was the famous Mass production period. Later when Europe automobile industry abandoned its adherence to noble origin and introduced the popular car concept, Europe came into car era too.

The U.S. and Europe had kept ahead in the world automobile industry from the beginning to the middle of the 20th century. They were characterized by capital monopoly and technology advancement. However, due to the world economic recession, energy crisis, market competition and other factors which influenced the automobile industry, the development in western countries has been slowed down since 1970s. The U.S. vehicles production fluctuated year after year, and the Europe vehicles production also stagnated from then on.

Japanese automobile industry started its fast development after World War II. By learning Mass production from the U.S. and developing Lean production, Japan

surpassed the U.S. and reached the top level in automobile manufacturing. Toyota and Honda were the most prominent representatives. Until 1980s, Japanese had created numerous self-owned brands such as Lexus, Acura, Infiniti, etc. Soon Korean cars followed and emerged in the world market, with low price and fast-growing market share.

In order to survive in the fierce competition, the major western automobile companies started the step of exporting capital and technology instead of exporting products. Outsourcing became one of the most important practices. With this practice they tried to cut cost and got positive results. Under this background, Modular production was introduced into some developing countries. New technologies and equipments were also spread into these countries and soon they realized the leap from importing to exporting cars. Brazil and Korea are their representatives. However, the practice of Modular production is different in different countries and different companies, hence it was still a fuzzy concept until today (Takeishi & Fujimoto, 2001).

It can be concluded that new innovation and management always push industry going forward. In the process of pursuing new technologies, imitation also emerged as an important approach. Imitation was applied first in some developing countries and has achieved remarkable improvement today. This is also true for Chinese automobile industry. However, in one hand, China bears many features as a developing country; in the other hand, China has large population and complete industrial system. It may create large difference to the other areas of the world. Hence the objectives of this study will be: 1) how the Lean production was implemented in China; 2) what are the management methods in Chinese automobile industry; 3) which new phenomenon appears in China.

This study is organized as follows: Chapter I goes through the literature review, which is mostly about the history of automobile industry and surrounds the clue of three important production methods; Chapter II describes the methodology, which includes research method, questionnaire development, and data collection; Chapter III presents detailed cases study of four representative automobile companies in China; Chapter IV displays and discusses the results of the investigation; Finally, a general conclusion is given for this research.

CHAPTER 1 LITERATURE REVIEW

1.1 The history of automobile industry in the world

Since the invention of the first car in 1896, automobile manufacturing has gradually become one of the most important industries in the world. This industry is commonly recognized as a driver of many other industries such as mechanical industry, chemical industry, electrical industry, service industry, etc. (Fu, 2006), and is encouraged by many governments for economic and employment reasons.

As a capital and technology intensive industry, automobile manufacturing has always been a source of management improvement and innovation. These improvement and innovation are usually connected with technology development, consumer demand, labor cost, as well as different market characteristics (Lu & Mu, 2003; Wild, 1975). As a result, each country has its distinctive path in the development of automobile industry (Dosi, 1982).

At the beginning of the twentieth century, Ford Motor Company created the famous assembly line. With this new method, automobile manufacturing changed from the inefficient single-pieces production process to Mass production. Dependent on this, the U.S. automobile productivity increased greatly during this period and automobiles became popular means of transportation in the world. Automobile manufacturing, first time named as an industry, was accepted by the public (Wild, 1975).

From the seventy of the twentieth century, Japanese automobile industry developed very fast, based on its strong pre-war industry. Toyota Motor Corporation invented Lean production where more varieties, less batch production were adopted in vehicles manufacturing, and high quality and low fuel consumption were also achieved (Teresko, 2005). Toyota soon surpassed the U.S. colleagues and became one of the most successful auto makers in the world. Automobile was known as “The machine that changed the world” from that time (Womack, et al., 1990).

In recent 20 years, Chinese automobile industry is growing very fast, along with its fast growing market. When the major developed countries were hit by the global economic crisis from 2008, Chinese automobile production and sales still increased and approached 14 million in 2010 (Center & Association, 2009). China now has surpassed the U.S. and became the top one vehicle maker and consumer in the world. Meanwhile, Chinese own-brand cars such as BYD, Chery, Jeely, etc. started to occupy a large portion of the Chinese market. The vehicles production comparing with U.S. and Japan is showed in Figure 1.

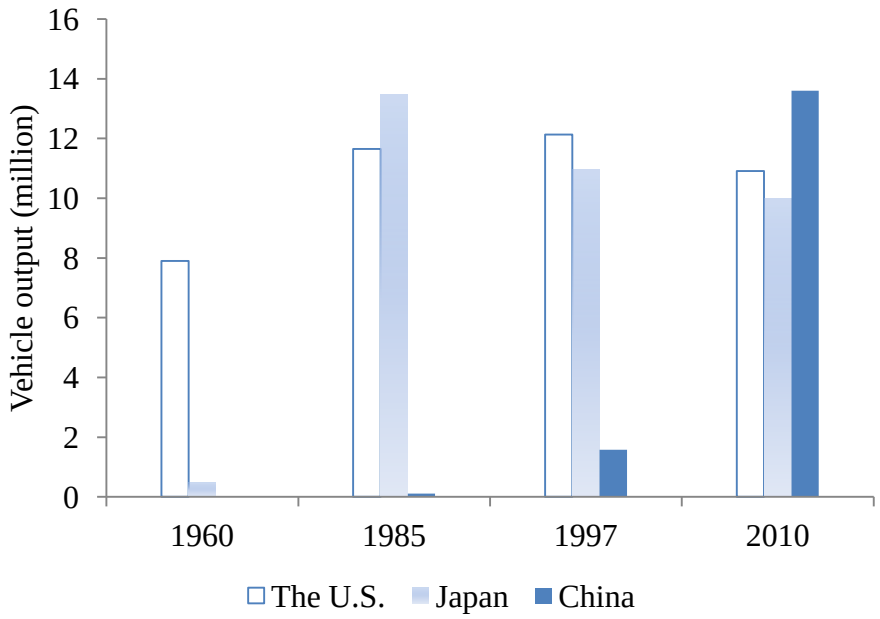

Figure 1.1 Vehicle productions in different countries in certain years

(Source from the World Automobile Manufacturers Association and Chinese Automobile Manufacturers Association)

1.1.1 The United States automobile industry

At the end of the 19th century, the U.S. economy had already reached a very high level. The total industrial production was on the top of the world. Major industries such as steel, oil and chemical developed fast and created condition for the appearance of automobile

industry. At that time, the U.S. also had capital and technology to promote the invention and creativity, and hence had the potential to bring out the automobile industry.

In 1890s, the American automobile industry started with hundreds of car producers. Different technologies such as internal combustion engines, battery-powered electric engines and steam engines were used in automobile production. Charles Duryea and J. Frank Duryea are the first two car markers in the U.S. Ransom Olds in his Oldsmobile factory first introduced assembly line in 1901. In 1909, Ford Auto Company invented model T car which could meet the customer's purchasing power. From then, automobile was not monopoly for the rich people but many common people could afford a model T car, even for an assembly line worker. The climax of universal car appeared in the U.S.

With the advent of assembly line, automobile manufacturing had been changed from inefficient single-pieces processing to mass production. Dependent on this technology, automobile production increased greatly and the automobile became an important tool for transportation in the U.S. Automobile manufacturing was named as an industry for the first time and accepted by the public (Wild, 1975). Mass production was hence defined as: the production of large amounts of standardized products on production lines. It was also called "flow production" and was applied to many other industries thereafter.

The assembly line reduced producing time greatly so that the production cost was cutting down. In this wave, Ford was the first Mass production car maker in the world, and also used many other efficiency management methods. Hence, Fordism became a famous production theory and was copied by other major industries. Also in this time, General Motors Corporation was built. These two big carmakers led the flouring of the U.S. automobile industry.

Model T started a new era for the U.S. vehicle manufacturing. This car occupied most of the auto market over 20 years. In 1927, Model T was produced in a volume of 15 million, which was a merit in the industrial history. However, during this period Ford Auto Company paid more attention on the cost, while little improvement was made on developing new models. At the same time, automobile manufacturing was getting mature and more and more people possess cars. In this situation, Model T seemed to be poor and

monotonous. By 1927, GM Chevrolet cars with luxury accessories were produced and much welcomed by the customers. GM firstly established the Department of Art and Color. Automobiles specially designed for rich people became a new tendency. Thereafter, the standardization and integration of car parts emerged in the U.S. automobile industry. Aluminum body and power brakes were also used in the U.S. In 1925, Chrysler - the third carmaker in the U.S. was founded. In 1929, the U.S. auto production and sales broke 500 million.

Soon GM and Chrysler became the first and second automobile manufacturing companies. These two giants took similar strategies to acquire other auto brands and introduced new models every year. Technology innovation helped them realize giant leap. Many other automakers also rapidly expanded. The U.S. automobile industry occupied the absolute position in this time (May, 1990).

It is worth of mention that during the very early years of the U.S. automobile industry, automobile industry was restricted by the poor road condition. In 1916, the Federal Road Act and Federal Highway Act invested on road construction, and the government's support promoted the development of the U.S. automobile industry.

During the Great Depression, the U.S. automobile industry suffered huge losses, especially for the luxury carmakers. Stutz Motor Car Company, Pierce-Arrow Motor Car Company and others had to be out of their business. Under the economic pressure, new technologies had to be introduced and applied in automobile industry to improve competition ability. Synchromesh manual transmissions, automatic transmissions, hydraulic brakes, independent front suspension and so on were widely adopted during this period.

During World War II, the U.S. automobile industry was turned into war industry and made military tanks and aircrafts. The U.S. economy benefited from the war, even though the car production was affected. Due to the bad working condition in automobile production plants, the United Auto Workers union was formed and strikes happened in General Motors Corporation, Chrysler Corporation and Ford Motor Corporation. During

this period, some auto makers stopped their production and the big three giants in the U.S. automobile industry played important roles.

After World War II, the car production in the U.S. grew rapidly. New technologies were used in car design to meet the market requirement, whatever in styling, plating and others. The overhead valve V-8 engine, Hemi engine, Cadillac Eldorado, Imperial appeared in the market. After the war, imported cars started to compete with the U.S. domestic auto makers. Compact cars were the representation of this competition. Soon after, pony, muscle cars and other full size cars were introduced quickly to satisfy diversified customer demands.

In 1970s, more foreign cars entered the U.S. market. Under the high oil price, especially during the energy crisis in 1972, almost all automobile companies were hurt gravely. To reduce the cost, new models were introduced by the big companies with great effort. Chevrolet Vega, Cadillac Cimarron was their representative. Disc brakes, fuel injection, electronic engine control units and electronic ignition were also used in car construction.

In 1980s, Japanese automobiles poured into the U.S. market. Also Japanese car makers began to invest their auto production plants in the U.S. Lean production at the same time was introduced to the U.S. (Womack, et al., 1990). Operation management and technological innovation in automobile industry led to car productivity improvement. With the falling-off of the oil price, Chrysler Corporation recovered. The Minivan, K-cars came out in the market. In 1987, Chrysler purchased American Motors to produce the Jeep. Ford came back to leading position in the U.S. automobile industry. In 1985, Taurus was the most successful model. The U.S. automobile industry started to revive.

In the mid-1990s, light truck including Sport utility vehicles, Pickup trucks and Minivan was welcome in the U.S. market. Also automobile industry focused on standardizing outsourcing, sharing platforms and applying IT technology (Takeishi & Fujimoto, 2001). However, Japanese automobile companies still brought strong thread to the U.S. automobile industry. Moreover, the U.S. automobile industry heavily depended on gas price, due to their large size models. Big Three turned into Big Two because Chrysler

was acquired by German auto maker Daimler-Benz. GM and Ford also ran into debts by global economy. The U.S. automobile industry began to fall.

From the early 20th century until now, the U.S. automobile industry has gone through more than 100 years. The U.S. auto makers competed with the rivals by continuous innovation and development. They catered the customers on car styling and performance requirement. The U.S. dominated the world automobile industry for long time. The U.S. became the true big and strong country (Coffey, 1998).

1.1.2 Europe automobile industry

In the western countries, automobile industry mostly concentrated in the U.S. and Europe. Actually Europe automobile industry ran ahead of the U.S. at the beginning. In 1886, Benz Karl Friedrich first invented a car. Soon Motor vehicle companies appeared in Europe. Earliest companies were Mercedes-Benz, Daimler in German; Peugeot, Renault in France; Austin, Rover in UK and Fiat in Italy. Europe was the cradle of the world automobile industry. Europe automobile was known for the meticulous work, elegant design, and unique fashion. Differently from the U.S. and Japan, Europe automobile industry created unique style because each country in Europe had very different geographical and culture. Europe automobiles were all showing a tread of diversification.

Europe automobile industry had occupied the dominant position in the early history of world automobile industry. Europe automobile companies mostly produced cars with craft production. However, emphasizing on luxury and expensive, Europe limited the development of automobile industry.

After the World War I, French Citroen first introduced Mass production into Europe. In 1929, GM and Ford brought the factories from UK and German directly and operated Mass production in their European companies. This large scale production had spread into Europe soon. In 1930, European car manufacturing kept up with the U.S. production, which also promoted the development of Europe automobile industry.

Europe auto carmakers could not compete production scale and price with the U.S. However, Europe auto makers found the U.S. automobile's weakness of single model, more fuel consumption and higher vulnerability. They used their advantaged technologies to develop the colorful products such as front engine, front drive, rear engine, rear drive, uni-body, micro-fuel cars, etc. These vehicles can adapt to different road conditions and individual requirement. Mercedes-Benz, MMW, Ferrari, Citroen, Jaguar, Beetle, Mini had been introduced at this time with their individual features.

Another important issue for Europe automobile industry was the Union government policy of abolishing the national tariff. During the late 50s to early 60s in the twentieth century, Europe canceled tariff for every country so that cars from the world could be sold free in Europe. Diversification in design became the biggest advantage at that time. The auto production surmounted 10 million units per year. In 1973, Europe automobile output reached 15 millions. Annual average growth rate was 10.6%. The auto manufacturing center changed to Europe from the U.S.

Since then, due to the two oil crisis, Europe automobile industry went into slow growth stage. In 20 years from then on, Europe automobile output has been kept between 15 to 18 million. This production mostly came from five countries in Western Europe. They not only had similar automobile development process, but also had their own characteristics:

Germany (West Germany): Before World War II, Germany automobile industry already had a good foundation. Daimler, Benz, Audi, Volkswagen were in a certain scale. Although Germany was defeated in World War II, the automobile industry was recovered and developed rapidly. In 1950, vehicle output was 300,000. With the popularity of domestic cars and increase of competitiveness, Germany auto industry grew significantly. During the early 60s, the rates of German vehicle production growth reached 21%. German became the largest car producer and exporter in Europe. From 80s in the last century, Germany automobile output was 400,000-500,000.

France: Before World War II, France automobile industry had already been in the top level in Europe. After World War II, France rebuilt the automobile industry. National car

was getting popular fast. Car exports were also growing. From 80s in the last century, French cars' annual production was 300,000-800,000.

United Kingdom: Before World War II, UK had the most powerful automobile industry in Europe. In 1938, Austin, Rover and all others produced 450,000 cars. UK automobile industry was less damaged in World War II. Its automobile industry got rapid recovery after World War II. In 1955, UK automobile industry output was 1,200,000.

Italy: Before World War II, Italian automobile industry had a certain development. Vehicle products were about 50,000. During World War II, this number was down to a few thousand. After World War II, Italy rapidly developed its automobile industry. In 1963, vehicles production reached 1,180,000.

Spain: After World War II, Spanish economic level was low, automobile industry had not been developed well. In 1960, vehicle products were less than 60,000. However, with the increase of Spanish economy, automobile market was getting expansion later. Moreover, more export and less import pushed Spanish automobile industry forward. In the late 80s, Spanish automobile outputs surpassed UK and Italy and became the third one in Europe, only after Germany and France.

When Japanese auto makers came into Europe, Lean production was introduced into. However, this "best practice" in manufacturing (Takeishi & Fujimoto, 2001) had not brought good results because Japanese models in difference countries had limited success (Dankbaar, 1996).

In the mid-1990s, two German automakers first applied modular production in their Volkswagen and Mercedes-Benz in Europe (Takeishi & Fujimoto, 2001). Europe automakers had more interesting on outsourcing among the modular system. However, under the global crisis, R&D for auto parts was facing a severe situation. In order to avoid the high production cost in Europe, many Europe automakers moved their factories to China, India, Japan and South Korea. In addition, crude oil price raised, raw materials prices skyrocketed, which made Europe automobile industry at a big risk.

1.1.3 Japan automobile industry

Japanese automobile industry went through a different way to the U.S. and Europe automobile industry. The deficiencies of national resource led to more difficulty in developing automobile industry. Government support became the driving force.

In 1907, Torao Yamaha built the first domestic engine car in his Tokyo Motor Factory. From 1914 to 1917, Masujiro Hashimoto with his Kaishinsha Motor assembled British cars and sold them in Japan. They also produced Dattogo-Japanese car. Kaishinsha was the first automobile manufacturer in Japan. Also in 1914, Mitsubishi Zosen, as the first Mass production practitioner in Japan, made 22 car models.

In this period, a number of car manufacturers appeared in Japan. Toyota was just one of them. At the early time, Toyota was a family business. One of Toyota family - Kiichiro visited Ford in 1929. In 1937, Toyota Motor Company was founded. Toyota in this period was fully involved in the U.S. Mass production. At the beginning, Toyota produced a model by coping Chrysler Airflow, then they imitated Swedish Volvo pv60. They firmly believed that imitation was simpler than innovation (Ma, 2010). Several years later, imitation happened more often in Japanese automobile industry, such as Subaru 360, known as Lady Beetle, which was similar with Volkswagen Beetle in Germany. Milliliter Corolla 1000 was just the same as Opel kadett, with little change in the body. They insisted on safe, economic and traditional cars instead of innovation products. However, the military government tried to produce trucks during the war, Toyota's passenger cars had to fail. Family management also exposed its shortcoming. In addition, Japanese were failed in the World War II, and Japanese automobile industry was damaged. By 1950, Toyota Motor Company only produced 2685 automobiles.

In the early 1950s, the U.S. cars and Europe cars flooded into the Japan market. This situation posed a mortal thread to Japanese automobile industry which was in reconstruction. At that time, Japanese government wanted to protect its own automobile industry, and increased automobile imports tariff up to 40%. Moreover, foreign capital was strictly prohibited to seep into Japanese automobile industry. Some small auto

makers had to collaborate with foreign manufacturers. Only Toyota developed domestic cars by their own production.

In the spring of 1950, Eiji Toyota invested in Ford's Rouge plant in Detroit who could produce 7000 automobiles per day. After he was back to Japan, Eiji Toyota and Taiichi Ohno compared local automobile production with the U.S. Mass production, and found that Mass production needed to be changed in Japan because Japan has small market and small quantities with many varieties. Also lack of cheap labors made that simply copy could not improve their production system. Lean production emphasized on reducing cost and eliminating the waste by the workers' effort. In Wikipedia, this production was defined as

"A production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. Working from the perspective of the customer who consumes a product or service, 'value' is defined as any action or process that a customer would be willing to pay for."

This new management method brought revolutionary change to automobile industry. In 1961-1971, Toyota was in its great development time. Automobile output improved from 200,000 units in 1961 to 2,000,000 units 1971. In this period, Japanese auto makers launched many new models: Kei car, Subaru 360, Suzuki Fronte, Mitsubishi 500, Mazda carol and Honda N360.

In this period, government introduced some policies again to develop the economic cars. In 1955, Ministry of International Trade and Industry - MITI announced policies to encourage the development of the national car and provided business loans and tax incentives, so that automakers could get adequate funding for their innovation. In 1965, first highway in Japan from Nagoya to Kobe opened. In 1966, Japanese cars came into the family. Since then, the Japanese cars set off an explosive wave to population.

From 1970, with the increasing domestic demand and joining the foreign markets, Japanese automobile production continued to improve in a fast speed. With Lean production, Toyota not only went though oil crisis smoothly in 1973, but also obtained

the high profits than other companies. Lean production was then popularized. In 1980, Japanese automobile output reached up to 11 million. Under the leadership of Toyota, Japanese automobile production surpassed the U.S., Europe and became the biggest and the most successful one in the world.

At the early 90s, Toyota corolla, Lexus got success in oversea market at the same time. It was the first Asian brand in North American and UK. Celica, Land Cruiser, Hi Lux, etc. obtained success also. Honda Accord, Nissan, Acura, Infiniti, Scion, and so on occupy the most car market. Japanese car manufacturers insisted on affordable, credible and modish cars and became the top automobile producing nation.

By building new factories in the U.S. and Europe, modular production was introduced into Japan automobile industry. However, Japanese automakers took different paths in the application of modular production, because this new method was implemented with different ways by different regions and companies (Takeishi & Fujimoto, 2001). With the essence of Lean production, Japanese more focused on modularization in in-house production. They more emphasized on redesigning the modules. With this improvement, Japanese automobile design capability reached the top level in the world in recent years.

Today, Japanese automobile manufacturing mostly concentrates in Toyota, Honda, Daihatsu, Nissan, Suzuki, Mazda, Mitsubishi, Subaru, Isuzu, Kawasaki, Yamaha and Mitsuoka. They take innovation to support Japanese automobile industry. However, market share has changed since 2000. New competitor from South Korea, China and India bring thread to Japanese automobile industry. Moreover, the U.S. and Europe automakers have been revived through mergers and acquisitions. Now, GM has 20% shares in Fuji, 49% shares in Isuzu and 9.9% shares in Suzuki; Ford holds a 33.4% share in Mazda; Daimler-Chrysler has a 34% share in Mitsubishi. Japanese automobile industry is going to be decadent.

Auto production in different countries during different periods is shown in Figures 2-4. These figures illustrated that world automobile manufacturing center is always changing: the automobile industry first began in Europe and then transferred to North American,

then back to Europe again. Now, Japan and Asia are gradually dominating this industry and leading it forward (shown in Figure 5).

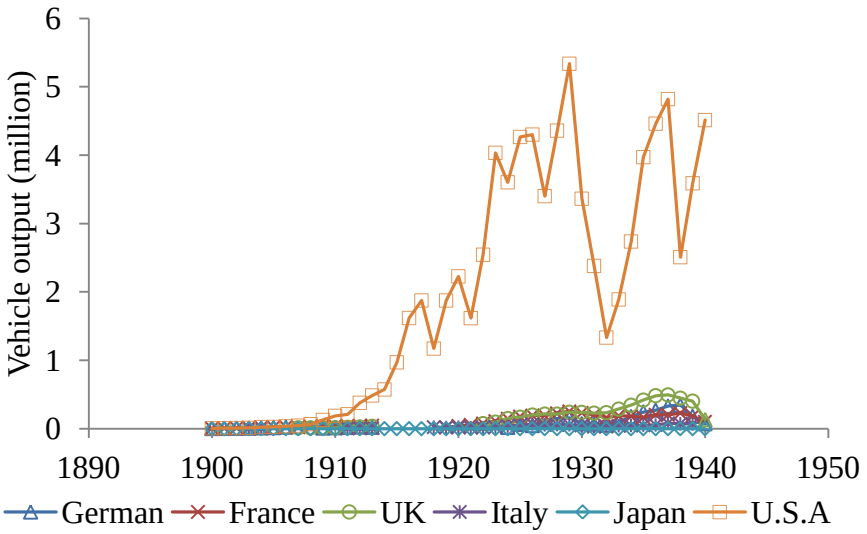

Figure 1.2 1900-1940 vehicle output in the U.S., Japan and five countries in Europe.

(Source from the World Automobile Manufacturers Association)

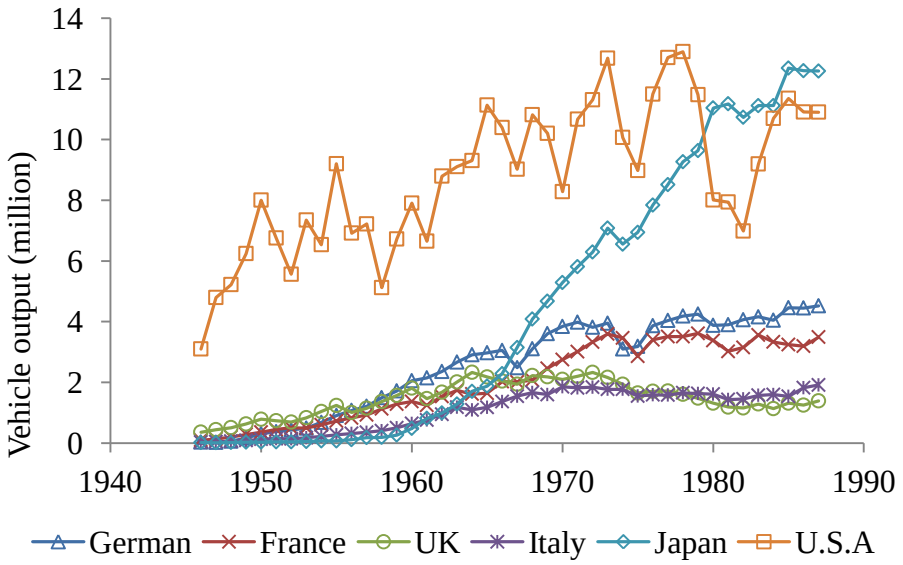

Figure 1.3 1946-1987 vehicle output in the U.S., Japan and five countries in Europe.

(Source from the World Automobile Manufacturers Association)

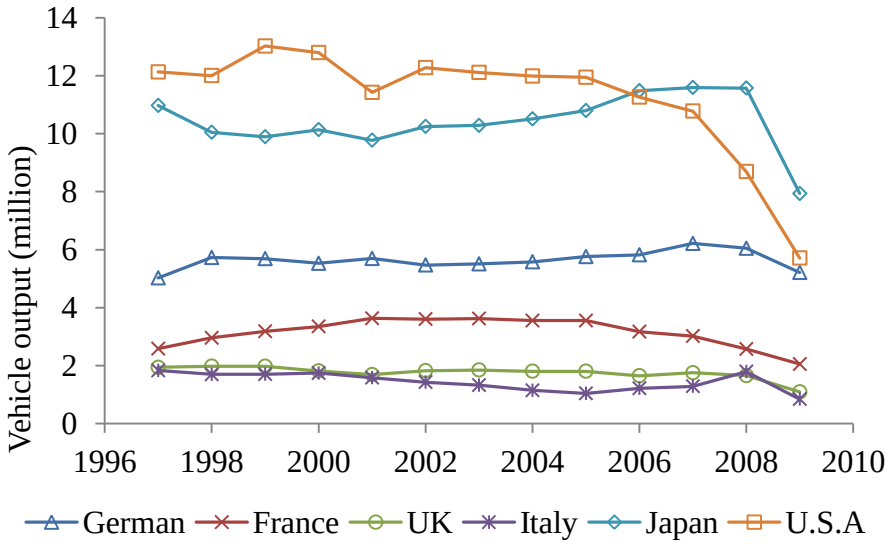

Figure 1.4 1997-2009 vehicle output in the U.S., Japan and five countries in Europe.

(Source from the World Automobile Manufacturers Association)

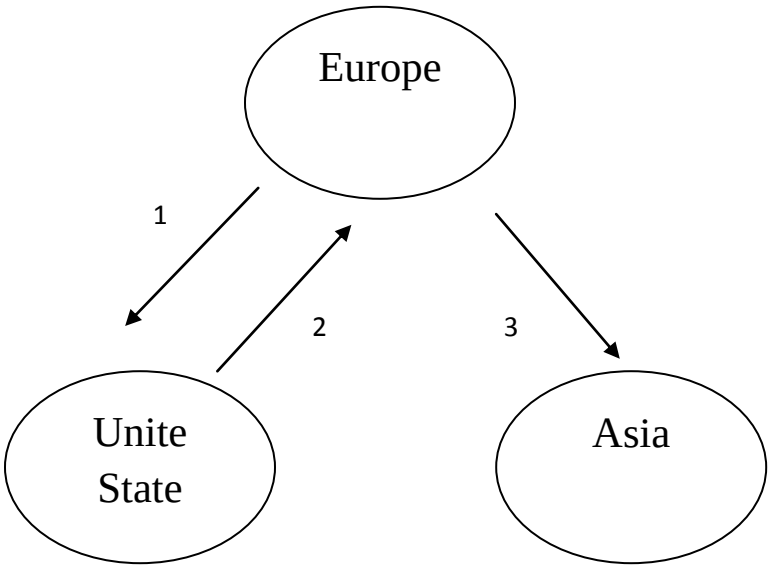

Figure 1.5 Transition diagram of global automobile industry

1.1.4 Korea automobile industry

Korea automobile industry started from the mid 1950s. At that time, the Korean War had just ended and national economy was just recovered. Automobile demand was urgent. This real need became a major reason for the development of automobile industry.

In 1955, Choi Mu-seong produced the first car by refitting an Army Jeep. He named Sibal to mean a new start. In this period, Korean automobile industry is mostly repairing or refitting old vehicles. In 1960, Sinjin Automobile introduced Sinjin Publica with Toyota's help. In 1962, Korea auto production was less than 2000 units. To develop the national automobile industry, Korean government promulgated "Automobile Industry Promotion Policy". Also "Automobile Industry Protection Act" helped Korea's puny automobile industry grow rapidly. Foreign auto companies could only cooperate with Korean companies; otherwise they couldn't manufacture cars in Korea. New joint venture companies appeared in Korea, including Kia Industry with Mazda in 1964; Saenara Automobile with Nissan; Hyundai Motor Company with Ford. This joint venture companies only assembled imported parts from their overseas partners. At this time, Korean automobile industry was based on KD assembly.

In 1969, Korea government proposed "Basic plan for the development of automobile industry". In this plan, government put forward that automobile industry must achieve localization. In 1973, Korean President issued "Declaration of heavy chemical industrialization". Automobile industry was included in the ten industries in Korea, and government gave priority and support.

In order to promote the great development of automobile industry in Korea, some small automakers were stopped or merged. From then on, Hyundai, Kia, Asia and GM Korea were formed to establish the production system. In this period, Korean automobile industry took effort to develop national cars, design their own vehicles and introduce new models. In 1973, Kia industry developed the first 2000cc car engine. In 1974, Hyundai Motor Clubs created Pony car. Korea started to product cars independently.

In 1976, Hyundai was exported to Ecuador in Latin American; Kia and GM Korea trucks were exported to the Middle East. Korean automobile hence entered the international market. In 1979, Korea government announced officially that automobile was one of the exporting commodities. Korea auto production exceeded 200,000 units, with exports over 30,000 units.

From the late 70s to early 80s, Korea economy was a negative growth. The government revitalized the automobile industry into the international market. In 1981, "Rationalization Measure for Automobile Industry" focused on implementing specialized production and enhancing competitiveness by joint venture or combination. Government clearly prescribed that Kia and East Asia concentrate on fire engines and 5 tons Vans; Asia Auto Clubs focused on Jeeps and so on. To create a competitive system, more than 5 tons of trucks and buses were allowed to be freely produced by other auto clubs. Since 1982, with the recovering of Korean' economy, vehicle production had increased rapidly. By 1983, Korean production reached more than 220,000 vehicles. In 1985, it was 378,000.

After the mid-80s, Korean government proposed new goal which further expanded the production scale, speeded up technology development, increased exports so that Korea could become big auto production and export country. To achieve this goal, Korean government opened the auto market from 1987. Meanwhile, automobile manufacturing was no longer restricted on vehicles or cars, which promoted the development of automobile industry in Korea to a higher level.

In this situation, Korean automobile companies were scrambling to develop new types, new models, and adopted various measures: Hyundai began to produce more advanced Pawnee Sedans; Daewoo started to develop Leemans; Kia introduced Bei Sita Sedans and so on. At the same time, various auto clubs competed to enter the international market including Latin American, Southeast Asia, North American, and finally European market. Also Korean automobiles were squeezed into Japanese market. Now the Korean cars have been exported to more than 190 counties and regions.

Throughout the history of automobile industry in the world, it's clear that western countries had strong economy before starting their automobile industry. Advanced technologies in other industry were used in the automobile industry. New management and new innovation stimulated the auto invention and the development. However, in Asian countries, economic base was very weak. To catch up with the developed countries, imitation was the first choice to fast develop automobile industry, and then followed by their second innovation (Schaik & Van de Klundert, 2010). It is also a wise choice at the beginning for many other developing countries. Today China is taking the same path with Japan and Korea and has achieved a surprising progress.

1.2 The history of Chinese automobile industry

There are always some arguments about the development of Chinese automobile industry, even with the division of the development periods. However, in this study, the history will be mostly focused on the recent 60 years, after the end of the civil war in 1949. Before this, China was always in troubled time for more than a century, while western countries were developing their industries much faster. Chinese automobile industry is then divided into three periods according to this consideration: first, independent manufacturing period; second, Joint Venture period; third, innovation with imitation period. These three periods clearly mark the development of Chinese automobile industry from 1950s to 2010s.

1.2.1 Independent manufacturing

The first period was from 1953 to 1978. Chinese automobile industry started by learning from the Union of Soviet Socialist Republics (USSR). But soon it had to develop this industry all by themselves after Chinese government argued and fought with USSR government. This period was also called "truck industry time", as the major products were trucks. However, Chinese automobile industry had been constrained during this period because of various historical reasons. In addition, technology, capital, talent, and many other factors bottlenecked the development of Chinese automobile industry.

The First Auto Factory was built in Changchun in 1953 with the assistance of USSR's experts, when Chairman Mao decided to establish automobile industry in China. All technology was from USSR. Its first product was named Jiefang, which means 'liberation' in Chinese. That was a four-ton CA10 truck which originated from Soviet Kyrgyzstan. All parts were produced in China, while technology of construction and production was completely copied. Soon the political environment changed, and the First Auto Factory had to innovate the technology themselves. They developed CA30 and CA30A off-road vehicles. These two trucks were the first imitated products which specially produced for armed forces. From then on, imitation to production began to expand: in 1957, Nanjing Auto Factory produced NJ130 light truck by coping Soviet GAZ51; in 1958, Shanghai Auto Factory trialed the first car which was a simulation of Poland Warsaw chassis and Chrysler Plymouth styles; in the same year, Beijing Auto Factory produced a sample car by imitating Germany Volkswagen Beetle. During these imitations, innovation was also adopted (Schnaars, 1994; Shankar, Carpenter, & Krishnamurthi 1998). Self-owned brands autos such as Dongfen, Hongqi, Shanghai, fenghuan, Jinggangshan were created. Chinese Government also invested a large amount of money in automobile industry. Many factories could develop their own brands independently.

However, government system and policy limited the development of Chinese auto industry in this period (W. Li, 1997). Planned economy curbed the innovative ability; decade of Great Culture Revolution interrupted the progress of Chinese industry. In nearly 30 years, Chinese car output only broke through 5,000 units. The production of cars is shown in Figure 6.

During this period, Mass production had already been used in the U.S. and spread to Europe and Japan. However, the technology source of Chinese automobile industry was USSR, and Mass production technology was not adopted because of various reasons. Another important issue was that China was lack of marketing mechanisms and factories were built by the central or local government, which resulted in tough difficulty for the development of Mass production. Hence Chinese automobile industry had large gap with the U.S. and Europe at that time.

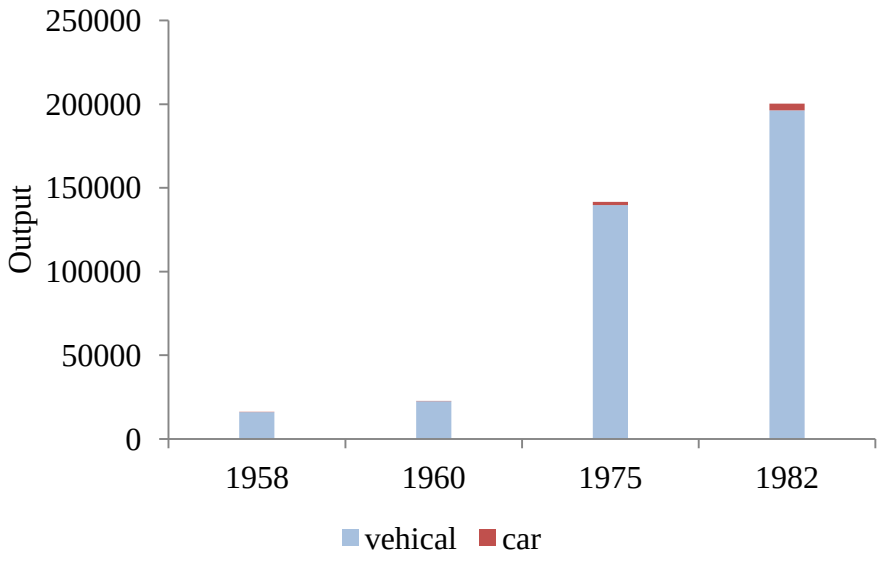

Figure 1.6 1953-1982 vehicle and car production in China

1.2.2 Joint venture companies

Xiaoping Deng was in power after 1978, and a new era was started. As a general policy, reform and open became the very popular terms in China. Joint venture companies were introduced into China, and the second period of Chinese automobile industry began. Chinese government made much effort to encourage foreign (mostly western) capital and technology to come into China, with a promise of exchanging with Chinese market. The market – technology theory by Chinese government thought that this practice could quickly improve the auto productivity and the industry, and was a win-win strategy (Y. Zhao, 2002).

At the beginning, Chinese market was just opened, and the amount of imported cars exceeded the nationally-made cars (shown in Table 1). Cars were imported from everywhere in the world, from the U.S., Japan, west Europe, East Europe, India, etc. Some policies were quickly enacted to encourage foreign companies to cooperate with Chinese factories with special approval by the central government (L. Li, 2008).

As some researchers concluded, technological improvement in a developing country is often not from the national range, but from the foreign technological transfer and

diffusion. That was true in China, and the Foreign Direct Investment (FDI) had become an important channel for international technology diffusion (Eaton & Kortum, 1999). Some joint venture companies such as Shanghai Volkswagen, Guangzhou Peugeot, and Chongqing Suzuki brought their technologies and capitals to China, which greatly pushed Chinese automobile industry forward.

Table 1 The imported cars in China between 1981-1985

Year	1981	1982	1983	1984	1985
Car imports	1401	1101	5806	21651	105775
Car imports over domestic total output (%)	40.87	27.32	96.03	360.25	2031.4

The first joint venture was between Beijing Auto Factory and the American Motor Corporation (AMC). Another important joint venture company was Shanghai Volkswagen. In 1983, Shanghai Auto Factory bought a knock-down kit (KD) assembly line from German Volkswagen to produce Santana.

In developing countries, usually KD was a popular practice at the beginning of automobile industry: KD brought the engine, body, chassis, gearbox and other manufacturing technologies to Japan; it also formed the production capacity with basic components in Korea (Chu, 1997). It was explained in encyclopedia as:

"A knock-down kit which is a kit containing the parts needed to assemble a product. The parts are manufactured in one country or region, and then exported to another country or region for final assembly. CKD (Completely Knock Down), SKD (Semi Knock Down) and DKD (Direct Knocked Down) are a complete, incomplete and direct kit needed to assemble a product. This is also a method of supplying parts to a market."

KD and CKD methods made Shanghai Volkswagens more profitable, especially after some parts were manufactured locally. As a successful model in China, Shanghai Volkswagen vigorously promotes in a short time.

The success of Shanghai Volkswagen attracted more foreign companies to find Chinese partners. Although there was a well-known policy for foreign companies which limited their shareholding for less than 50%, more and more FDI came into Chinese market. Guangzhou Peugeot, Nanjing IEVCO, Yiqi Audi and Erqi Citroen were produced in China. This pattern greatly achieved the government's goal "High starting point, high volume and specialization". As the key production method, CKD, SKD, even DKD played important roles in joint venture companies. In 1997, only after 15 years development, Chinese automobile output exceeded 330,000 (CATRC, 1997). In contrast, those previous state-owned auto companies all gave up their own brands. KD hence became a restriction to the national auto development capacity (Qu, 1994). Chinese also paid for the success of joint venture policy – their own innovation ability was lost.

In the second period of Chinese automobile industry, joint venture companies practiced different management skills. Guangzhou Peugeot was a typical negative example (Thun, 2004): in 1985, Guangzhou Automobile Group cooperated with France Peugeot Company. There were arguments about car models' updating and technology introduction. Moreover, Guangzhou local government made too much constrains for the project. Guangzhou Peugeot started to lose money from 1994. This Joint Venture company announced failure in 1997 (Office, 1993) (Center & Association, 2009).

It is worth of mention that Lean production was introduced into China during this period. All essence in Lean production such as zero defects, zero inventory, JIT, Kanban, QCM, etc. were used in enterprise management. However, Lean production in Chinese automobile companies was still not a successful method today. Most Chinese carmakers reported a psychological dependence on CKD (Lin, Cai, & Li, 2002). Another issue was that in this period, Chinese automobile industry could only purchases technology that combined with the parts; there was no space for them to develop their own technology. Losing the power of innovation was so clear that Lean production started with doom then fall into failure finally.

During this period, by KD assembly auto parts, Chinese automobile industry had been able to survive and develop fast based on the support of Chinese government, with

special policies in tariff, import and enterprise access conditions. In addition, foreign automobile partners learnt to adapt to Chinese policies so that FDI could get more profits in China (Lai & Bao, 2003). China improved its production capability with FDI's help (Qiu, Yang, Xin, & Kirkulak, 2009) (Liu & Zhao, 2006). In the meanwhile, some Chinese researchers hold a negative point of view on FDI (Wang & Zhu, 2008). They thought that joint venture companies could not bring the competent ability to Chinese automobile industry; the core technologies were still mastered by the foreigners. Under the nationalism waves, Chinese automobile industry had to start their independent innovation. From then, the third period of Chinese automobile industry began.

1.2.3 Imitation and innovation

From 1997, China speeded up the process of joining WTO. FDI then had less limitation to enter Chinese market. More automobile companies poured into China. Advanced technology and management method were brought into Chinese automobile industry. New joint venture companies developed faster to catch up or even exceed the old ones. In addition, green supply chain (Zhu, Sarkis, & Lai, 2007) improved environment protection and operation performance. Shanghai GM was a good example in this aspect.

Shanghai GM was built in 1997. It was derived from Shanghai Automobile Industry INC. and US GM. It was the first one to realize flexible production line in auto manufacture in China. In 2010, they produced 103 million cars; surpassed Shanghai Volkswagen's 100 million. Shanghai GM also directly used the most advanced car production lines and equipments. Their flexible production line not only produced multiple models, but also met the diverse needs of the market including the sales, service and parts required by customers. Modular strategy was also applied in all the process including manufacture, design, supply chain, and even in service.

Other new joint venture companies such as Guangzhou Honda, Beijing Hyundai, Tianjin Toyota, etc. cooperated with Chinese state-owned auto factories and realize great leaps. A more important issue was that these new members evaluated the development paths of old ones including how to manage the enterprise and deal with government (Thun, 2004). By drawing their experience and learning the lessons, they played a positive role in

Chinese automobile industry and developed even faster. Modular production became one of the very important methods that could be accepted by most automobile companies. With the development of Chinese economy and improvement of living levels, the demand of automobile products for Chinese consumers tended to be more individualized.

As a concept, modular was proposed in the application of arranging modules with variability and scalability. With this method, the flexibility of the whole system was increased and could adapt to different demands from the customers (Baldwin & Clark, 1997). Modular was soon used in automobile industry. The definition for modular by Automobile Original Equipment Manufacturer-AOEMs (Pandremenos, Paralikas, Salonitis , & Chryssolouris, 2009) is:

"A group of components, physically close to each other that are both assembled and tested outside the facilities and can be assembled very simply onto car."

Modular is a complex system (Starr, 1965). When modular was used in manufacturing, Modular production was proposed. Actually, Modular production has no precise definition. This production method also is a production system. This new system is based on new product-oriented manufacturing method from standardized machine elements. Hardware and software are early connecting with makers and suppliers. The overall goal is to provide rapidly design and configure for customer individualized products (Tsukune et al., 1993).

In automobile industry, modular can be executed in three fields, including Modular in Design (MID), Modular in Use (MIU) and Modular in Production (MIP) (Pandremenos, et al., 2009). Among them, MIP is used more frequently in automobile industry than others (Graziadio, 2003). Modular production in car assembly gets more benefit in improving productivity (Van Hoek & Weken, 1998). Outsourcing is another important part of modular. Increasing outsourcing, shifting territories, and moving towards modular supply (Collins, Bechler, & Pires, 1997) becomes very important competent advantages in new era. In China, there are lots of researchers focusing on the study of flexibility in MIP (Bao, Zhou, & Zhu, 2005) (J. Zhao, 2006) and Supply Chain (Dai, Gao, & Xiao, 2009) (Zhu, et al., 2007). MIU is considered as a method that can match customers' need

by configuring the equipment (Graziadio, 2003). This is also highlighted in Shanghai Volkswagen and Shanghai GM. Each customer can choose their own favorite car online, and they can also make their own personalization, such as configuration, color, and place where they want to pick up the car. Moreover, the order from internet will be formed automatically as a product instruction by the system, then come into the flexible production line. At last, under the control of this system, this personalized car booked from internet will be delivered to customers on time. Another highlight is that customer can check the situation of their car in this system: whatever is happening in the production line, in painting, or on the way of delivery. This new method is being used gradually in all the Chinese automobile industry.

The history of the first and second period of Chinese automobile industry already proved that Chinese automobile industry could not be developed without innovation. In the process of introducing Modular production, imitation to innovation had been carried out. MID realized the old and newly developed platform (Sugiyama & Fujimoto, 2000) for producing different models. In addition, MID itself had been improved. Modularity-based technology innovation (MBTI) (Gu & Xu, 2006) provided a theoretical basis for Chinese technology imitation. In the process of pursuing new technologies, as an important approach, imitation was applied in China. Actually, all Chinese self-owned brands automobile companies such as Chery, Geely, Jinlong, Yutong, BYD, etc. adapted imitation to realize innovation when they grew up. These companies are now in a phase of innovation with creation. This transition had been particularly studied (Dolson & Safarian, 2008). Hence the third period of Chinese automobile industry began.

Imitation is not a new concept in learning technology. Some researchers studied the difference between innovation and imitation and compared experience in different developed countries (Boyer, Charron, Jürgens, & Tolliday, 1998) (Yi, 2011). Imitation becomes a feasible method that can be applied in different demands. Aerospace industry in China (Chen, 2009) is a very successful example in technology imitation. The development of Japanese industry also took the same way (Bolton, 1993). Korean automobile industry more benefited from imitation (L. Kim, 1997). Today Chinese automobile industry is achieving remarkable improvement. However, imitation can only

catch up with others fast, but cannot be useful for surpassing them. Simple imitation is helpful for starting, but it is harmful for developing (Ma, 2010). Hence, imitation has to be stepped into innovation in China.

Under the global competence, reducing cost is always the final goal for manufacturers, although different period has different competence advantages (Davis, Heineke, & Balakrishnan, 2007). In the 21th century, product's short life cycle makes more new products being replaced shortly. Because development of new products does not depend on technology itself, but comes from the market (C. Kim & Fujimoto, 1991). So in today's market, product's fast change can be rapidly responded to market demands (Sun, 2002). In automobile industry, companies also can develop new products and markets with the imitation strategy (Zhou, 2006). Because old products can provide the information for new ones (Schnaars, 1994), the cost for imitation is much lower than innovation (Zhou, 2006). Even, imitators can fast catch up with innovators by copying old products to get progress (Kerin, Varadarajan, & Peterson, 1992), or purchasing common technologies (Chen, 2009). So imitation to innovation is a smart decision for enterprise that enters the market latterly (Zhou, 2006). In China, imitation is the only way to develop Chinese automobile industry in some degree (Guo, 2009).

In the third period all Chinese auto companies are focusing on imitation to innovation. This kind of method makes Chinese automobile industry realize surprising development. The output of Chinese automobile in this period is almost a vertical rise (Figure 7).

Moreover, their market share improves year by year. In 2009, Chinese own brands cars already occupied 44% of the Chinese auto market (Figure 8).

In today' China, producing self-owned brand cars in joint venture companies is becoming a new tendency. LAVIDA, NEEZA from Shanghai Volkswagen; SGMW from Shanghai SM; EVERUS from Guangzhou Honda, etc. raised a new wave between independent and joint venture companies.

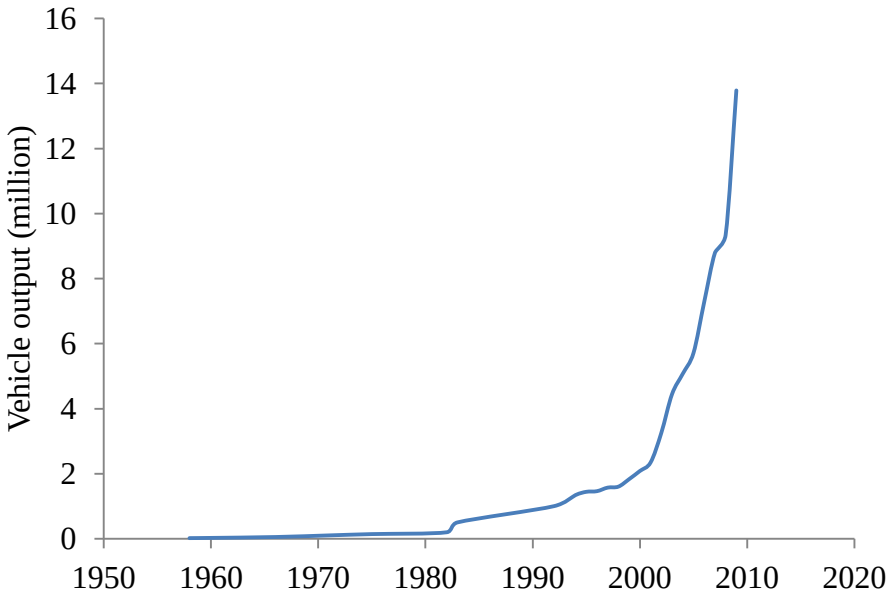

Figure 1.7 Vehicle output of China in 1953-2009

(Source from (Center & Association, 2009))

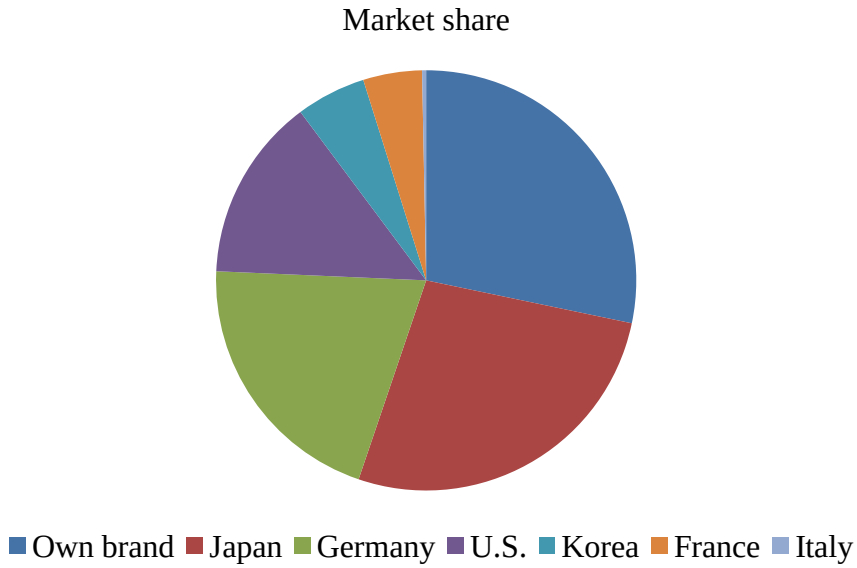

Figure 1.8 Market shares of national brands passenger cars in China

(Source from (Center & Association, 2009))

In Chinese self-owned brand companies, BYD is a miracle. In short 8 years, BYD became the top one of private carmakers from a cell phone battery manufacturer. Imitating technology helped them realize fast development and took fewer detours. Modular production in BYD was also being used in all production operation. They wanted to master more car parts production so that car parts could be highly concentrated for supporting. Modular production was more practice in enterprise management. Merger, reorganization and expansion became their development goal.

Moreover, BYD grasped the electric car and became one of the leading manufacturers in the world. This new development direction attracted more attention. In September 2010, Warren Buffett visited BYD and made his strategic investment. Today, Chinese automobile production has occupied a certain position in the world.

Concluding the Chinese automobile industry, the government restricted the mass production system in the first period. Technology introducing hindered Lean production in the second period. Modular production, however, greatly accelerated the development of Chinese auto industry, although modular production first adapted in developed countries. Imitation to innovation was the main method for improving the competent ability, in the third period. Moreover, some important policies also encouraged and pushed Chinese automobile industry. In today's China, Green Strategies is going across the whole country. Chinese automobile industry with green future plan is expected to play an important role in the world soon.

Today, China pays more attention to the world whatever its manufacturing market or customer market. Almost all famous automakers in the world have built factories in China. Chinese own car makers are developing very fast also. Until 2010, China has more than 120 vehicles manufacturing factories including 33 cars manufacturing factories. China becomes the largest automobile producer in the world.

1.3 Chinese automobile industry map

Chinese automobile industry started from planned economy but finalized in market economy. Along with its fast development, automobile companies formed large but

uniform production sections by mergers and acquisitions. Now automobile industry in China concentrates in five sections (Dong, 2006). Its map is shown in Figure 9 (white areas).

Figure 1.9 China vehicle manufacturing map

First section - Northeast China: FAW in Changchun is a representative company. It is the first carmaker in China. With government support, solid industrial base and strong industrial heritage, FAW is considered as the first-class automobile company in China. Currently, the Northeast China has formed the leading professional automobile section, including FAW Volkswagen, Shenyang Jinbei GM, Brilliance BMW, Harbin Motor and other companies. In these companies, particularly FAW-Volkswagen and Brilliance BMW are the most eye-catching ones.

Second section - East China: By virtue of location advantages in the Yangtze River Delta and excellent development models, automobile industry in East China catches and exceeds the Northeast section. As a latecomer, East China soon becomes second-class market in China. The typical automobile company in East China is Shanghai Volkswagen, Shanghai GM, and Anhui Chery. Chery is one of Chinese owned brands. Its development model is also a unique style, just as any other self-owned brand automobile company.

Automobile industry in East China has strong professional base. This section has a solid and professional foundation so that they can bring specific technical advantage to the powerful products and marketing management.

Third section - Central China: Wuhan is a leading city in central China. With the help of FAW, Dongfeng Motor developed rapidly. Based on the large scale joint venture, much more capital and broad influence, Dongfeng Motor becomes the biggest joint venture company in China. This raises the central region to a significant level. With the new change in China, the development of automobile industry in central China has encountered some problems. However, Dongfeng Motor still has the strong potential for further development. Automobile industry in central China will be able to achieve a new leap.

Fourth section - Southwest China: Chongqing is the key automobile production base in southwest China. Chongqing Changan Suzuki and Chongqing Changan Ford make southwest China an important section in Chinese automobile industry market.

Fifth section - Southern China: Guangdong and Fujian in southern China are typical representative regions. This region is also a latecomer. However, regional advantage such as the smooth flow of information, geographical location and strong talent pool pushed southern China to a high level. In Guangdong, there are Guangzhou Honda and Guangzhou Toyota. In Fujian, there are Southeast Lingshuai and other famous enterprises. BYD Company is located in this area. Southern China has formed a typical automobile industrial chain. The advantage of the chain contributes to the development of automobile industry in this section.

1.4 Chinese government policies

In the development of automobile industry, the government always plays an important role. Particularly in China where the economic system is so exclusive, the government role is very unique and much important, where many policies and regulations are announced from time to time. These policies and regulations are the most powerful supports to the rapidly developed Chinese automobile industry. In the 60 years, policies

and regulations kept changing and formed a track for Chinese automobile industry, and led Chinese automobile production from 0 to 14 million in short 60 years.

In the first period of Chinese automobile industry, the government's task in automobile industry was automobile producing and personal training. However, national strength was not strong; the development speed was much slow. In particular, a decade of Cultural Revolution caused automobile industry stagnant or even declined. Under the planned economy, auto products were considered as production materials, and the relevant state departments had the right to allocate the production to anywhere according to planning and proportional principles.

After China reformed and opened from 1978, Chinese economic system gradually turned from planned economy into market economy. A series of new policies were introduced:

In June 1980, National Machinery Industry Commission issued a "1981 to 1990 National Motor Vehicle Development Program" (Trial) and "Auto industry restructuring program adjustment" (Trial). These two policies made some key automobile enterprises such as First Auto Company; Dongfeng Auto Company started their combination. Many small factories were integrated into them or built around them, so that big auto companies could expand their production scale and reduce repetitive production.

In addition, Chinese Automobile Industry Corporation was also established and a unified economic entity was formed to operate national automobile industry, including Jiefang, Dongfeng, Beijing, Tianjing, Hebei, Nanjing, Chinese Heavy-duty Automobile Industry Associates, Shanghai automobile tractors and Auto Parts Industry Associates.

In April 1986, automobile industry was mentioned as a pillar industry in Seventh Five-year Plan. In October 31, 1987, "The State Council further notice about strict control of imported cars" clearly announced that the State Council was no longer involved in the new car production. This policy effectively prevented herd of too much carmakers, and avoided huge loss, to promote the healthy development of Chinese automobile industry.

In 1991, a policy about automobile industry was approved in Eighth Five-year Plan. It emphasized that automobile industry played an important role in the national economy; it

was not just a tool to meet the transportation needs. During 1980-1990, the central government implemented much more methods including decentralization, separating, and external cooperation. The introduction of technological policy also pushed Chinese automobile industry. Also in the mid-90s in the last century, China thoroughly completed the transition from planned economy to market economy.

In July 1994, ‘Automobile industry policy” was carrying out. This was the first Chinese automobile industry regulations by Chinese government. This regulation set out policy objectives and development priorities, product certification and industrial organization, industrial technology, investment and financing, foreign investment, import management, export management, and other domestic policies, industrial planning and project management. All of them gave guidance to Chinese automobile industry. Particularly in Chapter VI, the government for the first time clearly stated that it encouraged automobile enterprises to use foreign capital to develop Chinese automobile industry. This policy also led to the introduction of joint venture companies. In this automobile industry policy, the government also encouraged individuals to buy cars, and encouraged automobile companies establish their own sales system and after-sales service system in accordance with international principles and models. These provided more protection and power for individuals and enterprises.

In September 1995, Ninth Five-year plan proposed that automobile industry must focus on developing auto parts, economic cars and heavy vehicles by establishing a domestic technology development system.

In August 1996, General office of the State Planning Commission announced a notice to abolish the restrictions for economic cars. At the same time, the State Council promulgated that economical cars were the focal point in Chinese automobile industry, especially the small compact cars which had the features of low fuel consumption, small parking area and lower price so that they could be accepted by low income population at that time. Those policies greatly pushed the production and development of small cars market.

In August 1997, the Ministry of Internal Trade in China issued the car rental policy, which defined car rental method: the less provided services including automobile functions, taxes, and insurance, maintenance and parts services. This method let to the establishment of the first car rental company. Six carmakers were involved: FAW, Dongfeng, SAIC, Heavy Truck, Tianjing and Jinbei, as well as 17 distribution companies. At the same year, the network for national Taxi rental cars was set up in Beijing.

In the late-90s, automobile industry had become the star of Chinese industry. At that time, Chinese Automobile products already covered trucks, buses, cars, sport vehicles and other models from a single medium-sized truck.

In October 2000, Tenth Five-year plan was put forward to encourage the families to buy cars. From then on, Chinese huge automobile market was opened.

Until that time, Chinese automobile industry got the ability to develop fast. However, with the proposal of global environment protection, government policies turned to respond to this proposal recently. A series of policies enacted soon.

In January 10, 2001, China government introduced “Air Pollution Prevention Law”. Atmospheric pollutants must not exceed the prescribed discharge standards; this regulation also gave the specification for the vehicles emission standards.

Just one year after, General Customs Administration promulgated the notice to adjust the provisional tax rates.

To follow WTO commitments, from January 1, 2002, the government lowered car import tariffs for seven times. The tariffs on imported cars changed from 120% to 25%. This prompted the car import gradually.

In June 1, 2004, the National Development and Reform Commission promulgated “Automobile Industry Development Policy”. This policy guided automobile companies to merger and reorganize.

In October 1, 2004, defective auto recall regulations were implanted. This was the formal recall policy which was pioneered by Mitsubishi officially recall on February 14, 2001.

In April 1, 2005, Administration of Automobile Brands announced that automobile suppliers or their authorized distributors must use a unified store name, logo, and trademark to run automobile business. This policy clearly directed the trend of brand sales in the future.

In October 2005, Eleventh Five-year Plan was issued to encourage the production and use of energy-saving cars. In the following years, many new policies were again enacted which included new energy vehicles production, administration of auto financing companies, auto emission standards, new adjustment for consumption tax, reducing of the price for refined oil, etc. All these policies encouraged energy-saving automobile production and sales.

For protection of the environment, Chinese government also increased funding to support the updating of the cars, raised the subsidy levels and enlarged the scope of subsidies so that automobiles could be replaced fast. Also, Chinese government gave the necessary support to upgrade and improve the technological levels of recovery cars. All of these strongly pulled Chinese energy-saving cars' production and sales.

China automobile industry has gone through 60 years. Under the government's strong support, this industry keeps moving forward fast. Modular production helps auto production achieved great progress. Imitation speeds up the continuous updating of the products. Huge and growing domestic market and cheap labor are also the great advantages in the future. This industry in China will undoubtedly create new surprise to the world.

1.5 Outcome of the literature review

The history of the automobile industry is a history of management methods improvement. Each new method brought up a new overlord in the world. Europe was the origin of the automobiles with Craft manufacturing; the U.S. dominated this industry for more than half centuries by Mass production. Japan surpassed the U.S. and became the biggest

automaker in 1980s with a secret weapon of Lean production. In 2009, China stood on the top of this industry and became the largest auto producer. What brought up China again became the focus of the research in this field.

Chinese automobile industry experienced three development periods in 60 years. Socialism economy background led to special characteristics in different periods, more or less. However, the updated research of the automobile industry in this large emerging economy body is still not abundant. Some major and imperative research topics are still missing in literature, e.g., how the Lean production is practiced; if the Modular production is successful; if there is any new production method in China. The lack of these studies apparently hinders the understanding of the automobile industry in China, as well as this giant economy itself, especially for researchers outside of China.

Some of the above research topics are explored in this study. Four automobile companies are selected to represent different aspects of the automobile industry in China. The application of Lean production, Modular production, Imitation is investigated. Similar methodologies which were used by Womack are conducted here. All the collected data is analyzed and compared to those from Womack's study. However, the sample of four auto companies is too small to cover the entire Chinese automobile industry, although they can reflect most aspects of the general situation today. Further research with large samples is recommended in the future.

CHAPTER 2 METHODOLOGY

This study is focuses on Chinese automobile industry, specially the adoption and improvement of modern management methods. Mass production, Lean production, Modular production are investigated and compared. Case study is applied to find connections between Chinese companies with their oversea counterparts (Eisenhardt, 1989). Four companies are selected to represent Chinese automobile industry: Shanghai Volkswagen, Shanghai GM, Chongqing Changan Suzuki, and BYD Auto Company. The first three are joint venture companies, and the last one is a private company. Four cases can reflect the real situation of this industry in China.

2.1 Research methods

Womack and his term investigated 90 assembly plants in 150 countries, they compared Japanese automakers with the U.S. and Europe companies through five elements of Lean production: running the factory, coordinating the supply chain, dealing with customers, designing the car, and managing the lean enterprise (Womack, et al., 1990). In this study, however, only the first three will be investigated: the designing ability in Chinese automobile industry is still poor; and lean enterprise has not been well practiced, as they haven't developed much oversea market.

Currently used management methods in China are displayed and compared with the U.S. and Japanese companies in 1989. Although this comparison is not quite fair, the data can at least show at which level Chinese automobile industry is today.

Modular production was founded to be an important method in China. Outsourcing of supply chain was investigated in detail as a representative of this method. Some new management methods were introduced. Data from the above four companies are collected and analyzed. Imitation also emerged in Chinese automobile industry and will be discussed in this study.

2.2 Questionnaire development

For the technology sensitivity, the data used in this study mainly consists of questionnaire responses from employees in the four companies. The answers majorly came from three sections of the four companies: a) Assembly shop b) Department of procurement c) Department of sales. Seventeen items in assembly plant, ten items in the department of procurement, and three items in the department of sales were investigated. However, the questionnaire does not cover all the questions for different years and different management methods.

For the measurement units in some questions, we provide a brief conversion and explanation at the beginning of each survey, to easily compare with the U.S. and Japan companies.

2.3 Data collection

Data used in this study are collected from the four companies mentioned above. The items are the same as those in the book of “the machine that changed the world”. Data collection is either direct or indirect. In Shanghai Volkswagen, with a friendly engineer’s help, entering the assembly shop was possible and observing the production line became the reality. But visiting to the rest areas was unsuccessful. Hence all data was collected in the assembly shop and all questions were answered by engineers worked there. In Shanghai GM, the interview was done through visiting a senior manager in the company. However, some of the detailed data was not acquired from him, but from their web site. In Chongqing Changan Suzuki, the questions were answered through e-mail survey by a manager. For BYD automobile company, it was much harder to get the permission to visit their plant, and data was also collected by e-mailing an engineer, who helped to question her colleagues.

CHAPTER 3 CASE STUDY

Shanghai Volkswagen, Shanghai GM, Chongqing Changan Suzuki, and BYD Auto Company are selected to represent Chinese automobile industry. The first three are joint venture companies, and the last one is a private company. In these four cases, Shanghai Volkswagen is the first joint venture company after Deng's reform and opening. Shanghai GM is the largest one whose sales jumped to 1,000,000 units in China in 2010. Chongqing Changan Suzuki is the first Chinese-Japanese joint venture company. BYD Auto Company is a domestic automobile company and it is also the biggest and the most successful private company. Four cases can reflect the real situation of Chinese automobile industry today.

3.1Shanghai Volkswagen

Shanghai Volkswagen was established in 1984 and started its operation in 1985. It is a Sino-German joint venture Company with the investment ratio of 50%:50%. Chinese government helped and supported this joint with a goal to improve the automobile industrial level in China, by introducing capital and new technology from oversea. This proposed win-win strategy achieved remarkable achievements in short time. Today, Shanghai Volkswagen has four production bases: three locate in Shanghai Anting International Automobile City with total area of 3,330,000 square meters; the other is located in Nanjing with 635,000 square meters.

To 2009, Shanghai Volkswagen has the largest automobile production base in China. Based on its Volkswagen and Skoda brands, Shanghai Volkswagen now has SANTANA, PASSAT, POLO, TOURAN, LAVIDA, TIGUAN, and OCTAVIA, FABIA, HAORUI. Their products cover different market segments such as A0, A, B, SUV, etc. Total sales of all models in July 2008 and July 2009 are shown in Figure 10.

Historically, Shanghai Volkswagen broke through one million cars in 1998. Four years later, Shanghai Volkswagen realized two million cars' production. Soon, three million cars were made in 2005, and four million cars were coming off the assembly line in January 2008. Subsequently, in another 22 months, Shanghai Volkswagen reached five

million cars. Today, Shanghai Volkswagen is accelerating its sustained growth in production and sales. The time of exceeding a number of million cars is shown Figure 11.

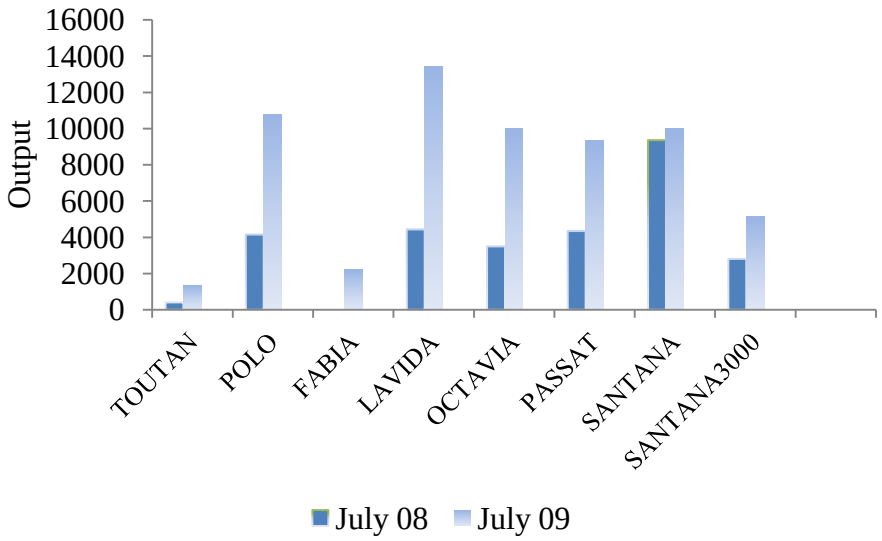

Figure 3.1 Shanghai Volkswagen total car sales

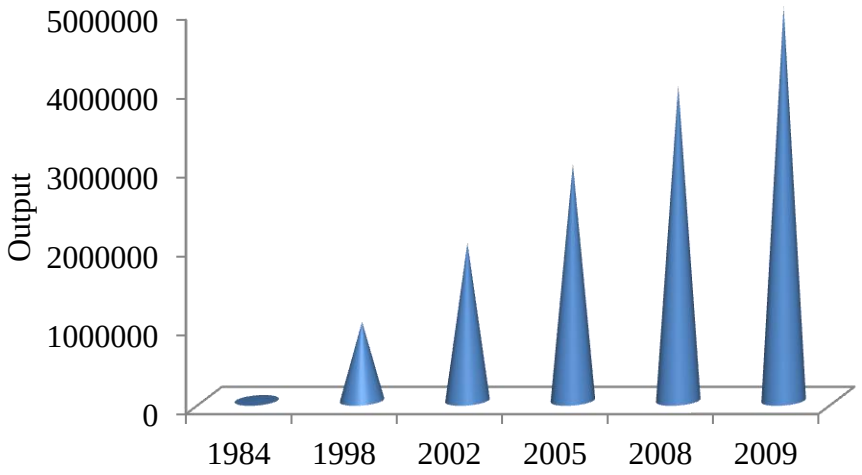

Figure 3.2 Car production of Shanghai Volkswagen in different years

Shanghai Volkswagen has also focused on the technical development. The company insists on using top level equipment and technology in the world, and continues to keep

them upgraded: advanced automated press line, advanced laser welding technology, a large number of welding robots, two-sides galvanized steel, advanced cavity wax injection machine, precise water honing system, automated production line, dynamic testing techniques, modular production line, and advanced laser testing equipment.

In addition, by following environmental standards, Shanghai Volkswagen effectively achieves "green production" and accomplishes the win-win prospect of economy and ecology.

3.1.1 Assembly shop

Shanghai Volkswagen is very sensitive to their technology exposure. However, with the help from a young engineer in the Engine Development Section in the R&D Center, our visit to the assembly shop became possible in January 2011.

This assembly shop belongs to the First Plant of Shanghai Volkswagen, which locates in the same area as its headquarters. The First Plant has been producing Santana since 1985, and was renovated and expanded in 2001. At the same year, a new compact car - POLO was created here. Now the First Plant can produce Fabia, Jingrui and POLO series flexibly in the same production line. Stamping, welding, painting and assembly shops are the four major production workshops in the first plant. The total area is 363,147 square meters.

An engineer who was a trainer for new workers in the assembly shop introduced us all their production lines. The shop was clean and well organized. The engine, transmission, front axle, front suspension were integrated into one module here. Modular chassis came from dollies, car bodies came from the other side, and all these were finally docked into the chassis. Basically no small parts were in sight. The only small parts were used for repairing purpose. Pre-installed modules, assembly line and assembly technology were the highlights of the shop. In this shop, there were totally 20 robots; they could automatically install all the mechanical parts and electrical circuits. They also had the most advanced tire screwing guns. Antifreeze, brake fluid, driving wheel fluid were automatically filled at one time; electrical functions were automatically tested; advanced

laser on-line testing equipment were also used; simulated rain storm testing technology and many other high technologies were fully adopted. Just as mentioned in their slogans: rigorous and careful management, the pursuit of excellence.

This assembly line is a pride of the company. They showed their pride not only on their public documents, but also on their employee's face. They didn't like to be compared to others; they were proud of their own enterprise spirit. However, their assembly shop was not the most advanced one in the world. The most surprise was that Lean production was not used in this shop. Another important thing was that there was much idle time in the assembly line. The workers were waiting for the coming module parts. These young workers looked much tedious. The employees did not know what was "five why". The questions for this study were gotten from this engineer, but he only knew a few.

3.1.2 Department of procurement

In this department, the most impressive thing was the modular parts existed everywhere. They called this a modular production line. When our visit was finished, a young engineer who worked in the Department of procurement gave a short introduction to their procurement process. It was noticed that Lean production was practiced well in this department. Enterprise Resource Planning (EPR), Electronic Data Interchange (EDI), and so on were their most popular tools during their work. However, the data could not be gotten from any single person, because each task belonged to a particular division. But the engineer said that their online procurement helped them save time and cut cost, so they did not have in-house divisions anymore. In addition, they adapted international globe procurements. In-site bidding and online bidding allowed them to choose the best bidders with high quality and low price.

Apparently Shanghai Volkswagen had the core competition of cooperation and success in this department. To achieve their goal, Shanghai Volkswagen had implemented a dynamic supply system which included eliminating the backward suppliers, introducing the potential suppliers, commending the outstanding suppliers and developing the reliable suppliers. They built the technology platform for the suppliers to allow them to participate in their workflow. This system also shared resources and information with

other departments to achieve other goals: first Shanghai Volkswagen started a new project to make the bidders competitive. Shanghai Volkswagen worked with the suppliers together and started from localization then to joint venture development. Soon they went into a new stage of modular development. Some major functional modules were finally included in this project: air conditioning system, exhaust system, seat system and so on. Second they established a forum for materials cost, so the cost problem could be solved creatively by optimizing the entire system. Last, they opened a project day when the suppliers could meet the customers and best understand their needs. Hence the suppliers not only focused on the parts, but also be concerned on creating the values for the final customers.

3.1.3 Department of sales

In this department, Shanghai Volkswagen dealed customers with Customer Relationship Management (CRM). They build connections between producers, dealers and customers. With more and more international cars coming into China, new models must bring impressive impact to the customers; also new challenge must be faced under the world-wide competition. In this domain Shanghai Volkswagen had several practices:

In a traditional market, brand was the only key assets. Uniqueness of the brand could be found by customers, but the communication to the customers was done only by dealers. This communication was usually not tracked and analyzed by the producer. As the customers were crucial to the market, the dealers had to find the uniqueness of their demands, and then to create a unique service. But this was a way lacking the support from producers, and a closed loop was not formed: producers and customers were independent to each other. To form a closed loop, Shanghai Volkswagen practiced CRM in their sales department.

They first built a customer population and stimulated their purchasing intention by continuous communication. At the same time, a feedback mechanism was established to understand customers' intention and collect their information. In addition, during the different stages in customers' purchasing process, they provided the corresponding products and market information. All customers' information was then feedback to the

same database, and each customer had a unique lifetime files. With the gradually deepening communication, customers' information was getting into details. By aggregated analysis and data excavating, a system for market, products, customers, and sales was formed, which would guide Shanghai Volkswagen's new product planning and marketing strategy.

Shanghai Volkswagen CRM plan included two targeted groups: vehicle end-users and dealers. The end-users included potential buyers and existing owners; it was also divided into private, government and company users. Dealers were the connection between Shanghai Volkswagen and the end-users. All products from Shanghai Volkswagen could not be handed directly to the end-users, but must be sold through the dealers. The dealers actually were the first level customers to Shanghai Volkswagen.

To service these two groups, Shanghai Volkswagen built Customer Development Center (CDC) in 2002. Free service line could provide reply, record the complaints and feedback the customers' information on time. During this process, they discovered the purchasing intention of the potential customers and record their detailed information. They followed up the communication by giving more description and explanation to the interesting customers. At the same time, CDC was also responsible for verification of outgoing calls, updating customer information, collecting mail information, organizing marketing activities, and gathering price information. So far, CDC in Shanghai Volkswagen had a total of 70 persons to accomplish their work. In addition, they built a network for dealers and consumers to develop their relationship.

Internet was another communication platform between Shanghai Volkswagen and their dealers. Dealers could get the customers' information developed and maintained by CDC. At the same time, dealers needed to feedback potential customers' information to CDC. Then CDC developed communication according to different situations to promote sales. Once a successful sale was done, the dealer was also obliged to feedback the customer and vehicle's information to CDC. Moreover, the most prominent feature in this network was the online training which could provide detailed product information, compare rival models and sales skills to help dealers understand the products and market better. In

addition, market activities of various models, the latest advertising documents and sales policies could be queried and downloaded here. The dealer could even point to the sale platform to order the promotional materials and gifts online. However, the dealers were required to feedback all information about their showroom and other activities to the workflow, so that Shanghai Volkswagen could conduct necessary evaluation. From 2004, 396 dealers in Shanghai Volkswagen were connected to the internet and communicate with Shanghai Volkswagen in a daily base.

Consumer network included potential customers and existing owners. For potential customers, Shanghai Volkswagen created a website showing all their models, so that customers who had purchasing intention could easily check the product information and download the products' images. Shanghai Volkswagen took full advantage of interactive media; they created beautiful product manuals in each site. The potential customers could virtually operate and enjoy the driving pleasure, thus the desire for buying was stimulated. On this basis, the site would further invite customers to register their personal information and online purchase intentions for CDC. This information would be introduced to dealers who want to develop ordinary customers into potential customers.

For existing owners, the website was their club and their loyalty program channel. Existing owners could update their contact details and easily check all the information about their own car, so that they could refer to their friends. Also they could check their current club location to change gifts. Shanghai Volkswagen also requires all their suppliers to join their loyalty program; hence owners could enjoy their articles online such as car refrigerator, child safety seat and so on. Meanwhile, owners could learn about the latest club activities, services benefits and other information. CRM in Shanghai Volkswagen also included customer information management and customer relationship management. Its customer service center had set many communication tools such as telephone, direct mail, fax, email, short messaging service and internet. This system combined with the dealers' network and forms a consolidation marketing framework.

Moreover, Shanghai Volkswagen had first launched "Techcare". This was a great service which integrates pre-sales and after-sales in the automobile industry. Under this service,

the customers could enjoy all service including buying, using, changing and welting the car. Shanghai Volkswagen hence realized a new industrial benchmark of service.

3.2 Shanghai GM

Shanghai GM was built in 1997. It was derived from Shanghai Automobile Industry INC. and the U.S. GM. The total investment was 1.52 billion US dollars. Each of them has 50% share. Shanghai GM posed three major production bases in Shanghai Pudong Jingqiao, Shandong yantai Dongyue, and Jiling Shenyang Beisheng. There were total four vehicle production plants. Shanghai Pudong Jingqiao located in Shanghai Pudong Economic Development Zone with an area of 550,000 square meters.

Shanghai GM could produce Buick, Chevrolet, Cadillac and SAAB brands and other twenty products. It was the first one to realize flexible production line in China. In the Shanghai base, there were stamping, body, paint, and assembly plants. Shanghai GM used the most advanced car production line, equipment, and modular design. Flexible production line not only produced multiple models, but also meets the diverse needs from the customers including the sales, service and parts. They also implemented single-level market sales strategy to drive marketing and brand management. User-oriented policy made Shanghai GM response rapidly to market change and user demand. In 2010, they produced 103 million cars, surpassed Shanghai Volkswagen's 100 million cars. Year to year growth was 42.8%.

In addition, Shanghai GM launched the "Green Future" strategy. The core of the strategy was to develop green products, built green system and took green responsibility. Through scientific and technological innovation, they brought green products of "better performance, lower power, less emissions" to Chinese consumers. Shanghai GM tried to play a leading role in business chain and created green industries for upstream and downstream ecosystems.

The key of success for Shanghai GM was their unique management - they executed General Manufacture System (GMS) by learning Lean production in a new way in all their supply chain. They implemented integrated management to divide their

responsibility, utilized Milk Run to optimize the logistics. They developed CRM system to realize personalization service, and promoted green strategy to attract more suppliers.

3.2.1 GMS system

Shanghai GM was the only automobile company in China that practiced Lean production well. Together with flexible production, Shanghai GM formed its own Lean manufacturing system. This was a specific GMS. Standardization, total quality control, shortening the manufacturing cycle, and employee involvement were the four important and basic principles to run this system. These four principles complemented and promoted each other, and ultimately formed a virtuous circle. In fact, these principles in Shanghai GM were not only parts of their manufacturing system, but also the basic concepts from procurement to sales operations throughout all their production process.

1, Standardization

In the workplace, Shanghai GM implemented standardization which included designated placement, fixed working hours, standard operation, and use of visual markers. First, tools and materials were placed in the standard stations or positions where the workers could access them easily, so working time and waste of resources were minimized. Second, fixed working hours was carefully calculated to reduce unnecessary or no value time. Third, standard operation in the production process was performed to achieve standard products. Fourth, visual markers were used in operation which was similar to "traffic light": red to stop, yellow to slow, green to go. In terms of material labels, red is for the waste, yellow for the substandard, green for the qualified, gray for the products in line. In their workplace, they also took the red, yellow and green bins as prohibited (waste), postponed (pending), and released (pass) products. For the basic examination, there were also some simple colored blocks: red to be warned, yellow to be improved, green to be released. The adoption of these simple colors greatly improved the management efficiency.

2, Total quality control

In the GMS system, quality was created rather than tested out. Quality was every employee's responsibility. The essence of this idea was that the quality lies on the manufacturing process, not just in the final testing sector. This was an active prevention, not a passive testing in the last step. At any time if the mistake was made, it was too late to be corrected. For example, a completed inspection report has already been made before assembly shop, but it still needed to be submitted after the assembly line. The overall quality control was also the basic principle: "do not accept defects, do not manufacture defects, and do not allow defects pass". This principle was promoted on every station, whether it was a separate process or on the process for the next station. The customers from the next station did not accept the defects coming from the previous one. If the next station found any defective product, they had the right to not accept them. These principles were also used in all the supply chain. One simple example was that if in one step a screw was missed, this defective product would be sent to the yellow line, and red light would flash, siren would sound, and the whole production line would stop until a new screw was added. Or if a station had any problem that could not be solved, the workers could appeal for aid by rope or light, and the team leader or section chief should come immediately to help. The method of using the rope and light was a typical Toyota symbol. Although today's automatic machine had precise detection ability depending on the advanced IT system, but it was still not enough to prevent all defects. In Shanghai GM, quality concept was in every employee's mind deeply.

3, Shortening manufacturing cycle

Manufacturing cycle was a process from receiving customers' orders until delivering the final products to them. Shortening manufacturing cycle depended mainly on logistics and integration management, not on cutting the production line. This was because the production sector had little to be shortened as for technology and quality reasons. Logistics management for workshop materials was mainly through Kanban, re-packaging, address distribution, etc. Kanban and e-Kanban greatly reduce inventory. CKD distribution refered to the parts shipped from oversea by containers, then re-packed, sent to the domestic suppliers' warehouses, and finally to the production site.

The so-called integrated management was a more efficient and professional method in the core businesses system. They thought that limited resources must be concentrated on high value-added process running on the core business. Shanghai GM was the first enterprise in China adopting integrated management to achieve overall efficiency. This system separated all non-core business to supply companies, so that Shanghai GM only focused on automobile production, hence to reduce cost and improve competition ability.

4, Employee involvement

The most important elements in an enterprise were the people. Shanghai GM promoted the concept of employee involvement, and constantly inspired the employees to participate, while delegated power to them at the same time. Promoting employee's participation could not only encourage individual initiative, but also create a team to participate in the realization of the company's objective. In Shanghai GM's workshop, there was an area for each work group to take break. In this place, there were papers and boxes to collect the rationalization proposals. Each proposal adopted by the company would get material and spiritual rewards. Shanghai GM now had 88% employees who participated in the activity. However, Shanghai GM mostly emphasize on the employee's safety. For example, when a fire was happening in the factory, the workers did not advocate senseless sacrifice to preserve the company's property, but should take the right steps and promptly notify the fire departments and help them to extinguish the fire.

Flexible concept was also reflected in the employee's training. Its purpose was to enable employees to be eligible in different positions and grasp more skills. The workers were not isolated in each station; they could easily change their positions in the production plants.

3.2.2 Supply chain optimization

Shanghai GM was a typical manufacturing enterprise; they needed more than 5400 parts for all auto models. Shanghai GM had 180 domestic and foreign suppliers including two import bases in North America and Brazil. In order to reduce the inventory and

transportation costs, Shanghai GM launched the Leading Logistics Management (LLM) project. This particular plan was divided into two steps:

1, Analyze the vendors' sites and cargo capacity to optimize transport routes. Modeling software was used to develop the online analysis. Shanghai GM took all the domestic suppliers' locations and cargo volumes. Currently, 80% suppliers in Shanghai GM were located in the suburb of Shanghai; a small number of suppliers were located in Jiangsu and Zhejiang province. Some suppliers produced very large parts; they should directly deliver their parts to the factory; while others supplied smaller parts and need to be integrated in their network.

2, Optimize the truck load by getting through a system: three-dimensional truck cargo load optimization system, which was a very technical one for lower transport costs. It could also be carried out by software. In addition, Milk run was also a critical method for cost saving.

Milk run was a transportation mode under the pre-designed pickup line, in sequence from suppliers A, B, C to pick up their parts and finally send them to auto makers or parts Redistribution centers (RDC). It was operated in a fixed time every day. Trucks started from the manufacturing plant or distribution center to the first supplier to get the parts or raw materials, and then followed the pre-designed route to the second, the third and so on, until all materials were picked up. This eliminates the waste of returning empty trucks by each supplier. Meanwhile, parts and materials could be supplied timely; suppliers who had little goods do not need to wait until the truck was filled.

In China, Shanghai GM was one of the earliest auto makers who adopted Milk run as a supplying operation. Instead of delivering parts by the suppliers themselves, logistics companies were used by signing contracts based on customer plant MRP. This could improve vehicles' loading rate, greatly reduced the travel distance and the number of returning empty trucks. This also effectively reduced the cost of suppliers' delivery and increases their agility and flexibility. From March 2003, Shanghai GM began to implement Milk run, and parts transportation costs savings were 3 million Yuan a year from then on, a decrease of 30%.

3.2.3 CRM system

Shanghai GM had 510 dealers in China. These dealers were called 4S shops, which were "four-in-one" including vehicle sales (Sale), spare parts (Spare part), after-sales service (Service), and feedback (Survey). It was gradually introduced to China by the European exporters from 1998 and now was the core of the automobile franchise mode, because of its close relationship between the production and marketing, along with the beautiful shopping environment, brand awareness and strong advantages. Their averaged sale was 2300 cars per year, including face to face sale and internet sale. The service of pre-sale, during the sale, and post-sale was getting stronger with the help of internet. Each customer could choose and buy their own favorite car online, and they could also make their own personalized choose, such as configuration, color, and place where they wanted to pick up the car. Moreover, the order from internet would be formed automatically into a production instruction by the system, then came into the flexible production line. At last, under the control of this system, this personalized car booked from internet would be delivered to customers perfectly on time. Another highlight was that customer could check the situation of their car in this system, whatever in the production line, in painting, or on the way of delivery, as they were using Customer Relationship Management system (CRM). IBM helped them create this system in 2002, so that the market competitive capacity in Shanghai Volkswagen could be gradually enhanced.

In the implementation of CRM, their focus was the customer life cycle, which concentrated on the potential customer development process (Lead generation), the potential customer management process (Lead management), and the customer loyalty programs (Owner retention). The emphasis was the customers' information exchange and management, which was a question of how to break the customer information into useful pieces.

First, CRM system took customers' information to explore existed problems. They subdivided the customers by data mining tools to analyze the services, response, customer satisfaction, loyalty and profit contribution, in order to effectively acquire customers and retain them.

Second, CRM deepened the process by feed-backing to the customers through advertising, promotion, cooperation activities, direct mail and other means to expand the customers list. Next step was to screen customers and further classify them for “potential customer management”. They developed a classification method for screening which was combined with the current computer system. This system applied not only to the existed customers, but also to the potential customers.

Third, CRM system enhanced interaction with the customers. Shanghai GM not only provided overall management information to the external world, but also increased the company’s sales through the interaction. Feedback from the leading distributors was also displayed. By this way, Shanghai GM achieved a customer loyalty index of more than 60%, which mean that 60% customers would buy General Motors again and also would introduce GM to their friends.

3.2.4 Green strategy

For Shanghai General Motors, green strategy was a systematic project through the complete business chain. In their suppliers’ selection, Shanghai GM and non-profit international organization "World Environment Center (WEC)” co-operated and made green criteria for suppliers’ selection. They also provided specialized training to encourage suppliers to achieve “clean production, energy conservation”.

Also, Shanghai GM made a request to the suppliers to save energy. For different suppliers, the request was different. The supplier’s plant, equipment, production sites, standardized process were all green-evaluated to help them improve technology, reduce energy and raw materials consumption. They gave the award to the top 10 supplies to encourage their participation.

Moreover, Shanghai GM proposed Green Future strategy. To realize their goals - better performance, lower power, less emissions, they launched new generations of green products series. Shanghai GM’s 20 models ranked first in the joint venture companies in China. This fully demonstrated the great achievement of green product strategy.

Shanghai GM “Green Future” strategy also looked into the future. They were imagining a better life by 2030, and announced the 2011-2015 “Green Future” strategic plan. In the next five years, Shanghai GM would launch 12 high-performances, low-emission engines, which would concentrate on the 1.2L-2.5L range. By 2015 the overall fuel consumption and carbon emissions would be reduced by 15% based on the current situation. At the same time, electric, hybrid, plug-in hybrid vehicles’ research and development were also included in this plan.

3.3 Chongqing Changan Suzuki

Chongqing Changan Suzuki was founded in June 1993. It is a quartet holding company: Chongqing Changan Automobile Co., Ltd holds 51%; Japan Suzuki Corporation holds 25%; Japan Sojitz Corporation holds 14%; and Suzuki (China) Investment Co. Ltd holds the rest 10%.

As a large automobile manufacturer, Chongqing Changan Suzuki Company covers a plant area of about 287,000 square meters. It locates in Chongqing Banan district. It possesses Tianyu, Swift, Alto, Lingyang series with about 20 models.

In production organizing, they introduced Suzuki’s scientific management model. Lean Production was their eternal theme. JIT, Kaizen, VA, VE were fully implemented in their daily production. They emphasized on quality improvement and energy saving. They adhered to human-oriented and continuous improvement. Chongqing Changan Suzuki provided innovated, safe, energy saving and environmental friendly cars for Chinese customers.

Chongqing Changan Suzuki strictly followed Japanese production and management. Their 85% employees were trained in Japan. In 2002, Modular production line was practiced. From then on, their management and execution system were involved in all supply chain including EPR, supply chain, distribution system and production workshop. With more competitors joining in Chinese market, Chongqing Changan Suzuki continued to practice Lean production to increase competitive ability. With the development of information technology, they applied this on all supply chains.

1, Changan Suzuki cooperated with the suppliers to release the supply arrangement plan which included three cycles. The first was the three-month long-term forecasts. The second is N*5 days of vehicles ordering program, which contained production model, color and numbers. These were also the days for delivery schedules. The third was an on-site pulling program. Changan Suzuki sent the data from production site to the nearest suppliers and asked them to deliver parts according to the order.

Currently their on-site pulling program mainly relied on JIT. In order to reduce the inventory cost, Changan Suzuki constantly optimizes their JIT plan. This plan included two kinds of parts: one was the closely integrated components such as bumpers and door handles; another was the large parts. Inventory time for these parts had been reduced to two hours per day.

In addition, Changan Suzuki introduced the plan of "supply chain optimization". They issued a delivery order, and all supplies or third-party warehousing companies must deliver according to this order. However, some trucks were unloaded, and the logistics cost would eventually be transformed into the parts' price. In order to change this situation, Changan Suzuki also practiced Milk Run Delivery Management system to help third-party warehousing companies reduce cost. Changan Suzuki realized the information transformation by JIT, so the arrangement and adjustment for the production plan could be done on a reasonable allocated time.

2, Changan Suzuki also put their attention to the customers' loyalty management. From 2004, Changan Suzuki began to focus on the customer management. At that time, the department of information technology applied on line sales system. They just wanted to get the information about their dealers' inventory. But these data was from the dealers only, and Changan Suzuki could not get a clear forecast for the customers. Meanwhile, the management for their 4S shops was still in a fuzzy state. In the assembly plant, after cars were sold to the users, the sale of spare parts had a great profit. Changan Suzuki expected more users to buy the same spare parts. But Changan Suzuki could not control the price of these spare parts.

To solve this problem, they developed a project called customer service system plan. They controlled the dealers' sale price in this plan. The picking up records and future marketing plans from 4S shops were also fed back to Changan Suzuki. Moreover, Changan Suzuki developed a set of standardized services, such as when the car should be maintained and when oil should be changed and so on. Department of customer service could quickly deal with customer complaints, and implement visiting back plan.

In 2008, Chongqing Changan Suzuki introduced Service-Oriented Architecture (SOA). This was the best way of connecting with the dealers. SOA was a new program that could provide the standard of different service modules.

3.4 BYD Auto Company

BYD (Build Your Dream) is a domestic enterprise in China. It was founded in 1995. At the beginning, they only had 20 employees. In just 15 years, BYD changed and developed rapidly into a world-class company of manufacturing IT facilities and electronic parts. In 2003, BYD became the world's second largest rechargeable battery maker. In the same year, BYD made the formal acquisition of Shaanxi Qinchuan auto company (in Xi'an) and build BYD Auto Co., Ltd., from where it entered the field of automobile manufacturing, and started to develop nationally-owned brand car.

BYD Auto adhered to the independent research and development, independent brand and models. They determined to revitalize the national automobile industry. At present, BYD has built Xi'an, Beijing, Shenzhen, and Shanghai industrial bases for auto manufacturing and mold development. Auto research and development have reached the internationally advanced level.

Modular production encouraged automobile companies to separate their parts manufacturing to the supplies. However, BYD started from retaking more parts production by themselves. Today, BYD has developed nine divisions, namely 11-19 divisions which are especially on vehicles production and auto parts production.

11th Division is an auto manufacturing division. Two auto production bases in Xi'an and Shenzhen are under this division. This division has 22,000 employees, five production plants including stamping, welding, painting, assembling, KD plant, and seven management sections such as general manager's office, human resource, and Department of planning, quality, cost, IE, and resource development.

12th Division is BYD's mold center. Its responsibility is inside and outside mold design and production, including circumference, fenders, large stamping dies, dashboard, bumper, lights, door handles and other accessories. In this Division, there are two production bases in Beijing and Shenzhen. The total number of employees is 1200. It has seven mold plants which can provide users full service with process analysis, structural design, solid casting, computer digital control. It can also produce all kinds of gages for assembly, sub-assembly and complex parts. Moreover, this division can accomplish the entire process including sub-module, designing, programming, planning, and testing.

13th Division is responsible for injection and light parts. It has four production plants. There are about 6600 employees here.

14th Division is the R&D center of core components for electric car. It owns an electric vehicle institute, a power plant, an electric plant, an electrical plant, a department for customer service, and a human resource. Currently, dual-mode electric car F3DM has been developed and it is the first one in the world. E6 also gets widely praise by customers.

15th Division is the electronic base including research, development and production. It locates in Xi'an and Shenzhen industrial parks. It has 11,000 employees. In this division, there are air conditionings, wiring harness, seat belt, instrumentation, multimedia, airbag, switching, etc.

16th Division is one of the most important divisions. It focuses on auto R&D, and production as well. It has 500 engineers in the R&D team. The products cover auto accessories, steering machine, transmission, suspension, braking, seat, etc. Also this division is responsible for welding, painting, and final assembly. Lots of factories belong

to this division including those make chair, brake, muffler, frame, suspension, sunroof, process equipment, structural parts, wheels, axles, drive shaft, etc.

17th Division has 8970 employees. The main production bases are located in Shenzhen, Xi'an, Huizhou and Changsha. They are R&D and production bases of engines and transmissions. The products series include BYD371Q, BYD473Q, BYD483Q, BYD488Q, BYD5T09, BYD5T19, BYD5RT10, BYD5RT14, BYD6T25, BYD6DT25, and BYD6DT35. These have been successfully carried on F0, F3, G3, L3, F6, M6, S6, S8 models.

Located in Huizhou and Xi'an, 18th Division has 2600 employees. In this division, there are rubber plant, plastic plant, surface decoration plant and other five management departments. They produce rubber, trim, rubber parts, hose, mounting, plastic particles, damping plate, brakes, IT coating, electroplating products, antifreeze, etc.

In July 14, 2009 BYD established the 19th Division. BYD purchased Sanxiang autobus plant and built a new-energy bus production base. In this division, they mainly engage in R&D and production of passenger vehicles, especially buses. This is another major development in the new energy field. It has departments of production, planning, technology, quality, equipment, procurement, cost, and human resource.

Among them, BYD Xi'an is in the leading level of car production. Its total production capacity is 200,000 cars per year. F3 and F3R are made in this plant. 'Motor City' in Shenzhen is a more modern one, with a total capacity of 300,000 cars. It is completing the second R&D center and will become an advanced auto production base. Beijing mold manufacturing center has gained the reputation of specialized, large-scale pattern in the molding industry.

In 2006, BYD Group reached a sales income of 12.9 billion Yuan, an increase of 101% from the previous year. Automobile industry also achieved a remarkable level, the main model of F3 car reached a sale of 63,153, an increase of 472%. Sales revenue is nearly 50 billion Yuan. F3 has also been exported for more than 5,000 to 16 countries and regions.

Since 2007, BYD F3 consecutively monthly sales have broken through one million. From May 2006 to June 2007, 100,000 vehicles left the assembly line. In just 14 months, BYD F3 got through the second threshold of survival for a mid-size sedan, and from June 2007 to June 2008, BYD F3 in 12 months created the miracle sales of 100,000. As "Speed King," BYD became the first one within Chinese owned brands auto makers.

In July 2007, BYD F3R - another midsize sedan hit the national market with extraordinary power, ultra-safe, and cool hatchback shape leading the new fashion. It sets off a new hatchback car sales storm in Chinese market.

In March 18, 2008 BYD F6 sedan appeared in the high level business car market. The impact of self-owned brands, high class car market started. By then, BYD Auto already had F6, F3, F3R, F0, F8, DM dual-mode electric vehicles in the market. Their production capacity is 800,000 units. So far BYD Group has formed seven million square meters of industrial areas and becomes the top one within the self-owned brand car markers in China.

It is worthy to mention that most BYD models come from imitation of others' technology. BYD F0 imitated Toyota Aygo. The front face of BYD F3 and BYD F3DM imitated Toyota Corolla; their rears imitated Honda City. BYD F3-R imitated Buick Excelle. The front face of BYD F8 (S8) imitated Benz SL500; their rear imitated Renault Megane CC. BYD F5 imitated Toyota Corolla. BYD G3 imitated Lexus ES350. BYD S6 imitated Lexus RX400. BYD T6 imitated Porsche Cayenne S. BYD M6 imitated Toyota Previa. The exterior of these cars are almost the same as the prototypes, but the interior materials are obviously cheaper. For example, F3 uses an engine of 1.5L Mitsubishi 4G15S, and the transmission is a manual D16. This combination is one of the most common auto power portfolios. Its advantage lies in its cheap but mature technology, economic and convenient maintenance. The power is enough for urban transportation. The highlight of F3 is its diverse configuration, including dual sunroof, anti-static antenna, decorative wood control center, console armrest, leather seats, luxurious multi-function steering wheel and so on. Although a large number of customers complain about its workmanship, many are still conquered by its cool appearance and low price.

In addition, BYD uses Modular production in the design, production and outsourcing. As its IT background, BYD has deeper understanding of Modular production. They think that the pronouncements of changing car body should be the same as changing shells of cell phone. This is a kind of Modular production. Even if BYD does not have the most advanced equipments, new management concept has already been reflected in their production.

First, BYD has a special production model that is called "vertical integration". The most important content of the model is integration, which means BYD try to master auto parts production as more as possible. Thus their downstream industry cannot be constrained. This model solves the biggest problem in Modular production – standardization and centralization of different parts. "Vertical integration" also includes upstream mold development and R&D research, which BYD already possessed. This model has brought much advantage to BYD in terms of cost and quality control.

Second, BYD has already been successful in IT industry. IT industry is an industry of precision manufacturing. So BYD owns lots of production experience in precision manufacturing. Because of the application of precision manufacturing technology, Modular production was originally developed in IT field. No doubt, grasping this technology and production experience is another advantage of BYD.

Third, BYD has advanced consciousness in their international business. BYD electric cars are going forward in China, and are marching the world market. They built several centers to develop and produce a variety of engines. In addition, BYD merged some small or collapsing companies. In 2010, BYD even acquired a Japanese mold factory.

Today, BYD has more than 40,000 employees worldwide, and a market value of more than 15 billion dollars. BYD Auto adheres to the international level, and committed to the development of fuel vehicles, electric vehicles and hybrid electric vehicles. BYD Auto continues to meet the customers' demand dependent on its distinctive technology and management methods. BYD is a leader in Chinese domestic automobile industry.

CHAPTER 4 RESULTS AND DISCUSSION

4.1 Data display and analysis

In this study, only the data from Shanghai Volkswagen was collected onsite. Others were all from indirect investigation, i.e., through phone, email, or internet. The details of assembly shop, department of procurement, and department of sales were analyzed and displayed for Shanghai Volkswagen. For other three companies, the final results were directly presented without detailed data analysis, while the method used was the same for all four companies.

4.1.1 Assembly shop

In the book "The machine that changed the world", Womack and his colleagues created 'box scores' to present the productivity and the accurate in assembly shop. In this study, we used the same method to compare the assembly shop of Shanghai Volkswagen in 2001 with Toyota Takaoka plant in 1989. We built 'box scores' to know how productive Shanghai Volkswagen was. However, we did not know the 'accurate' in this shop, which in Womack's book means 'the number of assembly defects in cars as subsequently reported by buyers', as no data was collected from customers in China. Also, all presented data were estimated values because the four companies were not performing the same task in their assembly shops. The calculation of gross assembly hours per car was to divide the number of hours worked by all employees by the number of vehicles produced. This data actually evaluated the effort of the employees in the assembly plant.

In the assembly shop of Shanghai Volkswagen, the production rate was 32 cars/h. 170000 cars were produced in 2010 and 2000 employees' were working there at that time. However, the number of workers changed from month to month; hence all employees work hours were different from time to time. We took the averaged work days of 260, and 8 hours for each work day. So the worked hours by all employees were 2000*8*260/170000=24.47 h/car. This data was higher than Japanese's in 1989, which was 16.8 h/car.

The size of the assembly shop in Shanghai Volkswagen was 43760 m^2 (1 m^2 = 10.764 ft^2). For welding shop, we estimated that they had the similar area. So the space (sq.ft./vehicle/year) was 2*43760*10.764/170000=5.54. That was almost the same as Japanese's 5.7 in 1989. The size of repair area was 11.4 (% of assembly space), lower than the U.S. but higher than Japan in 1989.

The number of workers was 900, which was larger than Toyota's 238 in 1989. However, this number was fluctuating in different months depending on the overall productivity. For example, the number of workers was 800 in December 2010, instead of normal 900 mentioned above.

Only 20 robots were used in the assembly shop. An engineer who visited Japanese company said that automation in Chinese automobile companies was not practiced well as that in Japan. It was also mentioned that job rotation was not quite often because they only changed the workers who could study fast. Otherwise, that would be a waste of time. For the suggestion, not every employee would be questioned, but there were two meetings which were held before and after work every day to collect their suggestion, and each department had one communication conference every two weeks. This was not lower than that in Japanese's Lean production in 1989. The number of job classes was 6, lower than America and Japan in 1989.

Training a new worker costs 160 hours, only half of Toyota's training time. Shanghai Volkswagen did not spend much time in training new workers. When production plan was large, many workers or new workers would be called back. When production plan was small, some workers would be laid off. Some of them only got several hours' training; this was one of the reasons why the automobiles quality was not good in China. Also, automation for each shop was not exactly the same. The engineer gave the estimated data: in welding shop, it was about 90%; in painting shop, about 80%; in assembly shop, about 10%. The automation level in welding shop seemed not significantly different from the U.S. and Japan in 1989, but in painting and assembly shop, it was much higher than them. The engineer also showed their Kanban and e-kanban. E-kanban seemed to be not used very often.

During the subsequent three months, the data from the other three companies was collected through various ways, and are shown in Table 2, as well as the data from Japan and America. The productivity of Shanghai GM was 35cars/h, higher than Shanghai Volkswagen. In Chongqing Changan Suzuki it was 21cars/h, but BYD had the highest productivity of 100cars/h. Gross Assembly Hours per Car for Chongqing Changan Suzuki was 27.73, for BYD it was 41.6. Assembly space for Chongqing Changan Suzuki and BYD was 3.03 and 3.105 respectively. Size of repair area was 5 and 8.5 for these two, which was lower than Shanghai Volkswagen. The number of workers in Chongqing Changan Suzuki was 650, no large difference with Shanghai Volkswagen. However, BYD had much more workers, almost two times of Shanghai Volkswagen. Job rotation and classes for these two companies were the same as Shanghai Volkswagen. They all did not spend much time on workers' training.

Table 2 Survey data from the assembly shop

Company	Japan	America	SVW	SGM	Suzuki	BYD
Production rate (cars per hour)			32	35	21	100
Gross Assembly Hours per Car	16.8	25.1	24.47		27.73	41.6
Assembly Space (sq.ft./vehicle/year)	5.7	7.8	5.54		3.03	3.105
Repair Rate			5%		5%	2%
Size of Repair Area (% of assembly space)	4.1	12.9	11.4		5	8.5
Number of Workers	238		800-900		650	1800

Job Rotation (0=none, 4=frequent)	3	0.9	2	2	4
Number of job Classes	11.9	67.1	6	11	10-13-13
Training of New Production Workers (hours)	380.3	46.4	160	40	168
Production Models/month				27	6
Flexible Production Line			3-4	2	4
Technical Requirement			Training school	Training school	none
Suggestions/Employee	61.4	0.4	50		0
Absenteeism	5	11.7	0	0	0
Stamping (% of direct steps)			80	45	50
Welding （% of direct steps）	86.2	76.2	90		80
Painting （% of direct steps）	54.6	33.6	80		40
Assembly（% of direct steps）	1.7	1.2	10		40

*Data for Japanese and the U.S. are in 1989; Data for Chinese companies are in 2010

The above data showed that “running a factory” in Lean production was not practiced well in Chinese automobile companies; the layout in the assembly shop was the same as or less than Japan in 1989. The automation level was lower than Japan today. But the productivity was unusually high, especially in BYD Auto Company. This had already been pointed out by Womack in his book.

In China, cheaper labors were still playing important roles. Although some private automobile companies were built later than joint venture companies, they did not use new and advanced equipments. Chinese automobile companies intended to use more workers than machines, although the workers were the critical point in Lean production.

4.1.2 Department of procurement

With the data from the departments of procurement in all four companies, a survey was made and shown in Table 3.

In this department, Die change time in Shanghai Volkswagen was 20 minutes, longer than Japanese but shorter than American in 1989. The machines per worker were 4, more than Japanese in 1989. The inventory level was 6 days, which was longer than Japan’s 1.5 days but shorter than America’s 8.1 days. But engineering carried out by suppliers was more than 90%. Compared with Toyota’s 51%, Shanghai Volkswagen realized the modular parts outsourcing successfully. However, Shanghai Volkswagen did not have the data for parts defects.

Number of suppliers was 320 for Shanghai Volkswagen and 250 for Chongqing Changan Suzuki, more than Japanese in 1989. For Engineering carried out by suppliers (%), three joint venture companies all realized their outsourcing. However, a big surprise was BYD. While other companies tried to use more suppliers to reduce their in-house assembly, BYD was reducing this number fast. Now it only had 8 suppliers, and only 4% parts was produced by the suppliers. This difference is shown in Figure 12, 13 and will be discussed later.

Table 3 Survey data from the department of procurement

Company	Japan	America	SVW	SGM	Suzuki	BYD
Die change times (minutes)	7.9	114.3	20		8	3-4
Machines per worker	7.4	2.5	4		3	3-4
Inventory levels (days)	1.5	8.1	6		7	2
Engineering carried out by suppliers (% total hours)	51	14	90		83	4
Number of suppliers per assembly plant	170	509	320		250	8
Proportion of parts delivered just-in-time (%)	45	14.8	80		50	90
Proportion of parts single sourced (%)	12.1	69.3	80		60	85
Inventory level (days, for 8 parts)	0.2	2.9	0		10	0
Market shares in China (%)			19	20.1	2.2	28.9

*Data for Japanese and the U.S. are in 1989; Data for Chinese companies are in 2010

Proportion of parts delivered just-in-time (%) was 80 for Shanghai Volkswagen, much higher than Japan's 45 in 1989. Proportion of parts single sourced (%) was 80 for Shanghai Volkswagen, still higher than Japan's 12.1. For Chongqing Changan Suzuki and BYD, these data were close to that of Shanghai Volkswagen. For inventory level of 8

parts, Shanghai Volkswagen and BYD had reached zero. However, Chongqing Changan Suzuki was still in a high 10 days.

In this department, the total inventory level was higher than Japan in 1989. Engineering carried out by suppliers (%) was also higher. Three joint venture companies realized their outsourcing very well. Their suppliers made most parts, and their plants focused on assembly process. Most Chinese suppliers built their plants beside auto companies and tried to reach JIT delivery.

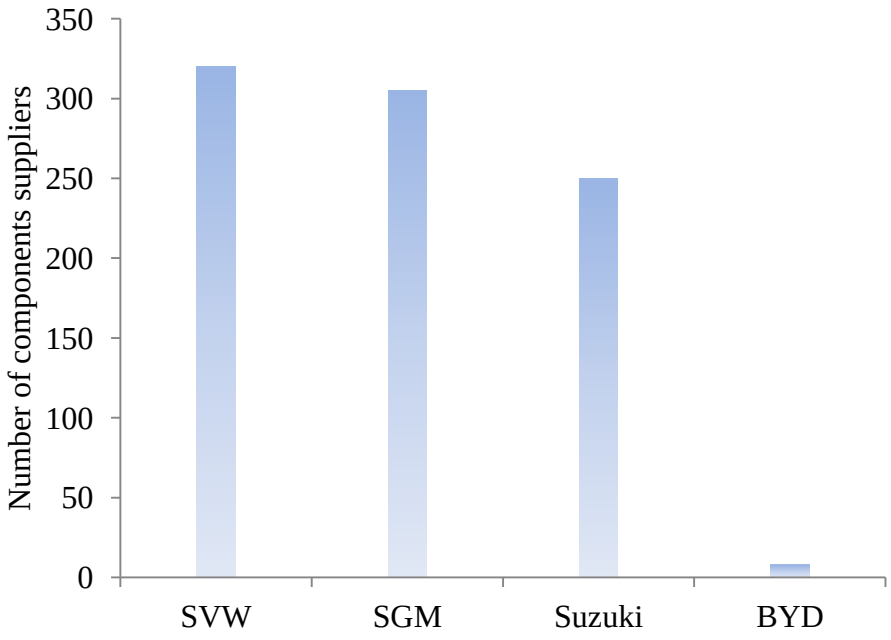

Figure 4.1 Number of components suppliers in 2010 for four representative companies

Figure 4.2 Engineering carried out by suppliers in 2010 for four representative companies

4.1.3 Department of sales

The number of dealers in Chinese companies was much less than that in the U.S. and Japan in 1989. Car producer and dealers were connected much closely here. Sales volume of each dealer was much more than that in the U.S. and Japan in 1989, except Chongqing Changan Suzuki. With the data from the departments of sales in all companies, a survey was made and shown in Table 4.

Only a few Chinese automobile companies exceeded the sales quantity of 1 million cars in a year, most others were still in small scales. However, the total volume was much larger than that in Japan in 1989. As presented previously, Modular production, imitation and IT helped Chinese automobile industry realized great leap, which will be further discussed in the following sections.

Table 4 Survey data from the department of sales

Company	Japan	America	SVW	SGM	Suzuki	BYD
Sales in 2010			800000	1030000	200000	800000
Number of dealers	1621	16300	497	510	1020	1000
Car sales per dealer	222	393	2300	2020	197	800

*Data for Japanese and the U.S. are in 1989; Data for Chinese companies are in 2010

4.2 What's more

1，In the book "The machine that changed the world", the author pointed out that there were poor producer, worse quality but very high productivity in developing countries. It is very true in today's China. In this survey, Chinese private companies were found to have higher productivity but poor quality.

2, In the late 1980s, Lean production had been proved to be a feasible way to improve the productivity and cut the cost. However, until today, Lean production has not yet been practiced well in China. The U.S. and Japanese joint venture companies' practice of Lean production was the best and has their own ways. Other companies such as European joint venture companies also introduced and implemented Lean production, but in Chinese domestic enterprises, Lean production was poorly practiced.

3, Another surprise was the number of workers. In the book "The machine that changed the world", Lean production defeated Mass production by reducing the number of workers. But in China, the number of workers was 4 times of Toyota's. This might be explained as the high cost of labors in the developed countries, where they must find some ways to reduce the workers as much as possible to cut the cost. In China, labors are still cheap and their overtime work is almost free.

4, In these investigations, the department of R&D was not mentioned, as this is a secret for every company. Fortunately, the young engineer who accompanied us was working in the department of R&D in Shanghai Volkswagen. She was a member of the engine research group. Even though she did not know many details about our questions, she said that the level of R&D in Shanghai Volkswagen was still very low from her opinion. The number of all Models was 7, and their own brand was only LAVIDA, with all design still coming from Germany. The agreement of joint-venture companies was that Chinese partner was not allowed to participate in car design.

5, Lean production was practiced better in Shanghai GM than in Shanghai Volkswagen. Japanese joint venture companies were also good executors. Shanghai GM surpassed Shanghai Volkswagen in short 13 years. This phenomenon indicated that Lean production was still a good management method, although in China it was difficult to practice. This will be discussed later.

6, Surprising findings were within Chinese private automobile companies. In only 13 years, the market shares of self-owned brands were 28.22% (Figure 8). BYD is on the top of them, which occupies 28.9% market shares. In short 8 years, BYD becomes the top one of private carmakers. When many companies are trying to transfer parts' manufacturing to suppliers, BYD tries to produce everything by themselves. Another successful point of BYD is the imitation from Japanese models. Their new models are mostly copied from Toyota and Honda. This imitation helps them realize fast development without taking much detour. Moreover, a large amount of cheap labors are used. They divide the production line into single steps which can be easily operated by labors. This approach not only solves the production problems, but also saves a lot of money. They utilize Chinese rich and cheap labor resources to reduce the cost and improve their competition.

4.3 Discussion

In the development of Chinese automobile industry, Mass production was not brought in because of historical reason. Lean production was still new and needed to be improved.

Modular production realized great leap for automobile productivity and reduced the cost. Imitation helped new automobile products emerge promptly.

4.3.1 Lean production in China

Interfered by the planned economy, Mass production was not introduced into China. Although Lean production has been spread in developed countries since 1980s, it is still new for Chinese, especially for those domestic automobile companies.

Lean production not only made Japan automobile industry achieved great leap in 1960s and 1970s, but also let the U.S. companies catch up with Japanese by learning this method in 1990s. Hence it is known as 'The machine that changed the world'. However, in China until now, only Shanghai GM is a good learner. Chinese domestic car producers are still in their early step of adopting Lean production, and effective practice is rare.

A typical example is FAW. In 1978, FAW sent some people to learn Lean production in Toyota, then invited Taiichi Ohno to give lectures about Toyota production system in their factory. Soon FAW launched a pilot production line. At that moment, FAW set off a wave of learning Lean production. But later Lean production disappeared. In 1990, FAW transmission shop introduced LF06S line, Lean production was reintroduced. This time the productivity was significantly improved. But Lean production had not been spread widely. In 2002, FAW specially set off a leading group to Japan to continually learn Lean production again. However, today FAW is still in the learning stage without much improvement (Sheng, 2007).

Is Lean production in China really hard to be practiced? Actually, Womack and his colleagues had already concluded that good executing of Lean production should have their own innovation rather than blindly cling to traditional ways. Why could Lean production not be sustained or successful in China? Professor Ershi Qi in Tianjin University, in his speech of "Lean production in China", concluded that Lean production has a unique set of techniques, such as Kanban, JIT, standard operation, etc. Also Lean production requires the workers achieve the detailed tasks, and the base philosophy of continue improvement must be persisted. This method also requires maximization of

eliminating visible and invisible waste. However, in actual practice in China, many companies only copy some pieces of this method such as Kanban, TQC, MRII, etc., and the essence of this method is neglected.

Lean production in Toyota is not only a management system, but also a full participation, thinking and continuous improvement. Lean production is the micro-organization in the workshop production and a manufacturing model. Professor Qi thinks that Chinese enterprises are not in the same management level as western and Japanese enterprises. So the application of advanced management system in China cannot be copied in the same way. At the same time, even if Lean production is strongly advocated in technology field, latecomer is unrealistic to reach the same high level in management field.

According to this thought, Lean production is an idea and a concept. It is not a line or product that can be copied. Different enterprises should have different models. However, there are still two possible ways to implement Lean production in China: first is the leader's strong support, which is crucial in China; second is the interdisciplinary cooperation. Successful implementation of Lean production relies not only on inter-departmental cooperation, but also on collaboration with suppliers, market forecasters and inventory managers. Therefore, a successful supply chain management is also the key to implement Lean production.

4.3.2 Modular production in China

Modular production actually was applied in developed countries first. The automakers in these developed countries used many modules including cockpit modules, rear axle modules, and door modules which were made by their suppliers oversea, and sent directly to the final assembly line. Western automakers performed outsourcing well because they wanted to lower the labor cost, reduce the investment and risk, and cut the first-tier suppliers (Takeishi & Fujimoto, 2001). However, with the development of modular supply, auto parts purchasing system became complex and some problems arise, especially the loose structure of the supply chain. Suppliers and manufacturers could not coordinate well in some fields. Auto production plants focused on their own interests, not on the suppliers'. They wanted to ensure adequate parts in inventory to stabilize the

continuity of production. Hence, manufacturers' difficulty had been transferred to their suppliers, whether in Lean production or Modular production. Suppliers had to increase their inventory to meet the supply requirement. This situation could not achieve the win-win strategy. The overall competitiveness of supply chain in automobile industry was getting weak. Under this structure, the suppliers' financial pressure was always high; they might lose the willing for new products development and efficiency improvements, and this might also affect the products' quality. In the end of 2009, Toyota required its suppliers to reduce 30% parts cost in the following three years. This fact might explain the recent quality problem in the "Toyota crisis" (Shang, 2010)

Modular production was not practiced perfectly in western countries. However, all joint venture companies in China, either from the U.S., Europe, Japan, or Korean, achieved unexpected success with Modular production. In the early 1980s, when first joint venture company was introduced into China, they started KD assembly immediately. This was one form of the Modular production. At that time, the concept of Modular production had not been introduced into China yet, except cockpit modules. Today Chinese not only use Modular production in production line and supply chain, but also in car design. Moreover, module concept has been expanded to auto sales. Car trading parks have been built in some cities. In those parks, some dealers only sell, some others only repair. But no matter in which shop, if they sell the same cars, customers can enjoy all service the same way as in a 4S shop. As a result, future dealers are not investing to build 4S shops, but rather to provide the whole process of sales and services by modular marketing concept.

4.3.3 New direction in China

Cheap labors still exist in China. This is one of the reasons why Lean production is not practiced well. This is also the reason why the assembly hours per car in all Chinese automakers are high. For this reason, when automobile companies in the developed countries try to utilize their suppliers, Chinese carmakers started to make auto parts all by themselves.

BYD is the most representative one. In the past few years, BYD brands are the hottest in China. It achieved breakthroughs in many points. However, its management model is

incompatible with Lean production, especially in workers and parts management (Tang & Peng, 2008).

Chuanfu Wang, BYD founder, is very good at low-cost innovation. Many of his ideas and practices are anti-traditional. For example, he hires a large number of workers to replace automated machines; he diversifies the company's business; he uses imitation to increase the competitive ability.

1, BYD does not use large-scale automated production equipments. In their production lines, numerous workers are used. Compared to frequent and large investment to permanent assets, an increase of workers is more flexible and acceptable. They fixed workers' positions in the lines to assemble the components efficiently, to improve the accuracy, and to ensure good quality. Different from others, BYD also split some assembly lines; each station does one specific task. Even some major works of the car production are done manually. They use robots only in the places where human cannot access.

2, After 1990s, the world's major automobile manufacturers tried to improve outsourcing in order to increase efficiency and reduce risk. However, BYD does the opposite way. According to Chuanfu Wang's statement, almost all ancillary parts such as shock absorbers, seats, lights, wipers, etc., can be produced partially or entirely by BYD itself. He also believes that a strong capacity in design and development of mold manufacturing is the key factor in modern manufacturing enterprises. This is an important way to achieve rapidly product conversion. In addition, introducing new materials and new technologies can help BYD shorten the production cycle, stable product quality and provide more various products.

3, Reverse development is a BYD-style imitation. The so-called "reverse development" is to dismantle similar products from other companies, learn them, and develop BYD's own products. By this way the cost can be saved up to one-third. In order to produce vehicles in the shortest time, BYD spent tens of millions Yuan every year to buy the newest models in the world. In Shenzhen BYD factory, cars can often be seen wearing a "trial" license like Mercedes-Benz, BMW, Lexus, Toyota, and Honda. BYD-style

imitation is different with other companies. They concentrate their limited resources on the high-quality products; they select the best-selling products; they save costs and control quality. In China, latecomers all adapt imitation, but BYD is the best among them.

However, automobile industry is going forward continuously. The biggest advantage of the machines is to guarantee the consistency of quality. Once the industry comes into the next stage such as electric vehicles and new energy, artificial advantage may no longer exist. Sooner or later, BYD will return to automatic road. Actually, BYD is already facing some troubles - patents problems. Imitation grasps the success quickly, but also be grasped by the lawsuits. In order to bypass intellectual property issues, BYD set up a team of hundreds people to study global patents, and also study non-patented technologies. They are trying integration and transformation of the patented techniques. At the same time, BYD begins to apply a large number of its own patents. In 2009, BYD became the third largest patent applicant in Shenzhen city.

From Mass production, Lean production to Modular production, Chinese domestic automobile companies are still in the initial learning stage. Lean production cannot be simply copied, it requires a combination of cooperated spirit, good habits, consumer attitudes and other factors. However, with the help of IT technology, Modular production is fast accepted and well practiced in China.

CONCLUSION

This study first reviewed the development of automobile industry in the world, and focused on Chinese automobile industry laterly. A large number of automakers coexist at the same time but only a few of them are in large scales. Up to date, almost all big automobile companies in the world have built their branches in China, but Chinese domestic companies are the fastest ones in terms of development and innovation.

The management and production level in China is still low. Mass production did not introduce in China because of history reason. Lean production has come into China 30 years ago, but not practiced well until today. Modular production is being spread fast in China, as it can shorten the manufacture process, reduce investment, and cut the cost. Information technology is playing more important role along with the time going. A new but special trend is that some private companies are using more workers instead of machines, which function is still in argument.

Chinese automobile market is much larger than any other country today, not only in manufacturing ability, but also in consumers' market. In one aspect, automobile industry still has much space to develop; but in another aspect, many serious problems may be hidden under this great prosperity.

The development of automobile industry in different countries has different characteristics because of their different economic basis and historic situation. The U.S. overcame Europe relying on Mass production; Europe regained overlord by outsourcing; Japan beat the U.S. and Europe with Lean production; China surpassed the U.S., Europe and Japan by Modular production, as well as cheap labors, imitation, and huge domestic market. Simple copy cannot achieve high and long-term development; only innovation can synchronize with the world's fast steps.

REFERENCE

Baldwin, C. Y., & Clark, K. B. (1997). Managing in an age of modularity. Harvard Business Review, 75(5), 84-93.

Bao, Y., Zhou, N., & Zhu, Z. (2005). The quality control and ascend system in flexible auto production line. Journal of Machinery, 32(11).

Bolton, M. K. (1993). Imitation versus innovation: lessons to be learned from the Japanese. Journal of organizational dynamics, 21(3), 30-45.

Boyer, R., Charron, E., Jürgens, U., & Tolliday, S. (1998). Between Imitation and Innovation. The Transfer and Hybridization of Productive Models in the International Automobile Industry. New York: Oxford University Press.

Center, C. A. T. R., & Association, C. A. I. (2009). Chinese Automotive Yearbook. Beijing.

Chen, Z. (2009). A brief history of China's Y-10: Imitation versus innovation. Journal of Technology in Society, 31, 414-418.

Chu, W. (1997). Globalization of the Korean Automobile Industry. , FY 97 IMVP working papers for International Motor Vehicle Program, Consult March 15, http://dspace.mit.edu/bitstream/handle/1721.1/1475/Imvp143a.pdf?sequence=1.

Coffey, F., Joseph Layden. (1998). American on wheels: The first 100 Years. 1896-1996.

Collins, R., Bechler, K., & Pires, S. (1997). Outsourcing in the Automotive Industry: From JIT to Modular Consortia. Journal of European Management, 15(5), 498-508.

Dai, A., Gao, X., & Xiao, J. (2009). Modularity-based Strategic Evolution Measure Model of Automobile Supply China. Journal of Science and Technology Management Research, 7.

Dankbaar, B. (1996). Technology management and public in the European Union. London: Oxford University Press.

Davis, M. M., Heineke, J., & Balakrishnan, J. (2007). Fundamental of operation management (2 ed.). Ryerson: McGraw-Hill.

Dolson, W., & Safarian, A. E. (2008). The transition from imitation to innovation: An enquiry into China's evolving institutes and firm capabilities. Journal of Asian Economics, 19, 301-311.

Dong, B. (2006). Study on the Development Problems of Chinese Automotive Industry.

Dosi, G. (1982). Technologic Paradigm and Technological Trajectories. Journal of Research Policy, 11, 147-162.

Eaton, J., & Kortum, S. (1999). International Technology Diffusion: Theory and Measurement. Journal of International Economic Review, 40(3), 537-570.

Eisenhardt, K. M. (1989). Building theory from case study research. Academy of Management Review, 14(4), 532-550.

Fu, Y. (2006). Some Thoughs about the Development of Automobile Industry. Journal of Automobile Practical Technology 1, 4-5.

Graziadio, T. (2003). Some Evidences of Technological Changes Associated to Modular Production and Supply, Consult in Jan, 2011. http://gerpisa.org/rencontre/9.rencontre/S05Graziadio.pdf.

Gu, L., & Xu, Q. (2006). Modularity of Products and Strategic Management of Technology and its Innovation of Enterprise,. Journal of Research and Development Management, 18(2).

Guo, W. (2009). Imitation to Innovation is the only Way to leap-forward development for Chinese Automotive Industry. Journal of East China Economic Management, 23(3).

Kerin, R. A., Varadarajan, P. R., & Peterson, R. A. (1992). First-mover advantage: A synthesis, conceptual framework, and research propositions. Journal of Marketing, 56(4), 33-52.

Kim, C., & Fujimoto, T. (1991). Product Development Performance: Strategy, Organization, and Management in the world Auto Industry. Boston: Harvard Business School Press.

Kim, L. (1997). Imitation to Innovation: The Dynamics of Korea's Technological Learning. Boston: MA: Harvard Business School Press.

Lai, M., & Bao, Q. (2003). Empirical Research on Technology Spillover Effects of Foreign Direct Investment in China. [Nature Science]. Journal of Hunan University, 30(4).

Li, L. (2008). Breakout-Door opens years. Shanghai: Central literature publishing house.

Li, W. (1997). The Impact of Economic Reform on the Performance of Chinese State Enterprise, 1980-1989. Journal of Political Economy, 105(5), 108-116.

Lin, Y., Cai, F., & Li, Z. (2002). China Miracle: Development Strategy and Economic Reform, . Shanghai: People's Publishing House.

Liu, D., & Zhao, Y. (2006). Ownership, Foreign Investment and Productivity- a Case Studt of Automotive Industry in China. Journal of Center for Economic Research (104).

Lu, F., & Mu, L. (2003). Local innovation, capacity development and competitive advantage: the Chinese laser disc player industry and its policy implication for the government role. Journal of Management(12), 57-82.

Ma, S. (2010). Imitation to Innovation: Insurmountable stage of small and medium enterprises in China. Journal of Ningbo University, 23(4).

May, G. S. (1990). The automotive industry. 1896-1920. New York.

Office, G. M. A. I. (1993). Tan Guangzhou shi ruhe fazhan jiaoche gongye Report on Guangzhou Municipality Auto Sector Development.

Pandremenos, J., Paralikas, J., Salonitis , K., & Chryssolouris, G. (2009). Modularity concepts for the automotive industry: A critical review, . Journal of CIRP Manufacturing Science and Technology, (1), 148-152.

Qiu, B., Yang, S., Xin, P., & Kirkulak, B. (2009). FDI technology spillover channels and total factor productivity growth in Chinese manufacturing research. Journal of southeast university Press.

Qu, G. (1994). Medium-sized car KD export logistics systems analysis, Chinese. Journal of automotive industry research (3).

Schaik, T. v., & Van de Klundert, T. (2010). Productivity growth and the labour market.

Schnaars, S. P. (1994). Managing imitation strategies: How late entrants seize marketing from pioneers. New York: The Free Press.

Shang, c. (2010). behind in the Toyota crisis. Fireign business, 01.

Shankar, V., Carpenter, G. S., & Krishnamurthi , L. (1998). Late mover advantage: How imitation late entrants outsell pioneers. Journal of Marketing Research, 35(1), 54-70.

Sheng, H. (2007). Why is hard to learn Toyota. China Logistics and Purchasing).(17), P 59-59.

Starr, M. K. (1965). Modular Production: a New Concept, . Harvard Business Review, 43(6), 131-142.

Sugiyama, Y., & Fujimoto, T. (2000). Product development for country specific vehicles in Asia: a dynamic view in global strategy.

Sun, C. (2002). New Characteristics of Product Life Period in Different Stages. Journal of Shenyang electric power institute, 4(1).

Takeishi, A., & Fujimoto, T. (2001). Modularization in the Auto Industry,: Interlinked Multiple Hierarchies of Product, Production, and Supplier systems.

Tang, Y., & Peng, L. (2008). BYD's success bring inspiration for SMEs Enterprise vitality 11.

Teresko, J. (2005). "It came from Japan," Industry Week 254(2), 49-50.

Thun, E. (2004). Keeping up with the Jones': decentralization, policy imitation, and industrial development in China. World development Press, 38(2).

Tsukune, H., Tsukamoto, M., Matsushita, T., Tomita, F., Okada, K., Ogasawara, T., et al. (1993). Modular manufacturing. Journal of Intelligent Manufacturing, 4(2), 163-181.

Van Hoek, R. I., & Weken, H. A. (1998). The Impact of Modular Production on the Dynas of Supply Chains. Journal of international logistics management, 9(1.2), 35-50.

Wang, Y., & Zhu, K. (2008). FDI and the Order Degree of Chinese Economic Development. Journal of South China Finance (8).

Wild, R. (1975). Work Organization: A Study of Manual Work and Mass Production. New York: Wiley.

Womack, J., Jones, D., & Roos, D. (1990). The Machine that Changed the World. New York: Harper Perennial.

Yearbook, C. A. I. (2002). Zhongguo Qiche Gongye Nianjian. beijing: Zhongguo Qiche Jishu Yanjiu Zhongxin.

Yi, S. (2011). Innovators from imitation to the first innovator, Imitation to innovation must stand on the shoulders of giants,. Journal of Trade Practice.

Zhao, J. (2006). The Logistics System Design of assemble shop Car plant III in Shanghai Volkswagen. Shanghai Jiao Tong University Press.

Zhao, Y. (2002). China's auto industry development trend and policy trends. General Office in Chinese Academy of Social Sciences, 35.

Zhou, K. (2006). Innovation, imitation, and new product performance: The case of China. Journal of Industrial Marketing Management 35, 394-402.

Zhu, Q., Sarkis, J., & Lai, K. H. (2007). Green supply chain management: pressures, practices and performance within the Chinese automotive industry. Journal of Cleaner Production 15, 1014-1052.

APPENDICES

APPENDICE A: MAJOR QUESTIONNAIRE ITEMS (51)

Assembly shop (21)

1. Gross Assembly Hours per Car
2. Adjusted Assembly Hours per Car
3. Assembly Defects per 100 Cars
4. Assembly Space per Car
5. Inventories of Parts (average)
6. Productivity (vehicles/hour)
7. Quality (assembly defects/100 vehicles)
8. Space (sq.ft/vehicle/year)
9. Size of Repair Area (as % of assembly space)
10. Inventories (days for 8 sample parts)
11. % of Work Force in Teams
12. Job Rotation (0=none, 4=frequent)
13. Suggestions/Employee
14. Number of Job Classes
15. Number of Workers
16. Training of New Production Workers (hours)
17. Absenteeism
18. Stamping (% of direct steps)
19. Welding (% of direct steps)
20. Painting (% of direct steps)
21. Assembly (% of direct steps)

Department of product engineering (13)

1. Average Engineering Hours per New Car (millions)
2. Average Development Time per New Car (in months)
3. Number of Employees in Project Team
4. Number of Body Types per New Car
5. Average Ratio of Shared Parts
6. Supplier Share of Engineering
7. Engineering Change Costs as Share of Total Die Cost
8. Ratio of Delayed Products
9. Die Development Time (months)
10. Prototype Lead Time (months)
11. Time from Production Start to First Sale (months)
12. Return to Normal Productivity after New Model (months)
13. Return to Normal Quality after New Model (months)

Department of procurement (15)

1. Die Change Times (minutes)
2. Lead Time for New Dies (weeks)
3. Job Classifications
4. Machines per Worker
5. Inventory Levels (days)
6. No. of Daily JIT Deliveries
7. Parts Defects (per Car)
8. Engineering carried out by Suppliers (% total hours)
9. Supplier Propriety Parts (%)

10. Black Box Parts (%)
11. Assembler Designed Parts (%)
12. Number of Suppliers per Assembly Plant
13. Inventory Level (Day, for 8 Parts)
14. Proportion of Parts Delivered Just-in-Time (%)
15. Proportion of Parts Single Sourced (%)

Department of Sales (3)

1. Sale for 2010
2. Number of Dealers
3. Car Sales per Dealer

APPENDICE B: CAR BRANDS IN CHINA

9 German brands

奥迪

奔驰

宝马

保时捷

大众

精灵

迈巴赫

迷你

欧宝

14 Japan and Korean brands

本田

丰田

光冈

雷克萨斯

铃木

马自达


讴歌

日产


斯巴鲁


三菱


英菲尼迪

起亚


双龙


现代

10 America brands


别克


道奇

福特

GMC 

悍马 

吉普


凯迪拉克 
克莱斯勒 
林肯


雪佛兰

21 Europe brands


标致 
雷诺 
雪铁龙


阿斯顿·马丁


宾利


捷豹

莲花

路虎

劳斯莱斯

阿尔法·罗米欧

布嘉迪


法拉利

兰博基尼

蓝旗亚

玛莎拉蒂

依维柯


柯尼赛格

萨博

沃尔沃

斯柯达

64 Chinese-owned brands

安驰


宝龙


北汽


奔腾

比亚迪


长安(轿车)


长安(微车)


长城


长丰


昌河


大迪


东风


东风风神


帝豪


东南


福迪


富奇


福田


风行

广汽日野


哈飞


汉江


海马


海马(商用车)

华普

红旗


华泰


航天圆通


汇众


吉奥


金杯


江淮

吉利


江铃


金龙


江南

开瑞


陆风


力帆


莲花（青年）

MG


美亚


庆铃


全球鹰


奇瑞


瑞麒


荣威


曙光


双环


上海英伦


天马


五菱


威麟


新大地


新凯


新雅途


野马


一汽


永源


中华

中客华北


中顺


众泰


中兴