A PHENOMENOLOGICAL RESEARCH IN THE RELATION BETWEEN SHIPBUILDING INDUSTRY AND NATIONAL ECONOMY DEVELOPMENT: A MAJOR INVESTIGATION OF CHINA

A THESIS

Submitted By

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ABSTRACT

This thesis is based on research which traces the development of shipbuilding industries around the world over the last three hundred years up until the present day. Except for the American shipbuilding, there have been another four challengers for industrial supremacy: the United Kingdom, Europe, Japan, and Korea. To gain a deeper understanding requires the consideration of their history of the development.

There is no detailed explanation of the development of the shipbuilding industry within these five world regions. In fact, it is difficult to make comparisons because countries were operating in different circumstances in terms of the world market and other socio-political contextual factors. Many studies have been made on the marketing aspect (demand and supply) of shipbuilding, but did not address questions as why shipbuilding industry was rising and falling in terms of economic performance.

The shipbuilding industry is worthy of further investigation. Some general ’principles’ exist that generate a tendency towards either prosperity or atrophy. With the exception of certain distinctive elements in some countries, there are many very similar driving forces that promoted development. They encounter similar problems, the consequences of these drivers being an initial flourishing followed by depression of shipbuilding.

The current research aims to establish the general ’principles’ of shipbuilding development. In a diagrammatic representation of all the ‘principles’, the shipbuilding industry can be seen to have had a developmental trend. The economic background, technology development and government intervention have been found to be the three greatest influences on this trend. This are generated through exploration analysis of the history and concrete evidence from Chinese shipbuilding in 21st century.

ACKNOWLEDGEMENTS

This thesis represents the end of my PhD research and beginning of a new life.

I wish to dedicate it to my parents in China who support me to study and live in UK for four years.

Thanks to Professor Kevin Cullinane from Napier University who encouraged and guided me all the time during my first half year of PhD, and gave me many advices to set research direction and help me finish the research proposal.

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PART ONE

PREPARING FOR THE RESEARCH

- This part aims to explain how to prepare the basic research materials.
- The background of the current research is presented in Chapter One, which also states the objectives and the construction of this research.
- The next chapter shows the methodology of current research. The phenomenology was selected as the key approach.

Chapter 1. Introduction

1.1 Background

1.1.1 *Shipbuilding industry*

A study of the shipbuilding industry should firstly consider what shipbuilding is understood to be at a very simple level. A very general definition of shipbuilding can be deduced from various descriptions and general principles:

> *Shipbuilding is the process of construction of ships and maritime structures in a specialized facility known as a shipyard.*

The original function of shipyards was constructing new ships such as fishing vessels, cargo ships and passenger ships. But since the 19^{th} century, shipyards have been developing many other related business activities. For example, American shipyards developed shipbuilding in warships to serve military demand; shipyards in European countries expanded their business by producing ship fittings, components and construction tools; shipyards in South Korea started building offshore constructions such as floating platforms. By the 20^{th} century, many countries had developed their shipbuilding enterprises into systemic industrial organizations, rather than acting as independent shipyards. They focused on various types of ships and other related fields such as producing materials, academic research and education. These business activities became an important part of their exports and national GDP developments.

Therefore, taking into consideration the development of shipbuilding and shipyards' diverse business areas, this thesis gives a definition of modern shipbuilding industry:

> *A shipbuilding industry comprises systemic organization and geographic concentration of interconnected manufacturers, businesses, suppliers, and associated institutions in shipbuilding; they work within an industrial cluster which services newbuilding, maritime structures and derivative productions.*

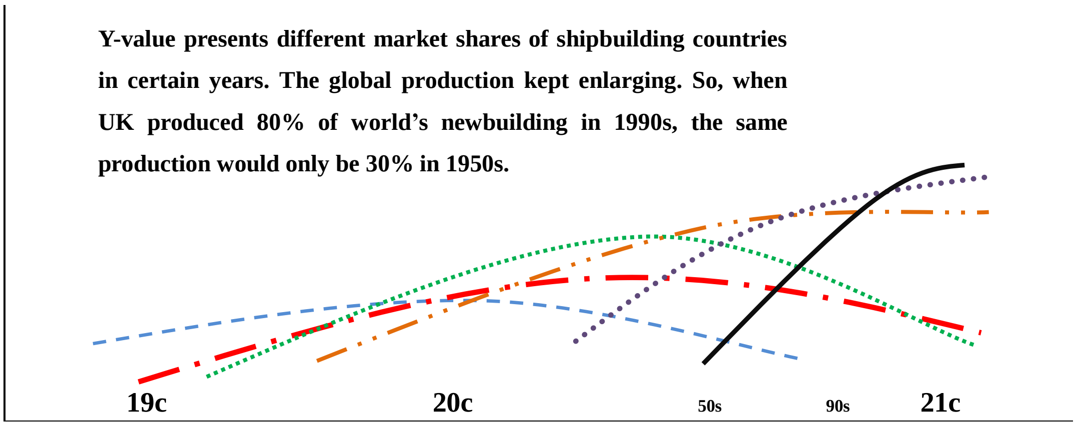
1.1.2 *World shipbuilding countries*

Historically, the shipbuilding industry played an important role in the economic development of countries. The ancient shipbuilding in Egypt, China and India was evidence to the world of splendid civilizations. Chinese wooden shipbuilding boomed in the 9th century and also helped to influence the development of other countries' shipbuilding [Xi, 2000]. Since the 19th century, the world's shipbuilding industry entered into a new stage – construction of steel ships. The shipbuilding industry in countries such as the United States, United Kingdom, Japan and South Korea flourished, their shipbuilding industries diversifying by building various types of ships, developing new materials, shipbuilding tools, ship equipments, offshore constructions, academic research and education. Moreover, in the 21st century, many developing countries started attempting to develop their shipbuilding industries. Countries like China and India, whose shipbuilding once flourished in ancient time, are now rebuilding their shipbuilding industries. Countries like Brazil, Thailand and Vietnam are creating shipbuilding industries as well.

1.1.3 *General trends of world's shipbuilding*

Since the 18th century, the world's shipbuilding countries have reflected a very common economic development trend: they boomed, dropped and were replaced by another nation's industry. Deduced from the historical data, as Figure 1.1 shows, the

US boomed the world's first-class shipbuilding in later 19th century. It was gradually declining and was replaced by the UK later at the beginning of 20th century. Next to emerge were the European countries that developed their shipbuilding industry and maritime manufacturers. Similar changes occurred in the latter half of the 20th century. Japan took the first place; Korea subsequently replaced Japan, and then came the boom of Chinese shipbuilding at the end of 1990s.



US		Rising in 19th century, falling in early 20th century.
UK		Rising in early 20th century, falling in first half of 20th century.
EU		Rising in first half of 20th century, replaced by Japan in 1960s.
Japan		Rising in 1960s; replaced by Korea in 1990s.
Korea		Rising in 1990s.
China		Rising in the end of 20th century.

Figure 1.1 Trends of Shipbuilding Countries

Shipbuilding countries also show common trends in developing technology and shipbuilding cost. As is shown in Figure 1.2, many shipbuilding countries (blue curve) build ships at a very low cost initially and gradually promote the technological aspects of their production. The increasing speed of technological development is reflected in the increasing speed of shipbuilding cost (including material cost and human cost). Developing countries such as China and India have an advantage in their supply of a cheap labour force. They can develop more technological content, but still keep the cost at a lower level in certain time periods (red curve). The developing speed of technology and cost will trend to even. And at the last, it will become countries like Poland whose technology will be maintained at the same level but cost will increase sharply. Accordingly, the lifetime of country's shipbuilding industry will move from the red curve to blue one, and end by the green.

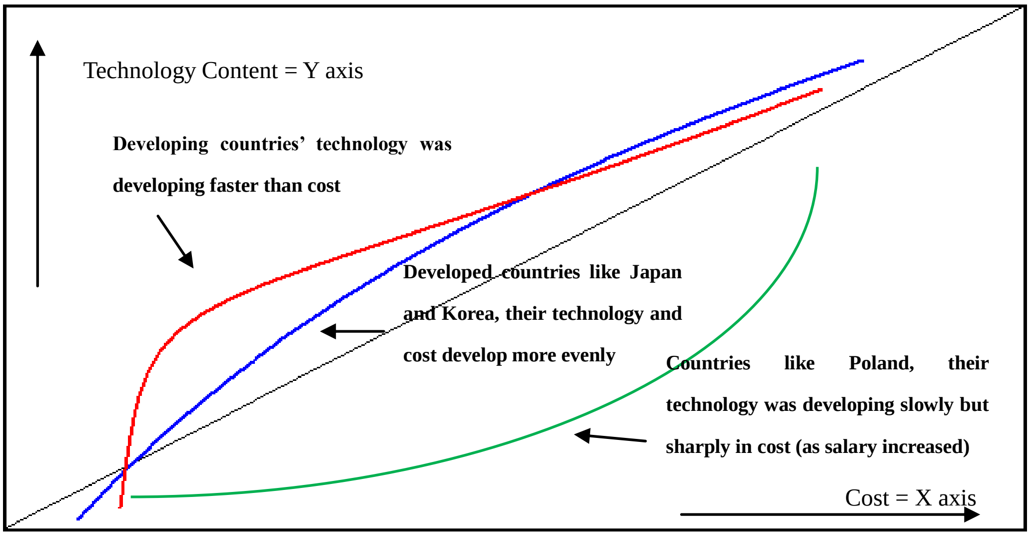


Figure 1.2 Technology Content and Shipbuilding Costs

1.2 Motivation

1.2.1 *Shipbuilding countries were rising and falling*

Various research theses about the investigation of shipbuilding industries around the world have been published. But they have not explained the reason why many shipbuilding countries have engaged in such a situation, i.e. booming, dropping and being replaced as market leaders by another nation. Take some published books for example:

- Parkinson (1960) wrote a book entitled *The Economics of Shipbuilding in the United Kingdom*, within which he discussed the progress of shipbuilding enterprises' development in the UK before the middle 20th century. And later he also described how the demand and supply for shipbuilding developed and changed in those years.
- Todd (1985) described the general picture of the whole development of world's shipbuilding industries in his book entitled *The World Shipbuilding Industry,* in which he examined the internal operation of shipbuilding and external factors such as the change of material's prices in the market.
- Chida *(1990)* in his *The Japanese shipping and shipbuilding industries: a history of their modern growth* presented the different development stages of the Japanese shipbuilding industry from the 19th century to 20th century. He also highlighted the government actions that had contributed to economic growth, citing their important role to lead, help, guide, manage and control the rise of shipbuilding in its various stages of development.
- Thiesen's (2006) *Industrializing American Shipbuilding,* portrays the historical picture of the shipbuilding industry that developed in America from the 17th century, and he also explains the character of early American shipbuilding and the reason for its flourish and slump.
- A more recent contribution is by Stopford (2009) who published a book titled *Maritime Economics,* within the third edition where he sets shipbuilding as one of the four maritime markets and uses market analysis to display the shipbuilding market cycle and shipbuilding price trends in the 20th century.

These books as well as many maritime journals and research theses, are trying to explain the characteristics of the shipbuilding industry. But, they do not make comparisons between different countries and have not found precise reasons to answer why shipbuilding countries will replace and be replaced.

1.2.2 *Relations between shipbuilding and national economy*

Shipbuilding has been more and more important in contributing to national economies. Not only for its important role in transporting massive commercial cargos but also acting as a country's pivotal industry. It has been highlighted as one of the interesting issues, since the end of 20^{th} century, when people consider a country's economic development.

However, comparing one shipbuilding country to another, even a person who has over 30 years working and business experience in shipyards cannot give a critical reason to this question: *Why two different shipbuilding countries took similar development strategies, but found totally different results later.*

Comparing US shipbuilding to UK shipbuilding, it was found that they both attempted to develop commercial shipbuilding in the 19^{th} century, but the US failed. The Indian government tried to develop its shipbuilding industry following the way of China in the 20^{th} century, but it was still uncompetitive at the beginning of 21^{st} century. No research had been done to explain in detail that what the reasons of such two different results were.

1.2.3 *Personal motivation*

When considering the different national economies, it might not be so difficult to answer the above two questions. Countries are different in the way they developed national economies. It is because there are different economic patterns such as capitalism and socialism, different economic power structures such as developed countries and developing countries. Moreover, countries are also in different stages of industrialization, for example, from agriculture to manufacturing or from manufacturing to service. Indeed, the different national economies also influence many other sectors such as technology and policies in various ways and all these factors can contribute to shipbuilding industries' varying performances.

Therefore, it might be seen that different countries take similar actions to develop shipbuilding but meet with different results. For example, government's subsidies to shipbuilding industry may have two results: developing shipbuilding with high technology power, or increasing industries' debit. The reason should be that their differing national economic development led to similar actions, producing different effects, which leads some countries' shipbuilding industries to flourish and others to be less successful. No previous research has completely explained such relations. The motivation of this thesis attempts to find the relationships between shipbuilding and national economies to answer the above questions.

1.3 Objective

1.3.1 *Research focus*

This research was discovering the relationships between shipbuilding and national economy, for example, how national economy development drives shipbuilding forwards. A general diagram that can show how individuals, businesses and organizations relate to each other is needed. The research focus of this thesis thus can be displayed in Figure 1.3. Different individual behaviors are taken based on the different functions from different business directions of the organization. For example, improving workers' skills in producing ship equipment should be based on the function of human resources and technology and is from the business direction of developing ship equipment production. Countries choose different business directions, but they should have some common issues in developing similar industries such as shipbuilding. It also represents a development trend of a certain industrial sector in the world's economy.

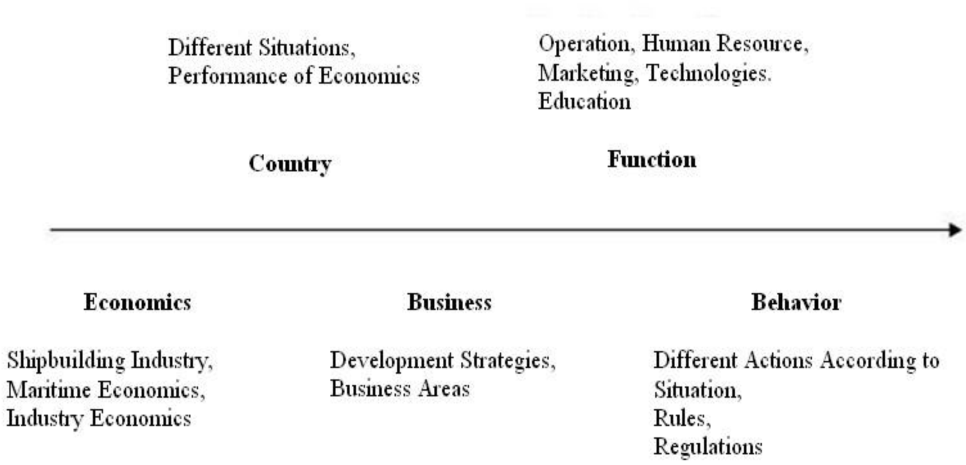


Figure 1.3 Relations among Sectors

1.3.2 *Research objective*

Following on from the above research aim, the objective of this research was to:

> *Understand the historical and economic development of the global shipbuilding industry and develop a general theory of the relationship between shipbuilding and national economic development.*

1.3.3 *Structure of the thesis*

This thesis comprises four parts with nine chapters:

PART ONE: PREPARING FOR THE RESEARCH

- Chapter 1. Introduction
- Chapter 2. Methodology

PART TWO: LITERATURE REVIEW

- Chapter 3. Research on Shipbuilding
- Chapter 4. World's Shipbuilding
- Chapter 5. Chinese Shipbuilding

PART THREE: DISCUSSION

- Chapter 6. The Three Elements
- Chapter 7. Economic Background
- Chapter 8. Technology Development
- Chapter 9. Government Interventions

PART FOUR: RESULTS

- Chapter 10. A Model of Shipbuilding Industry Development
- Chapter 11. Conclusion and Recommendations for Future Work

The first part of the thesis aims to prepare basic materials. The background of the research is presented in Chapter One, which also states the objectives of this research. The next chapter shows the methodology which adopted phenomenology as the key approach.

The second part of this research uses case studies to investigate the level of behaviour, business, function and country for this research. Chapter Four described the world's shipbuilding development over the past 300 years. To discuss the development trends by going through the five shipbuilding economies of United States, United Kingdom, Europe, Japan and South Korea. They have their own characteristics in developing shipbuilding. They all had the advantages and disadvantages that contribute to flourishing and going into decline in subsequent decades. Moreover, through investigation of different shipbuilding countries, the principle can be found that a shipbuilding industry is developed and should be developed at a certain stage of industrialization. Although there are many differences in those countries' shipbuilding industries, there are still common rules that can be deduced. They all have common characteristics in managing the economic background, technology development and government administration aspects for the shipbuilding industry.

Chapter Five discusses the situation of Chinese shipbuilding. The data generally presented that Chinese ancient shipbuilding was developed based on the flourishing national economy and sufficient technologies, and government behavior influenced shipbuilding noticeably, i.e. their incorrect action brought shipbuilding into slump. This situation did not change until the Chinese economy boomed again in the later 20^{th} century and, together with more active government actions, the shipbuilding industry developed quickly and China became the world's third largest shipbuilding country since 1995. Sufficient data then can be collected to discuss how the theory relates to Chinese shipbuilding from ancient times up to today.

The next four chapters in part three of the thesis discuss and explain in more detail how these three elements are displayed in the shipbuilding industry. Chapter Seven aims to prove that modern Chinese shipbuilding has obtained the necessary background to the economy which gives economic support to the shipbuilding industry. Chinese industrial progress leads to industrial conversion from agriculture to manufacturing, and the manufacturing system is developing from the very basic industry system (mainly processing manufacturers which are labour intensive) to capital and technology intensive. It follows that the shipbuilding industry in China can benefit from such industrialization as: a) there is sufficient support of labour from the farm industry to provide development at the beginning when shipbuilding is labour intensive, b) a flourishing manufacturer system assures shipbuilding the developed fundamental technologies and operations management, c) massive investments assured shipbuilding industry required the sufficient capital resources for expanding shipbuilding capacities or research in advanced technologies. Chinese shipbuilding thus has experienced a somewhat 'golden period' since 1990, the whole nation developed massive shipbuilding capacities in three economic centers on the east coastline: Bohai Bay, Yangtze Delta and Zhujiang Delta, and its immediate aims were to develop into the world's foremost shipbuilding country.

Chapter Eight discusses the importance of technology development in shipbuilding, and again, cases in the Chinese shipbuilding industry are used for discussion. The Chinese government distributes a large amount of national investment to develop shipbuilding through enhancing technical levels in building methods, designing ships, researching new ship types and enhancing internal operations management. Many of those technologies were developed from absorbing foreign advanced technologies to help build up technologies quickly. However, the Chinese shipbuilding industry is weak in self-innovation, especially in the area of ship equipment like engines and maritime electronic control systems which still rely on foreign production. Shipbuilding also needs establishing reasonable operations systems such as applying integration and establishing systemic industry clusters. But all those firstly need a developed operation system covers purchase, production, service and logistics.

Chapter Nine discussed the importance of government intervention. The government should act as the supervisor in developing shipbuilding, so national development plans, laws or policies should be used to guide and manage shipbuilding. The Government can help shipbuilding in difficult times, but it should also ensure that shipyards avoid depending too much on it and lose the ability of self-management. The Chinese government did very well in managing ownerships in the shipbuilding industry, to obtain both the advantages of a "market economy" and a "planned economy". But the Chinese shipbuilding industry still needs a complete legislation system such as that in the US, Japan and Korea to effectively supervise and guide shipbuilding in the long term.

The conclusions to the research and recommendations are outlined in part four of the thesis. As the conclusion, it firstly used the generated theory to compare and analyze two different shipbuilding countries: Korea and China. The economic background, technology development and government administration were used to explain their different performances and possible future trends. A recommendation for further research is generated as well. All those research and discussions would be established on the selected research methodology.

Chapter 2. Methodology

2.1 Research Paradigm

Positivism and phenomenology are two paradigms, they are opposite, and one was chosen as the philosophy of current research:

- Positivism asserts that the only authentic knowledge is based on sense, experience and positive verification. It usually sets a hypothesis, and proves it by using math or various other calculations (mono method, quantitative research). This is not a way of inducing. The essential issue of positivism is that all true knowledge is scientific, and is ultimately measurable (calculation).
- Phenomenology attempts to create conditions for the objective study of topics usually regarded as subjective: consciousness and the content of conscious experiences such as judgments. It reaches the inherent nature of the main advocates of traditional idealism, to return to the original "phenomenon" which was the "essence" of all kinds of experience.

The paradigm of positivism is not suitable for the current research. This thesis was inducing theory by archival research but not experiment. It was impossible that using calculation or any other kind of measurements to prove a hypothesis in this thesis, as there was not even a hypothesis created. And, quantitative research method was not that efficient for this thesis inducing theory. Due to all of these characteristics the current research followed the paradigm of phenomenology.

2.2 Research Methodology

2.2.1 *Why chose phenomenology*

This research examines the relationships between shipbuilding industry and economics, by choosing the paradigm of phenomenology but not positivism. The reason was because, this thesis was inducing the relationship between shipbuilding industry development and economics through investigating economic phenomena such as shipbuilding market cycle, supply and demand etc. It was not an action of thinking straight (deducing), but a reflection of the activity. And inducing the relationship between shipbuilding industry development and economics needs to research in historic data. Then, the current thesis used qualitative research and frequently returned to its “original state”, which means a simple, direct and clear explanation of such a relationship. This was much more close to phenomenology. To search for the essence behind the representation was not the fundamental thinking of positivism, and so positivism was not indeed a starting point of this research.

Choosing phenomenology was also because most of the research objects in this thesis were described social phenomena, e.g. commercial phenomenon (development strategies). These social phenomena were from archives and commonly presented in writing. But those research materials used very little study on the quantities or statistics results. The phenomenological methodology could help to achieve for this research the induction of all these phenomena.

2.2.2 *The methodology of phenomenology*

Phenomenology focuses on searching for the relationship between objective reality and its behavior that is presented as a phenomenon, answering “*why*” but not “*Was*” [Husserl, 1999]. Husserl (2001) specified the methodology of phenomenology as a method of analyzing reality in detail, and it must be also returned to reality itself, finding “*Evidenz*” in the sufficient developed intuitionistic materials and achieving a pure logical principle. In this research, the relationship between shipbuilding industry and economics was such a pure logical principle. Indeed, this relationship is universal and inevitable.

In fact, phenomenology is a methodology as well as a study [Spiegelberg, 1981] and the research methodology for phenomenology is phenomenology itself [Husserl, 1980]. Therefore, the three elements of phenomenology is also the three-step methodology as:

1) The first step was investigating objective reality only without any incongruent prejudice. This was mainly represented by literature review (selecting and investigating the archival) of this research.
2) The second step was called *“Eidetic Reduction”* [Husserl, 2001]. It achieved the “inside” of phenomenon which existed out of experience. Then, the research result can explain the entire external phenomenon and create new phenomenon. This step was showed in the part of discussing relationship between shipbuilding industry and economics.
3) The third step was called *“Transcendental Reduction”* [Husserl, 2001], which goes a step further to prove there is a pure principle that existed before the phenomenon and experience. The conclusion of this research was just the case: it showed relationship between shipbuilding industry and economics is inherent and unchangeable, and it causes all possible phenomenons in shipbuilding.

2.2.3 *Other research approaches*

This research also applied some other research approaches. Firstly, the quantitative research was presented during the data collection, i.e. collecting the data from archives that related to shipbuilding. Moreover, three Chinese local shipyards that operated as national company, private company and foreign invested company were interviewed. Such interviews were used to collect information for qualitative analysis. Kolb's learning cycle (Figure 2.1) was also applied for qualitative analysis, with the aim of following the cycle to generate and improve the concepts by working and reworking on various data.

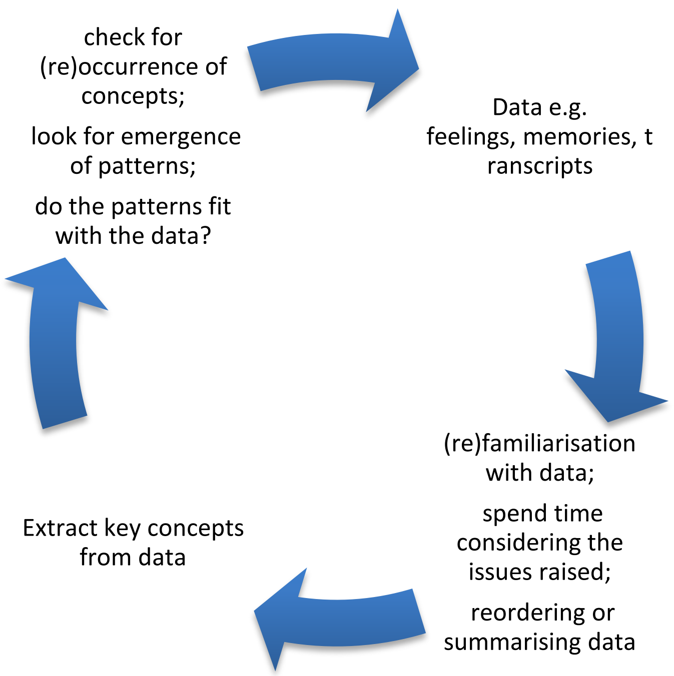


Figure 2.1 Kolb's Learning Cycle for Qualitative Analysis

Source: Kolb (1984).

2.3 Thesis's Framework Under Methodology

In detailed framework, the current thesis was divided into five stages to achieve the research objective. This was followed by the three-step research:

The first step:

***a) Knowing, Understanding and Summarising*.** Collecting a large number of data materials was used in knowing and understanding the shipbuilding industry and national economy development. Those data were referring to shipbuilding countries such as the US, the UK, European countries, Japan, Korea and China. They were mainly presented by books, journal articles, theses, market reports and also government documents. They were also classified by countries and research fields to make the vertical comparison (single country in different time scales) and horizontal comparison (many countries in the same time scale). The work will be displayed in Chapter Three.

b) Understanding the Relationships of Factors. By clarifying the relations among the phenomenon, it aimed to deduce the possible reasons why shipbuilding was rising and falling. It also followed the way of discussing the positive factors that as the basic reasons of booming and the negative factors that caused the falling of shipbuilding industries. They were presented in depth in Chapter Four and Chapter Five as well.

The second step:

c) Generating the Idea. The next stage of this research was generating principles from the relations between factors. By analyzing the historical data of shipbuilding development, it then concluded that countries used various strategies but still had common elements. They were generally presented in the economic background, technology development and government actions. It also evolved the discussions of almost all those factors (phenomenon) were created by historical data. This was displayed in Chapter Six.

d) Eliminating the unproductive and maintaining the useful. In the fourth stage, the research materials were selected and grouped again in three fields according to the generated idea. By adopting the phenomenology to eliminate and maintain useful materials to achieve a more detail and general theory - a relationship between shipbuilding and economy development:

- Economic Background. Countries necessitate common economic background to develop shipbuilding industry, which include the developed primary manufacturers, sufficient material resources, sufficient human resources and good marketing.

- Technology Development. Shipbuilding industry develops by the advanced technologies from domestic research or learning from overseas, and a scientific and efficient operations management as well.
- Government Intervention. Shipbuilding industry also makes quick progress under good government interventions. They were represented by national development plans, managing ownerships and establishing legal system.

This research work as well as *"Generating the Idea"* will be done in Chapter Six. They together proved it again that a pure relation with the expression of these three elements is existing between shipbuilding industry and national economy development, which is inherent and causing all possible phenomenon.

The third step:

e) Promoting the Theory. The last part of this research focused on improving the reasonability and availability of this generated principal, i.e. countries' shipbuilding industries must depend on the cooperation of economic background, technology development and government intervention for developments. In this part, the thesis utilized the most recent data from China to make the theory more reliable, and the characters of Chinese economy development and Chinese shipbuilding industry were used to support the discussion as well. These works were finished in Chapter Seven, Chapter Eight and Chapter Nine, which used both the quantitative and qualitative methods to conduct the discussions, and certain Chinese shipyards will also be used as small case studies.

The three-step research fulfilled the research ambition of this thesis. But all these should be started at the investigation of shipbuilding industry development in history. This would be done in next chapters in part two, which gives a complete literature review of world's shipbuilding development.

PART TWO

LITERATURE REVIEW

- This part mainly focuses on literature review.
- The Chapter Three explained how those research materials was found and organized for current research. A summary will be given to display what those research materials were discussing about.
- Chapter Four described the world's shipbuilding development over the past 300 years by going through the five shipbuilding economies of United States, United Kingdom, Europe, Japan and South Korea. They have their own characteristics in developing shipbuilding, but a similar principle can still be found.

Chapter 3. Literature Review

3.1 Introduction

The first part of this chapter explains how research materials (books, thesis, and journal articles) were selected to build up the knowledge background of current thesis. Three databases including university library catalogue, ScienceDirect and infotrieve were chosen to find research materials. And in these three databases, there were over 400 research materials discussed both shipbuilding industry and economics. All those research materials were used for inducing the theory of the current thesis.

The second part of the chapter briefly summarises the literature review. By reviewing those 400 research materials, a knowledge background for this thesis was established. This background was developed into three sectors including shipbuilding & national economy, shipbuilding & technology, and shipbuilding & government management. And these three sectors played as the most important role in constructing the thesis's framework.

3.2 Search Strategy

The searching results in the three databases were:

- In the library catalogue of Newcastle University, about 71 search results were selected as the research materials. These books, thesis and journal articles were discussing shipbuilding industry from the perspectives of economics, technological views and governments' management.
- In ScienceDirect journal article database, 322 research materials were selected.

Most of them were research theses discussed shipbuilding business and how government support shipwrights.

- In infotrieve journal article database, about 22 search results were selected as the research material. They were mainly discussing how shipbuilding industry and technology was developed along with national economy development.

Accordingly, there were 415 research materials selected for literature review and establishing the knowledge background of this thesis. They were re-grouped as shown in Table 3.1, then, the reason of selecting these research materials could be clarified:

1) They covered areas including shipbuilding industry, economics, shipbuilding technology and governments' administration in developing shipbuilding industry. Their viewpoints could be used for inducing the relationship between shipbuilding and those covered areas.

2) Many of them explained the basic connections between shipbuilding and economics. This was beneficial for developing the current thesis's theory. For example, one research material (this was in Todd's book, 1985, will be described in detail next) explained how economy developed global seaborne trade and then stimulated world's shipbuilding industry. This could support the theory of "shipbuilding industry needs a strong economic background".

3) Their research covered almost all shipbuilding countries including UK, US and Japan who once dominated world's shipbuilding. Those could be used as concrete examples and evidence to help complete the discussion and conclusion of this thesis.

Table 3.1 Selected Material Samples

	Newcastle Library	ScienceDirect	Infotrieve
Sorted by research contents			
Trade & Business	11	204	7
Industry & Shipyards	17	8	6
Shipbuilding Development	34	46	2
Governmental Regulations	9	64	7
Total	71	322	22
Sorted by research countries			
United Kingdom	25	49	2
United States	4	45	5
Japan	8	35	0
European countries	7	55	4
Korea	4	29	2
Other countries & World's General	23	107	11
Total	71	322	22

3.3 Literature Review

3.3.1 *Shipbuilding in economy development*

National economy development relied on industrialization, which was the process of social and economic change whereby a human group is transformed from a pre-industrial society into an industrial one [Kriedte et al., 1981; Hughes, 1988]. The industry system transfers from *Agriculture* to *Industry* and then to *Service*, and later *Information Sectors.* By such a progress, the whole industry system is developed from labour intensive to capital and technology intensive, and built up with high productivity, efficiency and profitability [George et al., 1992]. Then, a rule was stated as an advanced industry system evolved based on the developed lower level industry systems [Thomis, 1976; Kirkpatrick and Nixson, 1983].

Shipbuilding industry was such a capital and technology intensive industry developing from lower level manufacturers. A concrete example was as Kenwood and Lougheed (1982) noted that the booming metallurgical industry played an important role in the take-off of Japanese shipbuilding. And shipbuilding industry depended on certain economics' factors that evolved in industrialization for development.

3.3.2 *Shipbuilding industry and national economy*

Countries' shipbuilding industry developed well when its national economy was rising. In many shipbuilding countries such as UK and Japan, the rising national economy increased seaborne trade and directly stimulated shipbuilding production. It would become worse once the national economy was contracting. In the 1930s, world's economic crisis damaged the western countries' economy development, which decreased their shipbuilding production as well [Michigan State University, 1985].

There are also other economic factors that influence the shipbuilding industry. First of all, obtaining sufficient natural resources such as timber and iron can provide shipbuilding cheap materials. Thiesen (2006) described this as the sufficient natural material resources of timber enabled American shipbuilding to dominate the world's wooden shipbuilding market in the 19th century. Laughlin et al (1922) also stated that the rich mineral resources enabled British shipbuilding to be competitive. Secondly, shipbuilding depends on cheaper labour cost (low wage and production cost) to win business in the market. Asia Times (2009) stated that cheap labour was the most important reason of Japan and Korea built shipyards in China, as they can reduce shipbuilding cost to win competitions. Thirdly, shipbuilding also needs a developed home market for orderbooks. Stopford (2009) concluded that the domestic maritime business supply Britain's shipbuilding lots of newbuilding orders, this can also be found in history in Japanese or Korean shipyards.

3.3.3 *Shipbuilding industry and technology development*

Technology development was another factor that stimulates the shipbuilding industry. Zanden and Tielhof (2009) concluded that it appears that productivity of Dutch shipbuilding increased strongly between the 1550s and 1620s because of technological improvement. Thiesen (2006) noted that American shipbuilding was developed in the 18^{th} century because technology development created shipyards by facilitating high productivity and efficiency. Moreover, Ingvar (1983) also noted that advanced technology such as welding helped European shipbuilding develop high efficiency and qualities in the first half of the 20^{th} century. Chida (1990) and Lee (1996) concluded that advanced technology helped maintain the market shares of both Japanese shipbuilding and Korean shipbuilding, when facing strong competitors such as Chinese shipbuilding in the 2000s.

In the 2000s, the shipbuilding technology also focused on "soft-technologies" such as building methods, design methods, etc. In a journal titled *Computer-Aided Design*, Nowacki (2009) presented how important the development of Computer-Aided Design in shipbuilding was since the 1950s. Makris et al. (2008) also stated that the inside information system and operation of supply chain were of crucial importance to shipbuilding industries. And Kim (2007), using the examples of Daewoo Shipbuilding and Medison Shipbuilding, concluded that lacking of process management and organized systems was the very reason of losing competition in global shipbuilding market.

3.3.4 *Shipbuilding industry and government interventions*

Researchers have also discussed the importance of government in shipbuilding. There were many different government actions in managing a shipbuilding industry, for example, national development strategy. Shipbuilding was supported well by the European governments. A concrete example was Poland had a national shipbuilding strategy within the framework of planned economy [Stråth, 1987]. Similarly in the Far East, an export-led industrialisation strategy from the Korean government played an important role in developing Korean shipbuilding [Lee, 1996].

Another expression of government management was using laws, policies and development projects to develop shipbuilding industry. Chida (1990) calculated in his book that Japan had issued eight laws directly concerned with promoting the shipbuilding industry. Rhee (1994) also calculated that there were five laws enacted from 1960s to 1980 in Korea, which aimed to develop shipbuilding technology by using effective methods such as offering shipyards the sufficient capital resources.

3.4 Summary of Literature Review

There were many research materials highlighting the relationship between shipbuilding and economics. As far as the factor of national economy development was concerned, technology development and government management were another two factors influencing the development of shipbuilding. These three factors were used to construct the framework of the current thesis, i.e. set as the three-part discussion in next chapters. However, it might not be readily noticeable and little research in any depth of explaining the relationship among shipbuilding, economic background, technology development and government interventions. Therefore, explaining this relationship becomes the ambition of current research.

Chapter 4. World's Shipbuilding Development

4.1 Introduction

The Shipbuilding industry has developed around the world over the last three hundred years. Research on the relationship between the shipbuilding industry and national economy necessarily requires the investigation of the shipbuilding industry's development in history in different countries. In fact, it was difficult to make comparisons as countries were different in national economical power and political environments, etc. But these economies were still worth investigating as some special strategies promoted shipbuilding development in certain countries. These strategies were considered as the primary reasons that caused shipbuilding countries flourishing and subsequent depression, and in turn they could help us to understand the relationship between shipbuilding industry and national economy development.

This chapter firstly discusses the world's shipbuilding industry, to give an insight into shipbuilding within countries' industrialization in history. The main five shipbuilding powers before the 21st century were discussed. An attempt was made to explain the issues as to why they were successful in flourishing in shipbuilding, and why their shipbuilding then declined and was overtaken by another. The recent booming shipbuilding countries such as China and India were also described to show the possible current and future trends of world's shipbuilding. Through these discussions of shipbuilding development in history, the basic idea of the relationship between shipbuilding and economy gradually emerged.

4.2 World's Shipbuilding Industry in General

4.2.1 *The diversion of shipbuilding powers*

Supremacy in world shipbuilding has changed four times since the end of the 19th century. All these changes related to the transfer of technology at the turning point. For example, new building materials and advanced shipbuilding methods made ships stronger and more durable; welding ensured that ships became much lighter but still maintained a strong hull. Technology also minimized shipbuilding costs. Hardy (1964) calculated that new materials and welding reduced the total weight of ship by 5 percent at 1900s, and the fuel costs at the same speed could be saved by 10 percent.

The switch in power from the US shipbuilding to the UK shipbuilding in 19th century was because wars influenced technology development. To serve the wars, US shipbuilding industry evolved "Standardized Production" to reduce shipbuilding time and save shipbuilding costs. However, the disadvantages were: a) only military shipyards obtained the capacity of standard production and, b) few shipyards used "Standardized Production" for building commercial vessels. Therefore, by using new materials and scientific building methods in commercial shipbuilding, the UK shipbuilding exceeded the US shipbuilding in 19th century.

The next change from UK to European countries in 20th century was based on the new industry systems, specifications and diversifications in shipbuilding businesses. European countries developed accessory manufacturers for producing engines and many other types of advanced maritime equipments. That ensured European shipbuilding to boom in the world market. Their maritime accessory manufacturers even dominated a large global share in 2000s.

In later 20th century, shipbuilding technologies relied much more on high productivity, high quality and lower price. Korea took the place of Japan was largely due to the cheap and efficient shipbuilding workers. China won a lot of market shares by an even cheaper labour force (low wage and high production) at the end of the 20th century.

4.2.2 *World's shipbuilding market development*

Historically, different countries had different characteristics and development strategies in developing shipbuilding industry. In the 19th century, the US was well known for wooden shipbuilding, as its family based industry system brought efficiency and productivity. The UK shipbuilding was benefited from the new materials, the integration of shipyards' business and the promotion of scientific building methods by the end of 19th century. European countries developed shipbuilding industry in first half of 20th century by the accessory manufacturers who produced advanced ship equipments. Japanese shipbuilding was developed by the efficient cooperation between the industrial structure of "Private-ownership" and government administration in 1950s. Korea set shipbuilding as one of its national export-oriented strategies, shipbuilding thus boomed in the 1970s.

The changes between shipbuilding countries in the 20th century could be shown more clearly in Figure 4.1: UK shipbuilding occupied over 80 percent of the world's newbuilding by the end of the 19th century; European shipbuilding once occupied over 45 percent in the 1960s; Japan once accounted for over half of the world's total in the 1980s; by the end of 1999, Korean production exceeded Japanese to become the world leader. In the 2000s, Chinese shipbuilding boomed, China together with Japan and Korea then became the world's top three shipbuilding nations.

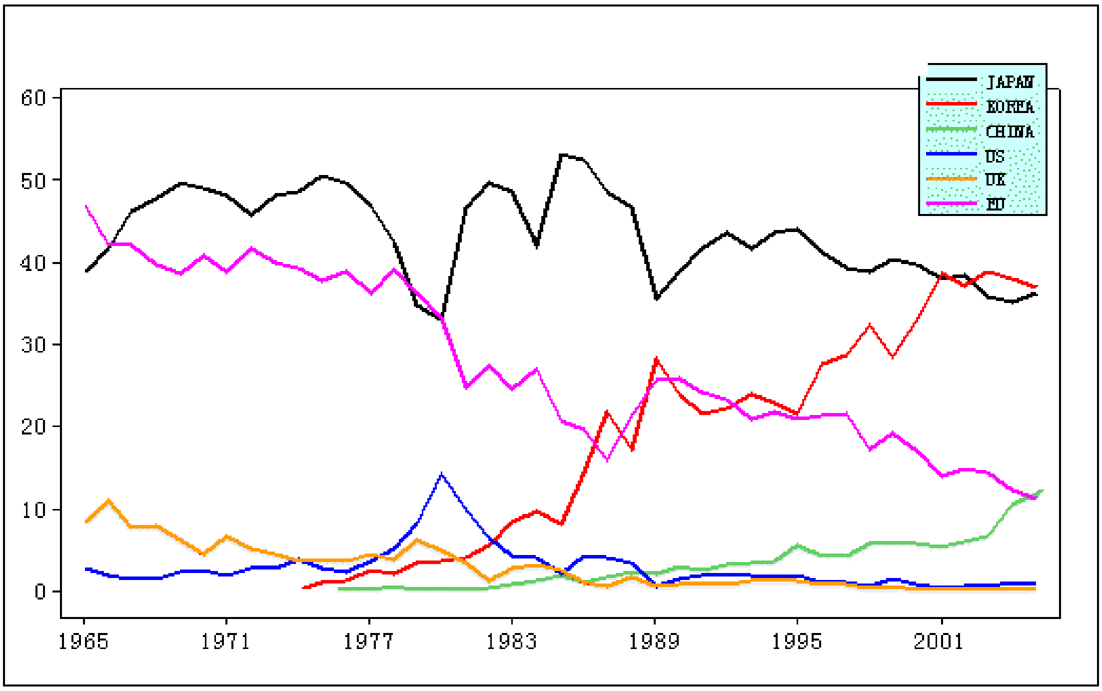


Figure 4.1 World's Shipbuilding Countries in 20th Century (%)

Source: Data from Parkinson (1960) and Clarksons (2003), reorganized by author.

4.2.3 *Ships become larger and faster*

As world's shipbuilding technology developed, it was noticeable that ships were built much larger. Take the container ship for instance, as Table 4.1 shows, container ship kept enlarging from only 1,000 TEU in 1960s to 10,000 TEU in 2006. Countries also attempted to build larger ships: both China and Korea set the development strategies of building 10,000 TEU vessels in 2000s [Zhang, 2007]. On the other hand, tankers and bulk carriers were also built in large capacities. VLCC was developed from 200,000 DWT to 300,000 DWT, and even a ULCC over 450,000 DWT had been built by the end of 20th century [Chinese Industry Research, 2007]. Handy bulk carriers were enlarged from 20,000 DWT to more than 35,000 DWT, and the capesize bulk carrier was developed to 200,000 DWT in 1990s as well [Chinese Industry Research, 2007]. Shipbuilding countries also developed their abilities in building larger special vessels. For example, the RORO ship was built in the later 20th century with the capacity of carrying about 4,000 units at a time, this capacity even exceeded 6,000 units in 2000s [Chinese Industry Research, 2007]. Moreover, to the LNG carrier aspect, the Korean shipbuilding obtained the ability in building the LNG ships over 266,000 cubic meters in 2007.

Table 4.1 The Developed Performance of Container Ship

YEARS	TEU	DWT
1960s	700~1,000 TEU	10,000 DWT
1970s	1,800~2,000TEU	25,000 ~ 30,000 DWT
1973 – 1980s	3,000 TEU	40,000 DWT
End 1980s	4,400 TEU	Over 50,000 DWT
1990s	4,800~6,000 TEU	Over 60,000 DWT
End 1990s	8,000 TEU	Over 90,000 DWT
2006 ~	10,000~15,000 TEU	Over 150,000 DWT

Source: Chinese Industry Research (2007); Howe Robinson Containership Index (2009).

4.2.4 *New shipbuilding methods*

Shipbuilding industry had developed various advanced shipbuilding methods. One of the most noticeable methods was designing ships by Computer Aided Design Systems. Shipyards also developed modeling test for building ships, by which it could forecast the new vessel’s capacity, building cost and any potential problems before producing.

Moreover, as technology was developing, shipyards could mainly build ships in four ways:

- **Offshore building.** Build the ship’s subsections and combine into a whole ship on land, move the ship onto a barge, then launch by submerging the barge. This saves building time by about 4 months, less conditions for on land works.

- **Combine in Barge.** Build two subsections on land, combine them into a whole ship on a barge, and launch by submerging the barge. This saves land for docks, but the building cost is much more than that for offshore building.
- **Bow subsection.** Build the bow on land, build the hull in dock, launch the hull in the dock and connect with the bow. This building method is for ships over 300 meters long.
- **Large subsections.** Build ships in less but larger sections to save work, transfer them into a float dock by crane, combine and launch. This minimizes the number of subsections and increases building efficiency, but larger facilities are needed.

4.3 The Five Shipbuilding Powers

4.3.1 *The American shipbuilding industry*

4.3.1.1 Begins with wood shipbuilding

American shipbuilding industry boomed by wood shipbuilding in the 18th century. According to Fassett's (1948) calculation, in the 1750s, there were 100 firms with an annual production of 300 vessels; this number was expanded to 125 firms in the coming decades and with an annual production of 400 wooden vessels. From 1769 to 1771, the average annual production even reached 440 vessels of 21,000 tons and most of them were sold to the British market [Thiesen, 2006].

The early US shipyards were operated by "interpersonal" works. Shipwrights shared work ethic, gained skills from practical experience and handed down by intermarriage relationships or apprenticeships. They thought wood shipbuilding techniques and knowledge could only be gained from practice and passed on under the elders' guidance [Thiesen, 2006]. It was quite different from the UK shipbuilding which depended on professional books and formal educations. Even when the British applied professional engineering and designed ships by modeling test, American still inspected ships in ports with pencil and notebook in hand [Renninger, 1911].

4.3.1.2 Primary technology development

In the 19th century, scientific shipbuilding technologies were gradually accepted in US shipyards. These technologies were not from formal technological researches but practical work. Shipyards could use those practical based technologies effectively and introduced to the whole national shipbuilding industries. So, at the beginning of 19th century, US shipbuilding gained the primary technology development. Vessels were built of iron and equipped with steam engine, and the propeller replaced the paddle wheel for more powerful propulsion.

Shipyards at this time were enlarged in shipbuilding capacities. Apart from technology improvement, this development was also stimulated by many other reasons. Those reasons were as Renninger (1911) and Thiesen (2006) noted: a) during the 1820s, the shipping business created lots of newbuilding orders; b) government ruled that ships shipping near coast lines should be built by domestic shipyards; c) immigration from Europe to America needed lots of large passenger ships and; d) the military demand also created many newbuildings. In 1855, the annual production of whole national shipyards reached 2,024 vessels with the total capacity of 590,000 tons; and another 21 new professional naval shipyards were established by then [Thiesen, 2006].

Moreover, many academies were established to stimulate the development of formal education in shipbuilding. This included the Society of Nacal Architects and Marine Engineers in 1893 and the Webb Academy in 1894 focused on developing shipbuilding techniques. And universities such as MIT also created shipbuilding courses which contributed to the technology improvements in navy shipbuilding.

4.3.1.3 Booming and losing by wars

The US shipbuilding industry underwent a very important development during the

First World War period. According to Thiesen's (2006) book: from 1915 to 1919, the steel shipyards increased to 72 compared with only 42 before the war; during 1914 and 1918, the annual production of war ships increased from 65,000 ton to about 137,000 tons, and the annual production of commercial shipbuilding increased from 130,000 tons to about 1.67 million tons; and by 1918, the nation's shipbuilding capacity had reached about 1.5 million tons.

In order to prepare for the Second World War, the American Congress allocated a billion dollars to develop the US navy. As Lindberg and Todd (2004) noted, from 1938 to 1941, there were 4,500 new building orders from navy to domestic shipyards. They also concluded that the year 1944 also became the most noticeable year for shipbuilding: the shipyards increased from 38 in 1938 to 84 in 1944; the employment increased to about 1.65 million; 2,500 war ships over 2.86 million tons and 1,600 commercial ships over 12.5 million tons were built.

However, these shipyards contracted after WWII because of over-supply and relying too much on military demand. Shipbuilding production was decreasing in the years immediately after the 2nd World War. In the 1980s, the poor world's economy development as well as cancelled US navy-expanding projects again held back the business of shipyards. Many shipyards had nothing to do during their work time [Thiesen, 2006].

4.3.2 The British shipbuilding industry

4.3.2.1 Enhancing shipbuilding technologies

Compared with the US shipbuilding, the competitive advantage of UK shipbuilding was more advanced shipbuilding technologies. In the middle of the 19th century, the UK shipbuilding started doing research in scientific methods. Formal education was applied in researching advanced technologies to promote the producing of high quality materials and new ship equipments [Thiesen, 2006]. These factors made UK the most powerful competitor of the US in commercial shipbuilding in the later 1850s. In the second half of the 19th century, the UK shipbuilding industry reached a high peak in production: 80 percent of the world's newbuildings were from the British shipyards [Parkinson, 1960].

4.3.2.2 Expanding shipyard's business

After attaining supremacy, shipyards developed rapidly in business. After the 2nd world war, the government strictly controlled the establishment of new shipyards to avoid a surplus market. Therefore, shipyards changed their ideas to focus on extending their business. For example, as Table 4.2 showed, there were 5 large shipyards expanding their business in building all types of ships, and all the others could build at least two types of vessels. Many shipyards kept upgrading their docks, by which they could build as many types of vessels as possible. Meanwhile, there were 24 shipyards (Table 4.2) expanding their business in ship repairing.

Shipyards also applied integrations to expand business by the end of 19th century. As Table 4.3 shows, shipyards applied vertical integration by combining firms such as steel manufacturers and equipment manufacturers. For example, *"Swan, Hunter & Wigham Richardson Ltd"* owned a subsidiary company called *"Wallsend Slipway & Engineering Co. Ltd"* to produce steam and diesel turbines. Some shipyards applied horizontal integration with other shipyards. The *"Fairfield Shipbuilding and Engineering Co. Ltd"* and *"Wm. Hamilton & Co. Ltd"* joined together to form the Lithgow group; *"Joseph L. Thompson & Sons Ltd"* and *"Sir James Laing & Sons Ltd"* combined to become a new larger company. All these commercial activities helped expand shipyards' business in shipbuilding and many other fields.

Table 4.2 The Selected British Shipbuilding Companies in the 1950s

Location	Annual output in AVG (1,000 GT)	Building types	Largest building (ft.)
Scotland			
John Brown & Co. Ltd.	69	All types and repairs	1,000+
Lithgows Ltd.	65	Tanker, passenger vessels and repair	650
The Fairfield Shipbuilding and Engineering Co. Ltd.	44	All types and repairs	1,000
Blythswood Shipbuilding Co. Ltd.	36	Tanker and cargo vessels	600
Wm. Hamilton & Co. Ltd.	30	Tanker and cargo vessels	550
Scotts' Shipbuilding & Engineer.	26	All types and repairs	600
Harland & Wolff Ltd.	25	Tanker, cargo vessels, repairs	750
Alexander Stephen & Sons Ltd.	25	Warships, special vessels and repairs	700
Charles Connell & Co. Ltd.	24	Tanker and cargo vessels	580
Barclay Curle & Co. Ltd.	21	Tanker, passenger vessels and repair	700
The Greenock Dockyard Co. Ltd.	19	Tanker, cargo vessels and repairs	560
Burntisland Shipbuilding Co. Ltd.	30	Cargo vessels	450
Caledon Shipbuilding	22	Cargo vessels and repairs	560
Hall, Russell & Co. Ltd.	16	Cargo, colliers, repairs	400
England			
Swan, Hunter & Wigham Richardson	107	All types and repairs	1,000
Vickers-Armstrong Ltd.	60	All types and repairs	1,100
R. & W. Hawthorn Leslie & Co. Ltd.	46	All types	700
J．Readhead & Son Ltd.	29	Cargo vessels and repairs	500
Blyth Dry Docks & Shipbuilding	21	Tanker, cargo vessels, repairs	550
Wm. Doxford & Sons Ltd.	47	Tanker and cargo vessels	600
Joseph L. Tompson & Sons Ltd.	46	Tanker, cargo vessels, repairs	600
Sir James Laing & Sons Ltd.	38	Tanker, cargo vessels, repairs	650
Bartram & Sons Ltd.	38	Tanker and cargo vessels	525
Austin & Pickersgill Ltd.	29	Cargo, colliers,, repairs	500
Furness Shipbuilding Co. Ltd.	88	Tanker, Bulkers and Floating docks	700
Smith's Dock Co. Ltd.	39	Tanker, cargo vessels, repairs	520
William Gray & Co. Ltd.	36	Cargo vessels and repairs	480
CammellLaird Co. Ltd.	86	All types and repairs	1,000
Vickers-Armstrong Ltd.	50	All types and repairs	1,000
Harland & Wolff Ltd.	123	All types and repairs	1,000

Source: Parkinson (1960).

Table 4.3 The Early Integrations in UK Shipbuilding

Name	Output (1,000 h.p. / year)	Production	Belongs
David Rowan & Co. Ltd.	78	Steam and diesel turbine	A subsidiary of Lithgows
John G. Kincaid & Co. Ltd.	66	Steam-reciprocating and diesel	
British Polar Engines Ltd.	35	British Polar diesel	
Wallsend Slipway & Engineering.	80	Steam-reciprocating and diesel and turbine	Part of Swan, Hunter & Wigham Richardson Ltd
Parsons Marine Turbine	52	Turbine	Associated companies of Richardsons Westgarth & Co. Ltd.
North Eastern Marine Engineering Co. Ltd.	52	Steam-reciprocating and diesel	
Hartlepool Ltd.	26	Steam-reciprocating and diesel engine	
George Clark & North Eastern Marine Ltd.(NEM)	44	Turbine, diesel engine	

Source: Parkinson (1960).

4.3.2.3 Losing competition in the 20th century

It was technology that allowed UK to overtake the US in shipbuilding. In the early 20th century, British shipyards had already a) applied cranes, lifts and other machines to construct ships; b) developed advanced technologies through high quality human resources and; c) recruited well educated graduates from certain universities. Research institutions such as the British Ship Research Association and the Marine Engineering Turbine Research also supported shipyards by many building techniques as well.

However, the British shipbuilding still lost competition in the first half of 20th century. First of all, the over-dependency on home market brought shipyards the looser management, poor marketing, inefficient labour force and low productivity. Even if government gave much more financial support to shipyards, very little improvements could be seen [Jamieson, 2003]. On the other hand, shipyards lagged in upgrading technologies. For commercial reasons, shipwrights did prefer to do research by themselves rather than to share ideas. Few organizations connected with foreign countries to absorb new ideas just as the U.S. did earlier [Milne, 1957]. Moreover, shipbuilding was limited by the size of docks to build larger vessels. Some of these docks were not large enough to build large ships which were preferred by the market [Parkinson, 1960]. Indeed, there were also insufficient workers and engineers for shipyards. Even if benefited from education, there were still less comparable qualities of the workers in shipbuilding than in other industries [Journal of Commerce, 1955].

4.3.3 *The European shipbuilding industry*

4.3.3.1 Develop maritime accessory manufacturers

In the middle of the 20th century, the shipbuilding industry in Europe was rising. European shipyards built ships with high quality steel and various advanced ship equipments. Shipyards also made investments to build many different types of ships. This effectively supported the domestic demand, for example, Norwegian shipyards' newbuilding could fulfil over 88 percent of home-market demand in 1939 [Nordvik, 1983]. Moreover, in order to save raw materials and reduce building costs, shipyards developed advanced building methods. Such as welding was used more effectively, which became the one of the most advanced shipbuilding techniques in the world at that time [Nordvik, 1983].

Meanwhile, division and specialisation were commonly developed in European shipbuilding industry. Shipyards expanded their business in producing ship equipments such as engine, or shipbuilding facilities such as large crane, or other fields such as repair and conversion. Most of these expanded business showed strong competitive advantages in the world market [Nordvik, 1983]. The profit they earned from other business fields were used to balance the loss in shipbuilding during those depression years.

4.3.3.2 Unsuitable government management

One of the characteristics of shipbuilding in European countries was that developing under sufficient governments' financial support. As the WWI broke out in Europe, countries such as Germany, France and Italy gave money to their shipyards to build both war ships and commercial ships. In response to the requests from navies, their shipbuilding technologies were enforced to quickly upgrade during this time: a) new building materials were tested and applied to strengthen the hulls of warships and; b) new power systems were used for increasing the navigation speed. All those new technologies were used in commercial shipbuilding later.

Shipbuilding industry was fully controlled by government until the 1970s. It was noticeable that countries such as France and Italy nationalized their shipbuilding industry. However, a directly result was that shipbuilding industry relied too much on government supports which brought shipyards over-supply, inefficiency and low productivity. And this was the reason of European shipbuilding lost market shares when facing Japan and Korea, who, built ships cheaper and faster in later 1960s.

4.3.3.3 Lost in shipbuilding but won in accessory manufacturing

After the 1970s, the European shipbuilding industry faced many problems. Firstly, the outdated shipyards' facilities were inefficiency, and could only build ships in low quality. Shipyards could not build advanced vessels, and thus failed to attract new orders. Secondly, governments' supports were no more acting as an encouragement for development, but made shipyards loss productivity. Shipyards' workers were paid by high wages even if they had not done work on time [Nordvik, 1983].

In the last decades of 20^{th} century, European shipbuilding industry lost its supremacy to Far East in building ships. Countries such as Japan and Korea won market shares by more efficiency and low building cost in 1970s. Meanwhile, developing countries especially China, with much cheaper labor costs, created high pressure on European shipyards by the end of 20th century. Even if many European countries provided a high R&D investment in shipbuilding which aimed to catch up the efficiency and productivity, the result was not positive.

However, the European shipbuilding industry still maintained its competitive advantages from accessory manufacturing. This was mainly in designing and producing advanced ship equipments especially engines. The new power systems such the electronic control system was also developed as the most advance one in the world. Manufacturers such as MAN B&W Diesel Engine Company and Wartsila Diesel Engine Company even established subsidiaries overseas for creating new markets.

4.3.4 *The Japanese shipbuilding industry*

4.3.4.1 Government rebuilt shipbuilding industry

In 1860s, the capitalist revelation (Meiji reform) of Japan enhanced the government's control at shipbuilding industry. However, at that time, the Japanese shipbuilding industry was weak in human resource, their engineers were unskilled and the management was poor [Chida, 1990]. Later, as Japanese government realized that the stated-ownership did not connect the benefits between employees and employers, it started applying private-ownership in shipbuilding industry. But this development strategy did not work effectively at the very beginning, as the human resource and operation management of the shipbuilding industry was backward at that time.

Fortunately, from 1891 to 1918, the wars (these were Sino-Japanese war from 1894-95, Russo-Japanese war 1904-05, and the First World War) facilitated shipbuilding businesses. Shipyards then turned to strengthen structures and improve technologies. Advanced technologies and construction methods were introduced from foreign countries, especially, the UK. This quickly built up Japanese shipyards the advanced technologies in building war ships and commercial ships. It was not until 1910 that Japan could support all its national demand for newbuildings [Chida, 1990].

Moreover, in the1890s, Japan applied a series of policies to support shipyards to enlarge their production. That became one of the momentums that led to the Japanese shipbuilding industry's first peak. Shipbuilding enterprises then started competing for patents from overseas. For example, Kawasaki Shipbuilding gained the agreement to construct maritime diesel engine from Germany in 1911, and in 1914, domestic shipyards' annual production increased to 2,300 vessels of over 305 thousands gross tons [Chida, 1990].

4.3.4.2 Government's efficient management

The Japanese shipbuilding industry was once oversupply in early 20th century. Shipyards were surplus of newbuildings in 1920 [Chida, 1990]. Government took actions to reorganize shipyards to solve problems. For example, the shipyards named Harima Zosenjo and Kobe Seikojo were combined into a new company, with the aim of strengthening finance ability and taking advantages of both shipyards' technologies.

In 1929, a very famous "Scrap and Build Scheme" was applied to stimulate shipyards business. In this scheme, the old vessels were enforced to scrap and replaced by newbuildings. As Chida (1990) noted: there were 94 over 25-year old ships with 399,000 tons were replaced by 31 newbuildings of 199,000 tons in 1932; and another 11 old ships of 52,000 tons were replaced by 8 newbuildings of 50,000 tons in 1935.

There were also many other new policies carried out between 1930s and 1940s. The "Superior Ship Building Promotion Scheme" in 1931 prescribed financial support for building new ships, training human resources and researching technologies. In May 1942, the "Temporary Ship Control Law" (all the ships should be owned by the government) and "Shipbuilding Industry Law" (the government should manage the structure of the industry) were enacted to increase the productivity of shipyards. The 1947's "Programmed Shipping Scheme" was taken to promote the newbuildings by sufficient subsides.

4.3.4.3 Influences from economy development

From 1961, the booming of the Japanese economy provided shipyards with lots of newbuilding orders. In later 1960s, Japanese shipbuilding industry boomed quickly to become the world's leading producer. The total Japanese shipyards' production increased from about 2 million gross ton in 1961 to nearly 4.2 million in 1964, and about 14.2 million in 1973 [Chida, 1990].

However, the economic crisis decreased Japanese shipbuilding production. The rapid growth in the shipbuilding industry in Japan was disturbed by the oil crisis in 1970s. It was a heavy shock that the economic crisis decreased newbuilding demand which increased shipyards the risk of oversupply. Many shipyards thus faced huge losses or even went out of business between 1971 and 1980 [Chida, 1990]. Only few shipyards could change their development strategies effectively to reduce newbuilding orders, or balanced their loss by starting new businesses, for example, producing cars.

4.3.5 *The Korean shipbuilding industry*

4.3.5.1 Boom under government's development strategy

Korean shipbuilding benefited from government's development strategies. In 1972, the Korean government set shipbuilding industry as one of the most important export-orientated heavy industries to facilitate Korean industrialization. The world's economy recession in 1970s did not fluster Korean shipbuilding industries, as the government encouraged shipyards to catch the opportunity to expand. Companies like Hyundai and Daewoo were ordered and supported by government to expand their building capacities even the market had not enough newbuilding orders for them. This made Korean shipbuilding occupy nearly a quarter of the world's total capacity in later 1970s [Rhee, 1994].

Meanwhile, Korean shipbuilding industry developed specialization under government's enforcement. For example, with massive financial supports, the government stipulated that Samsung should focus on building high quality exploration ships, Daewoo should start building large tankers, and Hyundai should engaged in researching and building LNG carriers. Such a specialization increased the technological level of shipbuilding, especially in high value-added ships.

The Korean government also developed national shipping industry to provided shipbuilding industry a huge newbuilding demand. In the 1960s, the government's decision of building larger national shipping fleets provided domestic shipyards massive newbuilding orders. The total national fleet tonnage was increased from only 104,000 gross tons in 1962 to nearly 5.2 million gross tons in the 1980s, and almost all of these newbuildings were from domestic shipyards [Rhee, 1994]. Shipyards also expanded their building capacities during this time, as Table 4.4 shows: the average annual growth rate of shipbuilding capacity from the 1970s to the 1990s had reached 10.5 percent.

Table 4.4: The Annual Average Growth of Shipbuilding Capacity

Country	70s-90s (Avg. %)	1990-2005 (Avg. %)
Japan	-3.23	3.10
Korea	10.5	9.68
China	3.46	10.38
Other	-0.84	-3.11
World	-2.64	3.87

Source: OECD WP6.

Moreover, government promoted shipbuilding industry by developing other industries such as steel industry. As the domestic steel industry supplied the cheapest building materials for the shipbuilding industry, the newbuilding cost was reduced. In the 1970s, nearly all the shipyards were supported by domestic steel and all the building costs were decreased [Rhee, 1994]. Similarly, to the ship equipment aspect, government developed more than 500 manufacturers to supply electronic machines and engines to shipyards. And later, there were 85 percent of ship equipments could be fully supplied by domestic producers [Rhee, 1994]. Rhee (1994) also concluded that the total annual production exceeded 5 billion dollars which helped Korean shipbuilding save over 3 billion dollars each year.

4.3.5.2 Long-term national development plans

The Korean government could develop shipbuilding industry effectively was also because the long-term national development plans. The famous "*Five-year National Develop Plans of Korea"* played an important role in developing shipbuilding industry. Government gave shipyards the financial support, and helped them to create development strategies. With these financial supports, Korean shipbuilding could steadily expand building capacity as well as researching in new technologies.

Korean government also provided privilege to new technologies in shipbuilding. In 1984, the *Fifth Economic and Social Development Plan* became the keystone of a revolution to build up advanced technologies [Smith, 1985]. Government pushed the establishment of professional institutions for researching in the ship equipment field. Shipyards were prohibited to import many items of ship equipment, but were strongly encouraged to buy equipments from domestic manufacturers. Shipyards were also ruled to carry out innovations in building ships or producing ship equipments every year [Rhee, 1994].

4.4 Shipbuilding in the 21st Century

4.4.1 *The new shipbuilding market in general*

In 2000s, Korea, Japan and China were the world's top three shipbuilding powers. Their total global share increased from 60% in 2000 to over 70% in 2006 (Figure 4.2). Korean shipbuilding accepted new orders over 23 million CGT in 2007, more than half were high technical content vessels [China Shipbuilding Industry Report, 2007]. Japan had kept the second place for nearly 40 years, with the advantages in advanced technologies and efficiency in building special vessels such as VLCC. China on the other hand, was developing fast by improving productivity and expanding building capacities. The global share of new orders kept increasing from 2000, as Figure 4.3 shows: it even exceeded Korea to move into first place in 2007.

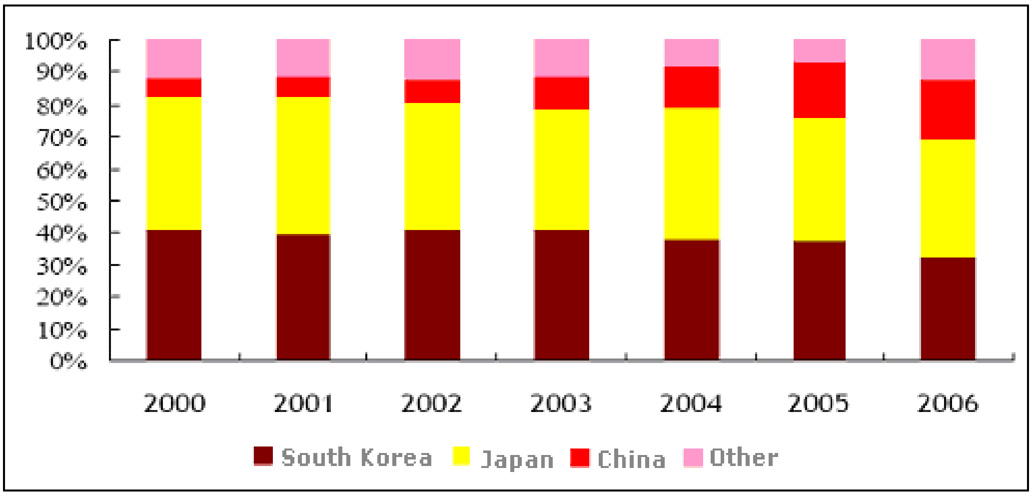


Figure 4.2 Proportions for Shipbuilding Completion

Source: China Shipbuilding Industry Report, 2007.

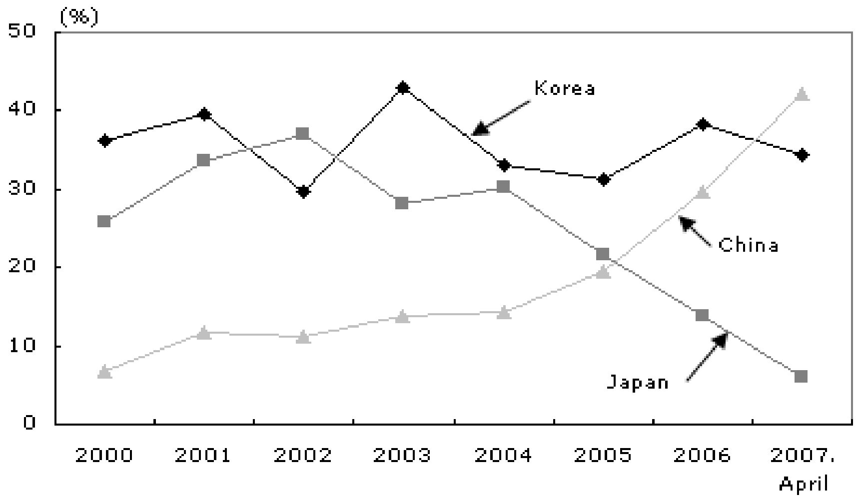


Figure 4.3 Shipbuilders' Global Market Share of New Orders

Source: Clarkson and Korea shipbuilder's Association, 2007.

4.4.2 *Vietnam*

Shipbuilding in Vietnam developed fast at the end of the 20th century. In later 1990s, Vietnam had established 20 shipyards and 14 maritime manufacturers including ship design, repairing and producing engines. The advantages of Vietnam shipbuilding were: a) minimizing newbuilding costs by the cheap labor cost; b) focusing on handy-size vessels that were easier for designing and building; c) attempting to reduce building time for quick delivering.

The Vietnam government set developing shipbuilding industry as one of the national development strategies. In 2006, the government reorganized its Shipbuilding Industry Cooperation and owned the majority of the group shares. It centralized national shipyards mainly in three business areas to develop the world-class shipbuilding centers. The government also supported shipyards newbuilding orders by establishing national shipping fleet. A 2.1 billion dollars national investment would be given to increase the national fleet, and most of those new ships would be built in domestic shipyards [Business in Asia, 2008].

4.4.3 *India*

The Indian shipbuilding industry was developed faster in 2000s. Indian government set a national development plan to promote domestic shipbuilding industry. That plan aimed to increased shipyards' production by building up the domestic shipping demand. The Indian government distributed over 5 billion dollars to introduce shipbuilding companies on the east and west coast, which aimed to supply shipyards more newbuilding orders [Indian Planning Commission, 2007]. Domestic shipyards were encouraged by government's financial support to expand building capacities as well.

Indian shipbuilding also faced many problems. One of the most noticeable advantages of Indian shipbuilding was low newbuilding cost [Indian Planning Commission, 2007]. However, the low efficiency and comparatively high service tax (say 12.24% in 2007) made shipbuilding extra costs and then lose competitiveness. There were also other disadvantages such as: a) there were few shipyards on the coastline; b) shipyards were small scale and weak in technology; c) the operation management system was inefficient; d) low quality infrastructures could not support the shipbuilding industry to build advanced ships.

4.4.4 *Thailand*

In 2000s, Thai shipbuilding was another new player in the global shipbuilding market. There were about 100 shipyards in Thailand in the 2000s, they specialized in building and repairing affairs, and the annual production achieved about 5,000 tons newbuilding and over 3 million tons repairing [Cholvijarn, 2007]. The Thai government attempted to manage its shipbuilding industry by reforming and organizing, and introducing foreign investment. It aimed to create shipbuilding a higher-level technology and productivity.

However, there were still many weaknesses. Firstly, large vessels could not be built or even repaired in shipyards. Cholvijarn (2007) noted that there were only 7 shipyards that could deal with ships over 4,000 tons. Secondly, the shipyards had a lack of engineers. Because of low wages, lots of skilled workers preferred to work in shipyards overseas such as Singapore. Thirdly, Thai shipyards also depended much on imported ship equipments. Over 60 percent of equipments were imported which increased the financial pressure of domestic shipyards [Cholvijarn, 2007].

4.5 Summary

In this chapter, researching in history, different characteristics were found in different countries' shipbuilding industry development:

- The US shipbuilding developed from wooden shipbuilding. In the 19th century, as the technology developed and military demand increased, the newbuilding production was booming to world's first place. But this lost US shipbuilding the market of producing commercial vessels.
- UK shipbuilding boomed and took the place of the US in later 19th century. Integrations in businesses promoted shipyards to expand businesses in other manufacturers. UK shipbuilding ultimately lost because government operated in a manner that was not as efficient as that of her competitors.
- European shipbuilding was developed under massive financial support from government. Division and specialisation were applied in developing accessory manufacturers. They lost ground on the competition in shipbuilding, but still won in ship design and producing ship equipments.
- Japanese shipbuilding developed under the government's efficient promotions. Government's policies stimulated shipyards' capabilities, and helped shipyards build up advanced shipbuilding technologies. The economic crisis led losing global shares.
- Korean shipbuilding was developed well under the Korean government's

development strategies. Government also developed other industries such as the steel industry and maritime machinery industries to fully support shipyards. But the increasing newbuilding cost since the end of 1990s was a big problem.

There were also developing countries whose shipbuilding industries developed noticeably in 2000s. One of the noticeable countries was China. Chinese shipbuilding was good in building advanced vessels with a considerable cheap newbuilding cost. This will be discussed in detail in the coming chapter.

Chapter 5. Chinese Shipbuilding

5.1 Introduction

The history of Chinese shipbuilding can be traced back to about 7,500 years ago [Xinhua News, 2002]. Newbuildings in ancient time had advantages in various aspects such as strong hulls, navigational aids, large dimensions and loading capacities. Indeed, Chinese shipbuilding contributed to many other countries' shipbuilding industries in the 7th century [Xi, 2000]. The "Close Policy" in the 15th century, however, led to the result of reducing business with foreign countries. It was that time that Chinese shipbuilding started declining and falling behind other countries'.

After the establishment of the People's Republic of China in 1949, Chinese shipbuilding entered into a new development stage. The people's government attempted to develop the shipbuilding industry by lots of strategies. After the 1990s, Chinese shipbuilding was booming again to become the world's third largest shipbuilding country. In the later 2000s, China occupied the world's first place in attracting new order books.

The development of Chinese shipbuilding in history showed many characteristics. Firstly, the strong national economy promoted lots of business opportunities for shipyards. Secondly, advanced technology was developed to support shipyards' efficiency and productivity in shipbuilding. Thirdly, the development strategies from Chinese government always played an important role in developing shipbuilding industry. This chapter will discuss these characteristics in detail.

5.2 The Ancient Chinese Shipbuilding

5.2.1 *Economy development promoted shipbuilding*

Investigating in the history, the ancient Chinese shipbuilding (before 1949) presented many characteristics. Firstly, the ancient Chinese national economy was strong, and it contributed to the shipbuilding industry development. The national economies in *"Han"*, *"Tang"*, *"Song"* and the first half of *"Ming"* were very powerful. The developed home-market provided lots of newbuilding demands. It stimulated the development of commercial businesses and a large demand for transportation, and then promoted shipyards' production [Xi, 2000].

The development of national economy also stimulated domestic shipyards to expand businesses. In the 7th century, the government's communications with other countries were more frequent, ships were used as the most important means for international business [Xi, 2000]. Building ships and developing a large national fleet became a demonstration of the very powerful national economy [Zhang, 1737]. Chinese shipbuilding was developed to a wide international market, and many new constructions were exported to foreign countries. It helped other countries (especially the ancient Japan) to develop their shipbuilding industries as well [Ouyang, 1060].

To the technology aspect, Chinese shipbuilding was the most advanced in the world before the 16th century [Xi, 2000]. According to the history records by Ouyang (1060), Toktoghan (1345) and Zhang (1737), the advanced technologies covered hull, deck, power and navigation systems. These were even learnt by many foreign countries to promote their shipbuilding technologies. For example, in the 7th century, Japanese missions brought Chinese technologies back to Japan for developing Japanese shipbuilding; the "Tang" government also sent engineers to Japan to teach shipyards the building techniques [Ishii, 1992; Kasumi, 1966].

5.2.2 *Government's affections*

It was those ancient Chinese governments influenced the development of shipbuilding and shipbuilding technologies. The ancient Chinese shipbuilding obtained development from wars as well. In the very instance of "Spring and Autumn Period" (770 BC ~ 467BC), "Warring States Time" (475BC ~ 221BC) and Han Dynasty (202BC), shipyards showed a very advanced technology in shipbuilding (see Appendix 1).

Shipbuilding industry in those times was so important to government. The reasons were: a) shipyards built ships for wars; b) it produced ships for national transportation of cargos like salt and iron which were of crucial importance to the national safety; and c) the governments could get taxes from both building ships and freight rate. For these reasons, the Chinese governments kept controlling almost all the national shipyards.

However, the government's policies also lagged the development of shipbuilding. The later "Close Policy" in 15^{th} century slowed down the economy and, restricted the development of shipbuilding. It made the Chinese shipbuilding fall behind foreign countries and even brought risks to national safety (e.g. China lost the Opium War in the 1840s as the weak battle ships).

5.2.3 *The home market*

The ancient Chinese domestic market created sufficient demand for many national industries' production [Hou, 2008; Wang, 1981]. The Chinese shipyards still developed between the 15^{th} century and the 19^{th} century after the government enforcing the close policy. The reason was because a large domestic market created a huge demand for transportation and newbuildings. The competitions in domestic market even contributed to the upgrading of technology and private shipyards [Xi, 2000].

5.3 Chinese Shipbuilding in the 20th Century

5.3.1 *World's third shipbuilding country*

At the beginning of 20th century, the Chinese shipbuilding industry was in depression. Although the wars could stimulate the development of shipbuilding and shipbuilding technologies, it did not happen in China as the wars only created debts (from war indemnities) for Chinese government. It exceeded the government's annual revenues, which then directly destroyed the national economy and industry systems [Ma, 2003; Wang, 2004; Wu, 2005]. The government thus did not have sufficient financial support for shipbuilding industry. This became the reason of why the Chinese shipbuilding industry could not develop well at the first half of 20th century.

After 1949, the new Chinese government started rebuilding the national economy. Then, the shipbuilding industry was fostered. Many shipyards were rebuilt in the 1950s and, they started learning technologies from foreign countries. At the very beginning, these shipyards could only build small passenger ships, bulk carriers and tankers for domestic transport. By learning technologies from other countries in 1960s, shipyards could build larger vessels for deep-sea shipping and special usage. In 1970s, China applied "Open Development Policy" which promoted shipbuilding industry effectively. Shipyards then had more opportunities to learn advanced technologies, and developed towards exporting ships to the world [Wu, 2005].

By the end of 20th century, the world's main shipbuilding center transferred from Western Europe to the Far East. This created much more business opportunities for Chinese shipbuilding industry. In 1995, the delivery of Chinese shipbuilding exceeded German shipbuilding to occupy the third place in the world (Figure 5.1). China retained this position, and attempted to increase the global share. As Figure 5.1 and 5.2 shows: the year 2004 was a notable year, the output exceeded 8.5 million gross ton, which occupied 15 percent global share [Xinhua News, 2005]; in 2006, Chinese shipbuilding produced ships at 14.52 million DWT, occupied about 20 percent of the global share [Chinese Industry Research, 2007]; in 2007, the data reached 18.93 million DWT of 23 percent of the world's total, more than 80 percent of newbuildings have been exported to over 100 countries and regions worldwide [China Investment Consulting, 2008].

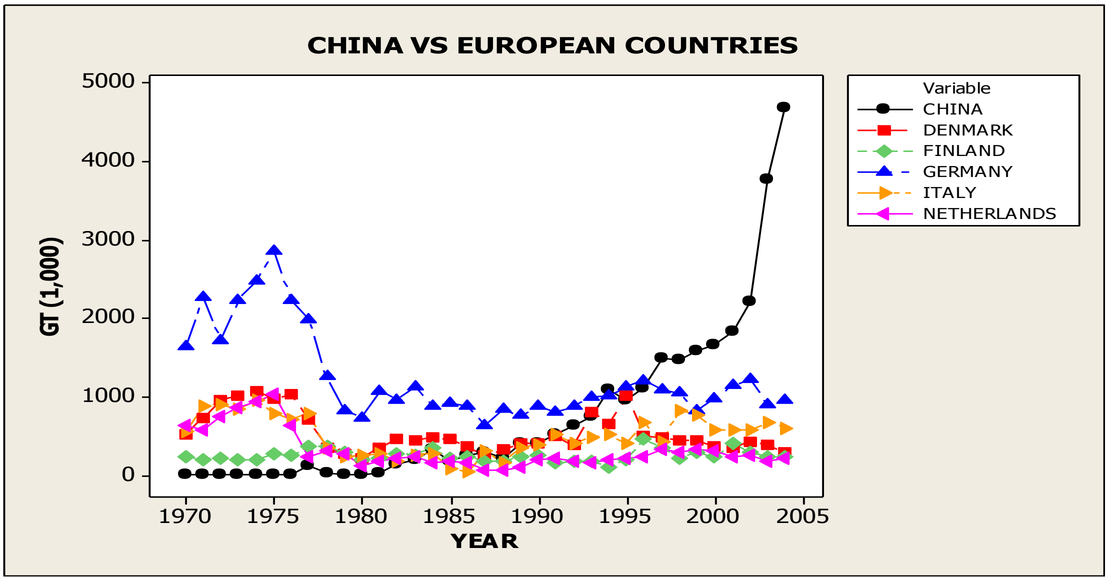


Figure 5.1 Chinese VS European Countries (1,000 GT)

Source: Data from Clarkson's statistics between 1970 and 2006.

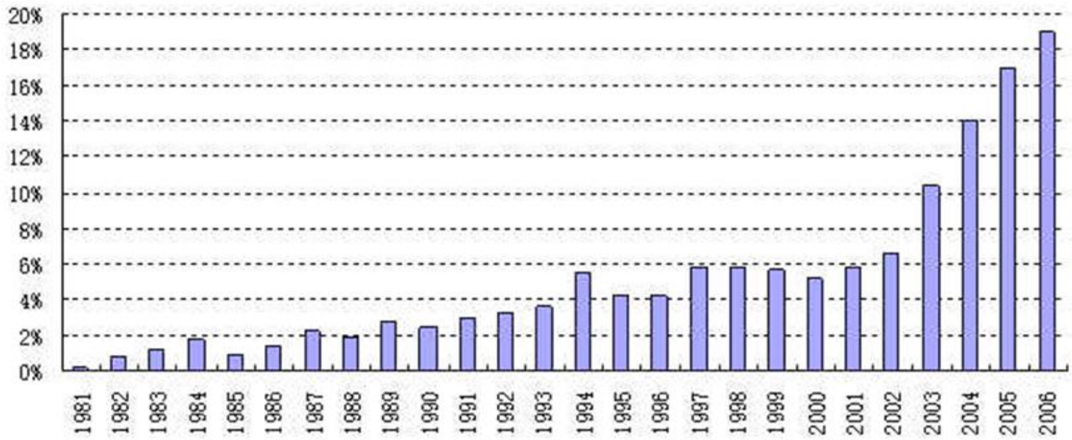


Figure 5.2 Global share of Chinese Shipbuilding

Source: Lloyd's Register's "*World Fleet Statistics*", 2006.

5.3.2 Characteristics of modern Chinese shipbuilding

5.3.2.1 Sufficient human resources

Shipbuilding industry was still a labour intensive industry. The labour cost was a crucial component of the total cost of shipbuilding. Even in the later 1990s, it still occupied more than 35 percent of total costs (Figure 5.3) especially in developed countries such as US. It indicated that cheaper labour cost was a comparative advantage for a shipbuilding industry.

China Shipbuilding Industry Corporation (2006) once noted that the labour cost in Chinese shipyards was very low. It was only one ninth of that in Korean shipyards and, one tenth of that in Japanese shipyards. For this advantage, those world-class shipbuilding companies such as Samsung and Mitsubishi all established subsidiary companies in China to minimize building cost [CSIC, 2006]. It might be seen that the Chinese labour costs would increase noticeably in the future, and then the Chinese shipbuilding industry would lose this advantage [China Science and Technology Statistics, 2007]. However, even if increased, it would still be lower than Korea and Japan as the economic situation (this will be discussed in chapter Six).

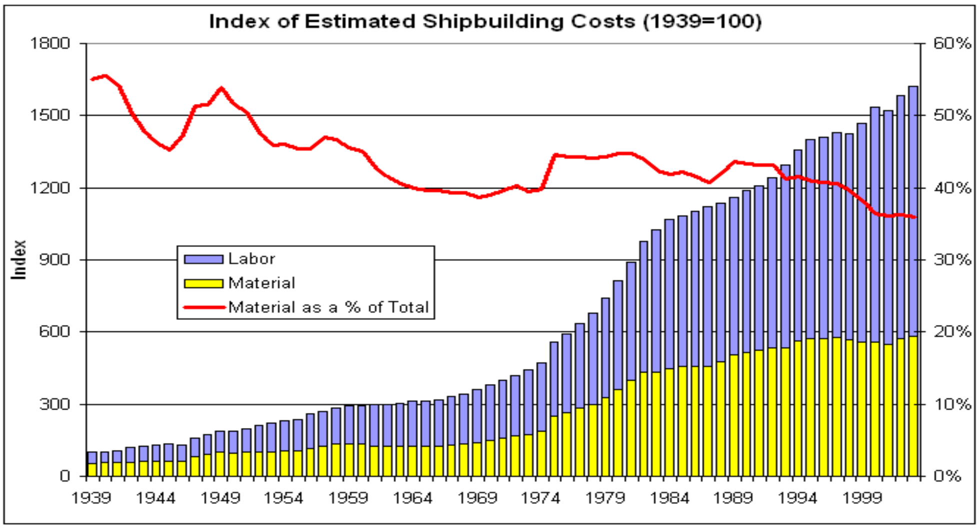


Figure 5.3 Index of Estimated Shipbuilding Costs (US)

Source: Bureau of Labor Statistics, 2009; extended by MBS, using the same data sources.

5.3.2.2 Good government support

The Chinese shipbuilding industry was benefit from government's efficient management. The strategies of Chinese government had taken were: a) developing shipbuilding industry by fostering a series of related industries such as steel industries and services industries; b) with the financial support, government zoned three shipbuilding bases in Bohai Bay, Changjiang Delta and Zhujiang Delta to establish the comprehensive industrial infrastructures; and c) government stimulated shipbuilding by developing national shipping business.

There were also national policies enacted to develop shipbuilding industry. In 2009, the Chinese government applied the *"Project for Adjusting and Enhancing the Shipbuilding Industry"* to develop shipbuilding. It was the first complete policy designed to optimize the shipbuilding industry. In addition, The National Development and Reform Commission (NDRC, 2008) had put forward a plan to make the Chinese shipbuilding the world's leading power by 2015. The policy package included tax breaks, open funding options and finance incentives to promote the industry's strategic structural readjustment.

5.3.2.3 Stable exchange rate

The exchange rate could affect international business and investment. Economists stated that if there were uncertainties in the exchange rate to be used for translation of currency it would create exchange rate risk [Maurice, 2005]. But in China, the stable exchange rate could reduce the investment risk for shipowners. Chinese currency had maintained in a very small change with the U.S. dollar. As Figure 5.4 showed, the Chinese Yuan appreciated against the US dollar from about 9.6 in 1995 to about 6.6 in 2010, which were a very little appreciation compared with other Asian countries. Compared to Japan and Korea (see Figure 5.5 and 5.6), it was stable enough to offer a better financial environment (reduce the risk of losing in exchange).

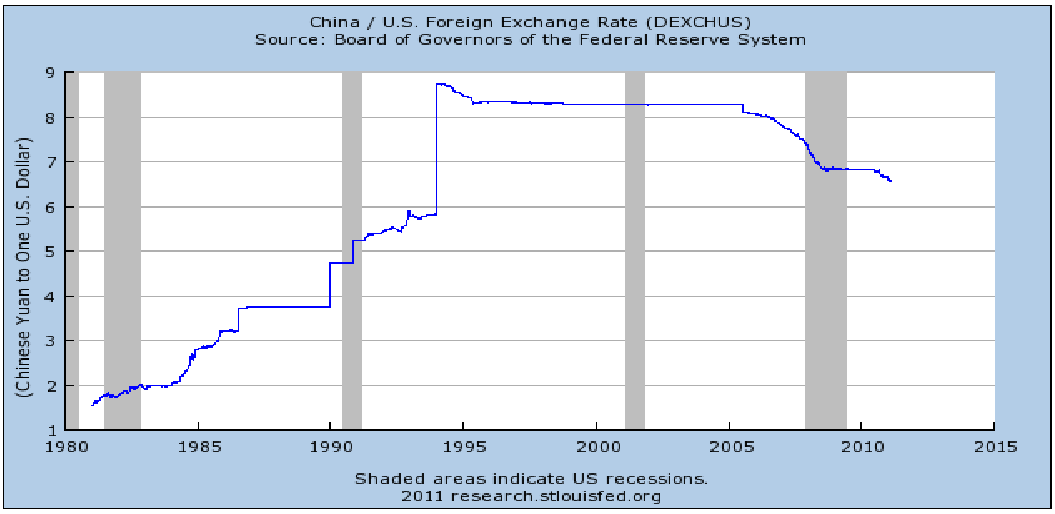


Figure 5.4 The Trend of Exchange Rate between the RMB and USD

Source: Board of Governors of Federal Reserve System.

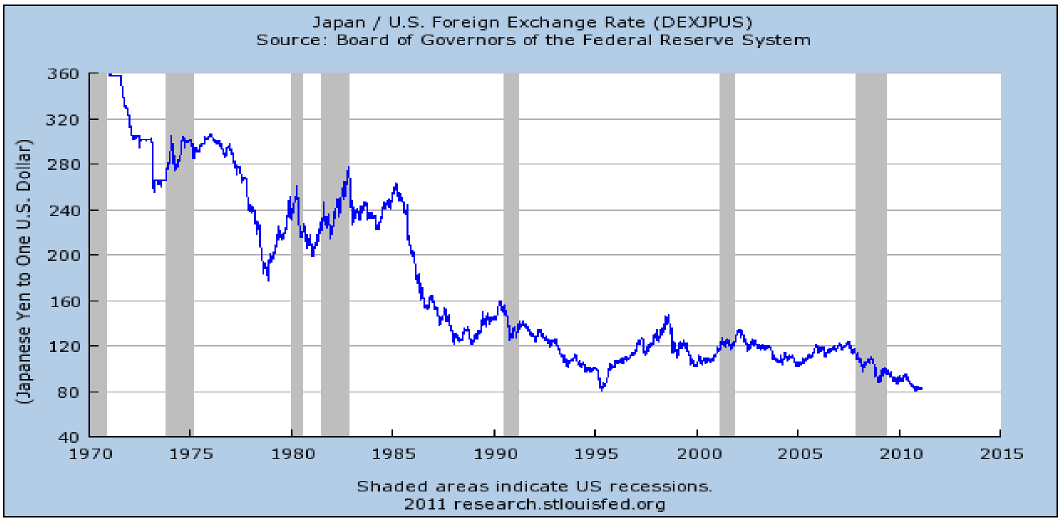


Figure 5.5 The Trend of Exchange Rate between the JPY and USD

Source: Board of Governors of Federal Reserve System.

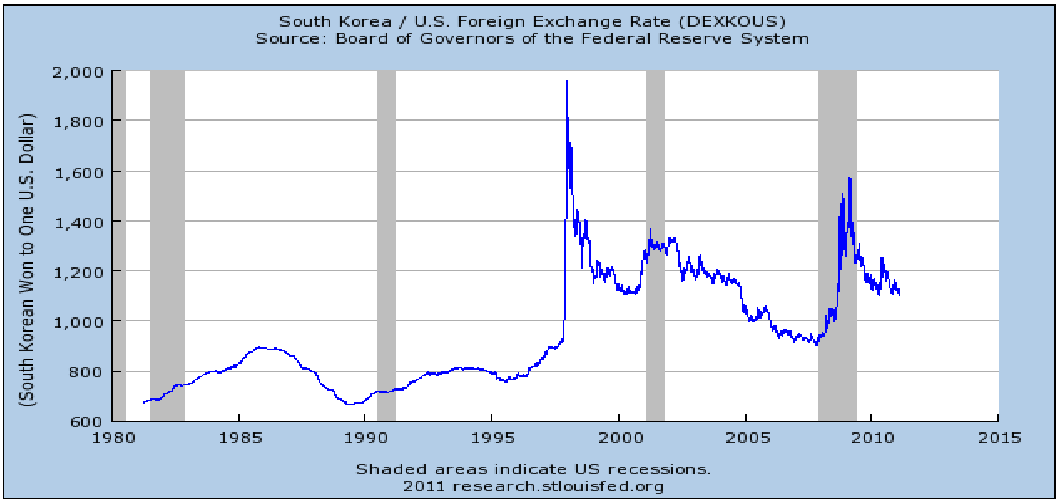


Figure 5.6 The Trend of Exchange Rate between the KER and USD

Source: Board of Governors of Federal Reserve System.

5.3.2.4 Developing technology

By the end of the 20th century, Chinese shipbuilding built the competitiveness in advance shipbuilding technologies. China was not only a competitive edge in its low labour costs but also the world-class technologies [Zhang, 2009]. Chinese shipyards improved the technology of producing high-tech and high value-added ships such as VLCC and LNG, etc. As the Liaoning provincial government (2009) reported, the shipbuilding industry had the major achievements in building self-designed panamax tanker, which was over 76,000 tons but could still pass the Panama Canal. Many Chinese shipyards improved the efficiency and productivity of building large vessels; they could reduce the building cost and time as much as possible [Zhang, 2009].

5.3.3 Potential problems

Chinese shipbuilding gained the most notable advantage of cheap labour cost. However, the rising economy would naturally increase wages, which brought potential problems to shipyards. The growth rate of the Chinese wage exceeded that of the United States and European countries to become the largest in the world [HG, 2007]. Chinese shipyards should enhance workers the technological skills and productivity, as this is more useful than trying to place constraints on the rising wage [Zhang, 2006].

There were also other weaknesses of the Chinese shipbuilding. Firstly, the Chinese shipbuilding was still weak in developing advanced shipbuilding technologies. Many middle-small sized shipyards were difficult in researching and innovating new technologies because of insufficient financial support from local governments. Secondly, the Chinese shipbuilding had not currently developed a systemic industry cluster, especially the accessory manufacturers. According to data from the China Customs (2006), about 80 percent of ship components such as engines and electronic operation systems were still need to be imported. Thirdly, the Chinese-produced steel plates could not completely meet the requirements of special vessels like LNG, but need some steel plates from Japan and Korea [Chinese Industry Research, 2007].

5.4 Summary

This chapter mainly discussed the Chinese shipbuilding in history. First of all, it was found that the Chinese shipbuilding industry developed much better when the national economy was flourishing. Secondly, the Chinese shipbuilding technologies were once the most advanced in the ancient world. Thirdly, the Chinese government always played an important role in developing shipbuilding industry. But the “Close Policy” after 15th century stifled the Chinese shipbuilding with repercussions, and the affects of this lasted until the 20th century.

After 1949, the Chinese government attempted to rebuild the national economy. The shipbuilding industry gradually recovered from the 1970s and, boomed again in the end of 1990s. China became the world’s third largest shipbuilding country in 1995. Those achievements were due to the national economy development, shipbuilding technology and government’s development strategies. The next chapter will explain why those three factors could develop shipbuilding industry.

PART THREE

DISCUSSION

- This part discusses and explains in more detail of how economic background, technology development and government management are displayed in the shipbuilding industry.
- Chapter Seven aims to prove that modern Chinese shipbuilding has obtained the necessary background to the economy which gives economic support to the shipbuilding industry. Chapter Eight discusses the importance of technology development in shipbuilding. Chapter Nine discussed the importance of government intervention in developing shipbuilding industry.
- All those chapters also show the discussion by referencing the most recent Chinese shipbuilding industry.

Chapter 6. Three Elements Support Shipbuilding

6.1 Introduction

Shipbuilding industry development depended upon: strong economic background, advanced technology, and efficient government administration.

- A strong economic background was the most basic factor in establishing and promoting the shipbuilding industry. The national economy development stimulated shipbuilding by providing skilled labour force, materials, and also creating business opportunities. The developed accessory manufacturers could supply various equipments, building tools and machines as well.
- Advanced technology was another factor of booming shipbuilding industry. Shipyards' advanced technologies were from both domestic research and overseas. They contributed to developing shipyards' competitiveness by improving efficiency and productivity.
- Government featured as another important role in developing shipbuilding industry. A good and efficient government management was represented by promoting shipyards by financial support, policies etc. This guided shipyards development and, solved problems that would not be solved by shipyards themselves.

This chapter explains how these three elements affected the shipbuilding industry and impacted on variations in its performance. The chapter also aimed to reach a discussion of how the differences between shipbuilding countries were caused by different ways of implementing each element.

6.2 The Developed Economic Background

The shipbuilding industry was established on a developed economic background. Global shipbuilding developed along with the increasing of world's economic activity [Stopford, 2009]. It was found that a country with more powerful economy was more likely to develop shipbuilding industry well. This was because: 1) economy development stimulated both domestic trade and international trade; 2) then a large demand of transportation was rising; 3) lots of ships were needed for transportation which boomed the shipbuilding industry.

A concrete example was Japanese shipbuilding in 20th century. As world's oil business increased noticeably in the 1960s, the large demand of tankers gave Japanese shipyards massive newbuilding orders. The Japanese shipyards were stimulated to build tankers, by which the Japanese global share of tanker delivery sharply increased to about 50 percent [Chida, 1990]. Many Japanese shipbuilding groups were established and expanded their building capacities at that time, or even created shipyards overseas [Japan Economic Foundation, 2003].

Economy development stimulated shipbuilding industry was a feature not only in Japan but also in many other countries. Some sub-factors in economic background could be summarised by their successful shipbuilding industries, those were: primary manufacturers, sufficient resources and good market condition.

6.2.1 *Primary manufacturers*

An industry that was highly technology- and capital- intensive developed from a large number of basic manufacturers [Famham, 1921]. Figure 6.1 showed a process of industrialisation was: 1) developed from basic industries like farming and mining to primary heavy industries; 2) after manufacturers were developing well, the high technology- and capital- intensive industries appeared. Countries could establish more advanced manufacturers on the developed low-level manufacture systems. Shipbuilding industry was the very case. As Siebert (2007) once noted, the strong support from fundamental industries allowed flourishing in high-technical-content manufacturers such as shipbuilding.

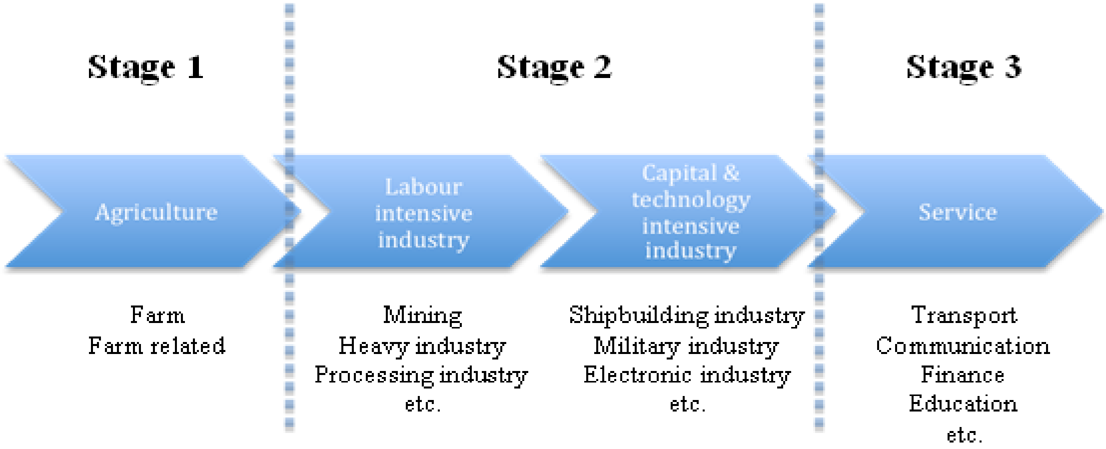


Figure 6.1 Stages of Industrialisation

In history, shipbuilding industry was developed based on those material manufacturers. American wooden shipbuilding was developed on the lumber industry, which provided the sufficient building materials. Those manufacturers could continuously supply shipyards with timber, and their tools for producing wood helped shipyards in effectively building ships [Thiesen, 2006]. Similarly, steel shipbuilding was developed well based on the steel manufacturers' support. The UK's steel manufacturers assured its shipbuilding industry a superior competitiveness, e.g. a cheaper but stronger hull [Clarke, 1986]. Indeed, in the 20th century, the Japanese and Korean shipbuilding became more powerful because of high-quality plates from their steel industries. They could take the advantages of those plates to build ships lighter and with better performances, especially like vessels such as Liquid Natural Gas Carriers and Chemical Tankers [Chinese Industry Research, 2007].

The development of shipbuilding industry also needed ship's equipments and construction machineries from manufacturers. In American wooden shipbuilding in the 19th century, many machine manufacturers produced lifting machines and the wooden hand-tools to support shipyards. In the UK, those manufacturers that produced metal handling machines supplied to shipyards in steel shipbuilding. In European countries such as Norway and Germany, the produced cranes, lifts and welding tools made it possible to build larger and stronger vessels. Korean shipbuilding also reduced the shipbuilding cost by ship component manufacturers.

6.2.2 *Obtaining sufficient resources*

International trade existed because countries had different resources [Porter, 1998; Frank & Bernanke, 2008]. And the commodities, which created by those resources were then transported between countries to fulfill the demand [Nelson, 2000]. Those countries who owned the superior or more coveted resources would frequently become the positive players in international business. This rule explained the international trade of the shipbuilding, as ships could be considered as a kind of commodity, shipyards' raw materials, labour force and industrial accessories (e.g. land, energy supply etc) were the very "different resources".

6.2.2.1 Raw materials for shipbuilding

Timber once facilitated the US as the world's largest shipbuilding nation. American shipbuilding in the 19th century developed primary technologies in constructing wooden ships, which became one of its competitiveness in world's market at that time. Shipyards were also established near wood resources to obtain efficiency and minimize building costs [Thiesen, 2006]. "They (shipwrights) cut the trees and hauled them out of the forest…transported those timbers by cart to the shipyards nearby and directly used for building" [Chapelle, 1988].

The British shipbuilding could occupy world's first place in the middle of 19th century was because of its sufficient metal resources and steel productions. The UK was once also a wooden shipbuilding country in the 18th century. The wooden shipbuilding failed in competition with the US later because of the insufficient wood resources [Thiesen, 2006]. However, its ample metal resources and steel industry redressed the balance by the end of the 19th century. Steel manufacturers were developed close to both mining and shipyards. The shipbuilding industry could thus use cheap steel to build ships with a stronger hull, and this helped quickly grab the business opportunities when the steel ship became the mainstream in world's market [Clarke, 1986].

6.2.2.2 Labour force

Labour force was another resource for the shipbuilding industry development. The original shipbuilding industry was less science-based but more labour-intensive. The early American shipbuilding was family based, and all the family members were building ships. This provided the US shipyards sufficient labour force. As the American Statistical Association (1918) once calculated, take the shipyards in New York for instance, the average number of workers in shipyards in New York had exceeded 100 in the 1850s, there was even a largest shipyard with 400 workers.

There was comparatively more research in the later 20th century regarding the significance of the labour force to the shipbuilding industries. The European shipbuilding gave the way to the Japanese industry in 1960s was also because of the labor problems (rising wages) [Stråth, 1987]. As Table 6.1 shows, in the second half of the 20th century, Japanese shipbuilding employment expanded significantly from 108,200 in 1957 to 246,500 in 1971, while those in European counties were decreasing. It was at this time that Japanese shipbuilding replaced European shipbuilding.

Table 6.1 Full-time Employment in the shipbuilding industry ('000)

	1957	1965	1971	1975	1978	1982
UK	294	221	189.4	78.4	72.1	60
W. Germany	92.8	73.2	67.4	46.8	31.3	27.6
Sweden	30.8	28.7	29	23.7	14.8	8
France	38.9	29.1	32.2	32.9	25.4	23.9
Denmark	23.9	24	25.3	16.6	12	11.2
Netherlands	55.8	46.8	47.6	49.7	39.3	34.4
Japan	108.2	169.3	246.5	183	137	116

Source: Date from Stråth (1987), included shiprepair.

In the 20th century, shipbuilding was still a labour intensive industry. However, during this time, the quantity of employment was not the only thing that shipyards should consider. Those workers should also be endowed with knowledge, experience and skills, and should work with high efficiency and productivity [Stråth, 1987]. American shipwrights found that building ships depended on practical experience was not enough, and so they learnt to establish formal education to train shipwrights and develop technologies in 20th century [Thiesen, 2006]. Similarly, in the 20th century, European countries, Japan and Korea were all developing their skilled human resources through formal education for both shipyards and maritime manufacturers.

6.2.2.3 Industrial accessories

There were also many other factors contributing to a successful shipbuilding industry. Firstly, shipyards needed advantages in geography such as a long coastline and deep draft. Shipyards were bounded to such a defined type of area, and were built in such locations in the river area or along the coastline [Colean, 1978]. Secondly, infrastructures were very important for industry operation. This was because shipyards needed more efficient logistics for transporting materials. For example, the early US shipyards were located near a wood resource where they could transport timber directly to shipyards [Thiesen, 2006]. Thirdly, shipyards also needed sufficient supply of energy such as water, fuel and electricity. Enough energy and, effective utilization of energy were both needed for better operation [Rajan, 2003]. In addition, the modern shipbuilding industry as a capital-intensive enterprise needed adequate financial support. A booming shipbuilding industry was based on the sufficient financial investment [Todd, 1985].

6.2.3 *Good market condition*

Based on historical research, shipbuilding market had been divided into domestic market and foreign market. They could both become a reason of booming shipyards' businesses. The home market could create massive demand for shipbuilding by expanding navy and national shipping fleet. Those massive domestic demands were usually coming out at the time when the foreign demand was insufficient [Kennedy, 1985]. For example, in both the 19^{th} and the 20^{th} century, American shipbuilding expanded its delivery several times was because of the US Navy contributed massive orders for domestic shipbuilding. Similarly, in Meiji revolutions in 1860s, the Japanese government attempted to develop its national fleet which boomed its shipbuilding industry. Shipping companies were encouraged to order newbuildings in domestic shipyards, and the shipyards thus were fully operating in shipbuilding [Chida, 1990]. This happened in Korea as well. As Rhee (1994) noted, the national fleet increased by 50-fold from 1960s to 1980s, many newbuildings were from domestic shipyards.

The international market on the other hand, also created lots of demand for shipyards. This was one of the most important reasons of why shipyards in European countries and Japan developed so quickly after the Second World War. For example, the increasing world's oil consumption in 1950s created significant demand for large oil tankers. The newbuilding orders were going out to world's shipyards, especially those in Europe and Japan. Even the Japanese shipyards who could build ships cheaply and quickly at that time were developing notably. They were not only enjoying the massive newbuilding demand but also undertaking considerable investments in expanding their building capacities [Chida, 1990].

6.3 Developed Shipbuilding Technology

Countries could establish a shipbuilding industry easily on the necessary economic background, and shipyards could also develop competitiveness from advanced technologies. But all these needed efficient strategies from government.

6.3.1 *Military stimulus to building capacities*

In world's shipbuilding history, it was military demand that stimulated shipbuilding technologies and expanded shipyards' building capacities. For example, in US shipbuilding, the wars did not destroy American shipyards but contributed to a rapid development. As Thiesen (2006) noted:

> *From 1915 to 1919, shipyards increased to 72 compared with only 42 before the war. In 1918, the new building capacity had reached about 1.5 million tons. During the WWI, the annual war ships delivery increased from 65,000 tons to about 137,000 tons, the volume of commercial ship was soared from 130,000 tons to about 1.67 million tons. The power system was improved and the navigation system was first used on the ship.*

Moreover, to prepare for the Second World War, the US shipbuilding developed more notably. The number of shipyards rose sharply, and 1944 became the year that was standing out in this respect, as Fassett (1948) described:

> *…. in 1938, the U.S. congress appropriated a billion dollars to build new*

ships, and the domestic shipyards supported American navy 4,500 new vessels in only three years time from 1938 to 1941. The number of shipyards increased to 84 with an employment of about 1.65 million at the end of 1941, it was 16 times as that in 1939. ... 2,500 war ships with a total capacity of 2.86 million tons were built… over 1600 commercial ships with 12.5 million tons were built at the same time, 50 times more than that in 1939.

Military demand could stimulate the development of shipbuilding technologies. The problem was, however, the shipbuilding industry might consequently lose the balance between military and commercial applications. The US shipbuilding was the very case that developed towards a military department in the second half of 20th century. The big risk was as Thiesen (2006) noted: depending too much on military demand, the newbuilding contracts were slumped and many shipyards went out of business once the military demand was reduced.

6.3.2 *Domestic research*

Shipbuilding industry developed technologies from domestic researches. This could be deduced from the turning point of US and UK shipbuilding. The early US shipbuilding preferred and relied much more on practical experience. They had no formal research facilities but attempted to evolve new technologies from practical experience [Thiesen, 2006]. This might fit well to small-scale workshops only, but it lost to UK later as shipbuilding needed more scientific and systematic production systems. The success of UK shipbuilding in the 19th century explained that the domestic research was the most important way of promoting shipbuilding technology. To facilitate technical research, a series of policies were used to encourage national-wide technology research [Parkinson, 1960]. Shipyards were encouraged to cooperate with academic research institutions and government departments to carry out research projects [Thiesen, 2006].

A country's strong research ability could promote its ability to maintain competitiveness in the world shipbuilding market. However, these generated new technologies should also be transferred quickly into practical usage, or it might lose competitiveness. Slowness in applying innovations to building ships could be an explanation of the decline in UK shipbuilding [Ingvar, 1983].

6.3.3 *Introducing foreign technologies*

Cooperating with foreign shipbuilding industry was another way to improve the shipbuilding technology. As The National Research Council of the U.S. (1996) noted:

> *Learning and combining these advanced technologies during cooperation, then self evolving new ones ......, this method can reduce technical risk, save capital costs, and also help facilitate commercialization with international standards.*

Japanese shipbuilding was an example that effectively took the advantages of integrating foreign techniques. Since the 1950s, the Japanese shipbuilding industry took over foreign shipyards that established in Japan before WWII, to learn the advanced designs of vessels and building techniques. New technologies thus could be innovated easily during this time, and shipyards could avoid the risks and save costs in exploring new technologies all by themselves [Todd, 1985; Chida, 1990].

Indeed, the development of world's shipbuilding industry was a process of technology transfer from one country to another. New shipbuilding countries always developed new technologies by learning from developed countries. Steel ship firstly appeared in the UK but the building technologies developed in European later. Another concrete example was in Japanese shipbuilding in the 1960s. As many European shipyards established sub-factories in Japan to reduce production costs, Japanese shipyards caught this opportunity to develop its own advanced technologies [Chida, 1990].

6.4 Efficient Government Intervention

Many countries' economic development underwent a progression from free-market to gradually increasing state intervention in market adjustment. In the 20th century, governments' interventions were rejected, as economists at that time believed the "invisible hand" of the free market could solve all problems in industries' development [McConnell, 2005; Friedman, 1975]. However, many countries' central governments still managed their economies, as the government did something that the "invisible hand" could not do. Developing countries controlled their national economies much more than developed countries [Chenery, 1959], and played an important role in solving "coordination failure" by policies [Bardhan, 1997].

In fact, state intervention had effected many good contributions in developing industries such as shipbuilding. The free-market theory might say that only the market should decide the price of newbuilding. But this was not accurate in the most recent shipbuilding market, as the newbuilding price was indirectly connected with government. For example, Warren (1998) noted that increasing material costs made shipyards defective in financial control in UK shipyards from 1969 to 1972; but it was the cooperation between the Ministry of Technology and shipbuilding industry that helped to solve the problem. Investigating in the history of shipbuilding industry development, many examples showed that different "forms" of government interventions had contributed to a success.

6.4.1 *National development plans*

Historically, countries had used national development plans to promote, stimulate and guide their economies in the long-term. The global economic crisis in the 1930s highlighted the weaknesses of operating the economy without such a kind of government intervention. Countries were always evaluating how to manage different industrial sectors. It was shipbuilding industry that had been featured in national development plans, rather than leaving it to free market. This was because shipbuilding was considered as very important to country's economy and national safety. And so the government would never loosen its control in shipbuilding industry but continued to make detailed long-term development plans.

National development plans presented many different ways in promoting shipbuilding industry. The US Congress made shipbuilding as one of the major suppliers for the navy, and thus regular plans were made for guiding the long-term development of the shipyards. European countries made plans to privatise shipyards, and there came compartmentalisation and specification as one of the development strategies to develop the whole maritime industry. Japanese shipbuilding relied much more on national plans to create a more systematic, reasonable and efficient industrial system [Morris-Suzuki, 1999]. Korean national plans were more specified for shipyards' performance by reducing shipbuilding costs by domestic material machinery manufacturers.

6.4.2 *Legislation for shipbuilding*

Government's management in developing shipbuilding industry was also represented by acting laws. Many countries' laws that used in shipbuilding were prescribed firstly to promote shipyards' business and performance. This could be deduced from those shipyards developed in US, Japan and Korea.

The laws that US government enacted for shipbuilding industry are shown in Table 6.2. Those laws were firstly carried out to prescribe subsidies and stimulate technical research to promote all shipyards' development [Thiesen, 2006]. Meanwhile, those laws that focused on naval shipbuilding objectives also offered vast new building orders to shipyards. And so the shipyards in the US had lots of business opportunities and gained the opportunity to enlarge their building capacities.

Table 6.2: Major Laws on US Shipbuilding

1789	All ships navigated on domestic rivers should be built in American.
1890	The duty on importing steel for shipbuilding was cancelled.
1936	"1936 Merchant Shipping Act": Government supports subsidies for domestic shipbuilding and repairing.
1938	Act to enlarge the Navy, appropriated a billion dollars for building vessels.
1950-1960	The government made several investments in building technical research, and expanded existed shipyards.
1970	"1970 Merchant Shipping Act": supports favorable subsidies for building ships which will employ domestic workers, fly the domestic flag and engage in international business. The subsidies can be half of the shipbuilding cost*.
1981	The Reagan government decided: 1). To expand the building of battleships; 2). To gradually cancel subsidies for the building of commercial ships.
1982-1985	Still provided subsidies for building special ships and battleships.
1997	"The agreement of maintaining shipbuilding capacity": those shipyards which accepted building orders for building both naval vessels and commercial vessels can obtain negotiable subsidies.

* From 1970-1985, the government supported about 57.6 billion dollars subsidies for shipbuilding and modifying business.

In the 20th century, the development of shipbuilding industry depended much more on laws. For example, the Japanese Transport Ministry issued eight laws for the shipbuilding industry (see Table 6.3). They (laws) effectively guided shipbuilding development by using various methods such as developing shipyards by building industry clusters, international business and commercial cooperation with foreign countries [Chida, 1990]. Hirohisa (2007) also noted that those laws controlled shipbuilding capacities or newbuilding quantities, they indirectly helped world's shipbuilding market go though economy crisis.

Table 6.3 Maritime Laws in Japan

Year	Maritime Law in Japan
1933	Ship Law
1933	Ship Safety Law
1950	Shipbuilding Law
1951	Motorboat Law
1953	Interim Shipbuilding Adjustment Law
1966	Law of Small Shipbuilding Enterprises
1978	Law of Fundamental Preparation for Shipbuilding
1980	Law of Ship Measurement

Source: Smith (1955) and Chida (1990).

Similarly, the Korean government followed the main maritime laws (Table 6.4) by providing financial support such as subsidies and bank loans for developing shipbuilding industry. Laws were also used in managing the homemarket in order to increase orders for domestic shipyards, building up advanced technologies and increasing domestic supply of ship equipments [Rhee, 1994].

Table 6.4 Maritime Laws in Korea

Year	Maritime Law in Korea
1962	Law of Shipbuilding Rewards
1967	Shipbuilding Promotion Law
1976	Shipbuilding Development Law
1980	Shipbuilding Law
1980	Law to Optimize the Shipbuilding Industry

Source: Rhee (1994).

6.4.3 *Other governmental interventions*

There were also many other forms of government interventions to shipbuilding industry. First of all, government carried out its management by various policies. In world's shipbuilding history, governments commonly used policies to develop shipbuilding industry. They were made from the national development plan and laws, and prescribed developing the shipbuilding industry in national strategy [Todd, 1985].

Financial support from government gave shipbuilding a competitive price advantage. The financial support such as subsidies, insurance and welfare were prescribed to stimulate shipyards' business and increase capital power. These financial supports were usually from government's financial department or national banks under government's authorities. Thiesen (2006) and Chida (1990) both noted those financial supports from governments to shipyards as: the US congress gave lots of money to shipyards for building warships; Japanese banks provided financial props including tax free or long-term loans to shipyards.

Moreover, the ownership of shipyards was another kind of management from government. Shipbuilding industry could be operated by state ownership or private ownership. The state ownership was used by governments to fully control industry, and the private ownership was used to stimulate industrial development in the market [Harrington, 1995]. Different countries' shipyards were developed under different ownerships according to the different national development strategies. For example, Japanese government privatised shipbuilding industry after 1860s (privatisation) to enhance their marketing capabilities; some European countries commonly nationalized their shipyards after the WWII for recovering national economy.

6.5 Summary

According to the research, the economic background, technology and government interventions were the three factors of a successful shipbuilding industry.

- To the economic background, firstly, shipbuilding was a highly capital- and technology- intensive industry which developed on primary manufacturers.

Secondly, national economy development supplied shipyards with sufficient resources such as capital and human, etc. Moreover, the developed homemarket and international market could create for shipyards lots of business opportunities.

- On the other hand, technology was the stimulant that brought shipbuilding industry the competitiveness. Shipyards could develop new technologies from both domestic research and foreign cooperation. Military demand was also another factor that stimulated shipbuilding technologies, such as that in the American shipbuilding industry.

- Moreover, the government management was also another reason of a successful shipbuilding industry. Government enacted national develop plans, policies and laws to promote shipyards' business, shipbuilding capacities and technologies. Indeed, government's actions such as financial support, managing shipyards' ownerships could also contribute to a shipyard's success.

In the following chapters, all these above factors will be discussed in detailed one after another.

Chapter 7. The Economic Background of China

7.1 Introduction

The shipbuilding industry was one of the most important national industries. Countries needed a developed national economic background to develop shipbuilding industry. In this chapter, elements of economic background (discussed in Chapter Six) are highlighted by the description of the Chinese shipbuilding industry in the 21st century.

Chinese shipbuilding industry benefited from the national economy development. Firstly, shipyards was developing and operating effectively on the developed basic manufacturer system. Secondly, Chinese shipbuilding had massive labour force, and its cost was very low which built up shipbuilding the most notable competitiveness. Moreover, the supply of Chinese shipyards that was fulfilling the market's newbuilding demand also contributed to a successful shipbuilding industry.

This chapter discusses these issues of the Chinese shipbuilding industry. It firstly discusses the importance of basic manufacturer system for shipbuilding industry. Investigating in the Chinese labour force would also explain the reasons why the shipbuilding was so labour-intensive and the cost was that low. Moreover, how "market sense" was presented and worked in Chinese shipbuilding industry will also be discussed.

7.2 Industrialisation

7.2.1 *Industrial conversion*

In the process of industrialization, countries' industry system developed from low industrial system to a higher level. And so the high-level industrial system needed the much solicited basic level systems [Famham, 1921]. When country's industrialisation was moving from agriculture (lower level) into manufacturer (higher level), there were lots of extensive and processing manufacturers developed. With their character of massive labour force, they were so called labour-intensive industries [Crouzet, 1972].

Many concrete examples have illustrated the fact that industrial conversion developed a more advanced industrial system, such as the development of Japanese shipbuilding industry. Before the 1960s, Japan relied much more on labour-intensive industries and processing manufacturers for its economy development, and then the Japanese shipyards were developed. Later, Japan vigorously developed higher education and the industrial system became more advanced technology (knowledge)-intensive in 1970s [Chida, 1990]. Shipbuilding industry thus transferred from labour-intensive to capital & technology-intensive. The massive cheap labour and advanced technology became the two primary competitivenesses of Japanese shipbuilding in 1970s [Chida, 1990].

7.2.2 *Capital and technology - intensive industry*

A capital and technology-intensive industry such as shipbuilding industry contained high capital and knowledge based professions. Except for developing on basic manufacturers, shipbuilding industry may have many other characteristics according to the summary from the research of Crouzet (1972), Peter (1978) and Kenwood (1982):

- Is large in size;
- Is large quantity of capital, labour, resources and technology;

- Is high technical content and productivity;
- Is high energy and material consumption;
- May relate to or operate in the military industry;
- May obtain accessory manufacturers.

Shipbuilding industry was considered as such a kind of industry. Firstly, shipbuilding industry was developed from developed basic manufacturers. Those manufacturers such as steel and machinery factories could fully support shipyards materials and building tools, or even helped promote shipyards' operation management. Secondly, shipbuilding industry was developed in large size, and built with large capital investment, labour force and materials. This could be deduced from the discussion of economic background of shipbuilding industry development in Chapter Six. Thirdly, shipbuilding industry promoted the development of new accessory manufacturers. A concrete example was Korean shipbuilding industry that developed many maritime light manufacturers for producing new and advanced ship equipments.

7.2.3 *The Chinese industrial system for shipbuilding*

The Chinese national economy was booming since 1970s. The national economy had an average annual growth rate of 7.5 per cent from 1970s to 2000s [World Bank, 2009]. The reasons were as Chinese Industry Research (2007) noted:

- Chinese industrialisation was developing quickly, which contributed to the high growth rate of national economy development;
- China had a large labour force, and was cheap, skilled and suitable for developing basic manufacturers which were labour-intensive;
- The stable national political-environment created sufficient capital resources;
- The "market economy" released manufacturers much productivity.

These reasons stimulated the development of shipbuilding industry as well.

7.2.3.1 Sufficient capital resource

The Chinese shipbuilding industry benefited from the large capital resource from Chinese Foreign Exchange (CFE). As Figure 7.1 showed, the CFE was increasing from only about 154 billion dollars in 1999 to over 1,946 billion dollars in 2008. This provided sufficient capital resources for industry such as shipbuilding developing towards capital and technology intensive [Li, 2009]. Moreover, Figure 7.2 showed the Chinese GDP has increased remarkably since 1999, during which a stable growth was obtained even at the world's economic crisis in 2008.

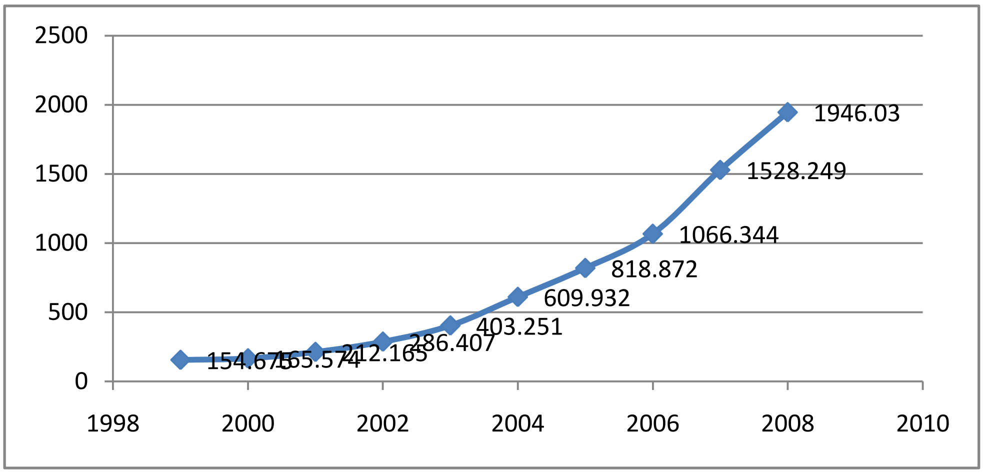


Figure 7.1 The Chinese Foreign Exchange (Billion Dollars)

Sorce: Data collected from State Administration of Foreign Exchange of China 2009.

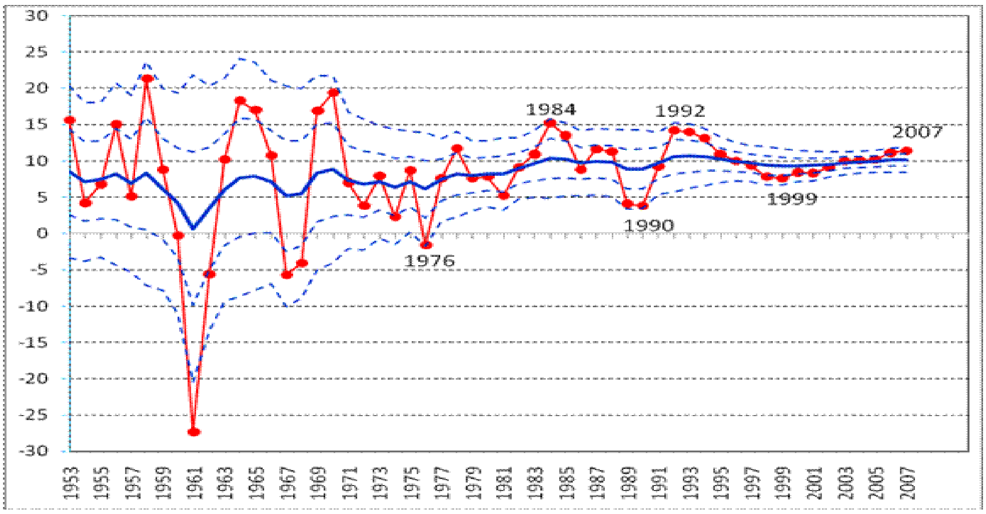


Figure 7.2 The Chinese GDP Growth Rate

Source: Chinese Statistics 2008; calculated by moving average blue curves.

7.2.3.2 Advanced technologies

Although Chinese shipyards' technology power was lower than that in developed countries, but it still obtained the competitiveness among developing countries. Chinese shipbuilding industry was attempting to enhance the efficiency and productivity, and was trying to establish an effective operational system. These will be discussed in depth in Chapter Eight.

7.2.3.3 Skilled labour force

Chinese education improved the quality of labour force, which supplied shipyards the skilled workers. As the report of China Academy of Science (2007) showed, in Table 7.1: the gross enrolment in 2006 was 106.3 percent in primary schools, 101.9 percent in junior schools, 57.7 percent in senior schools and 22 percent in higher education. The number over 100 percent was from re-education, e.g. a person who was 20 years old would join primary school again for re-education. Chinese shipyards could also benefit from a large quantity of skilled workers by higher vocational education (Figure 7.3). Workers from shipyards could still take trainings or professional educations for developing more technical skills.

Table 7.1 Gross Enrolments of Schools by Level

Year	Primary	Junior	Senior	Higher education
1995	106.6	78.4	28.8	7.2
1996	105.7	82.4	31.4	8.3
1997	104.9	87.1	33.8	9.1
1998	104.3	87.3	34.4	9.8
1999	104.3	88.6	35.8	10.5
2000	104.6	88.6	38.2	12.5
2001	104.5	88.7	38.6	13.3
2002	107.5	90	38.4	15
2003	107.2	92.7	42.1	17
2004	106.6	94.1	46.5	19
2005	106.4	95	50.9	21
2006	106.3	101.9	57.7	22

Source: China Academy of Science, 2007.

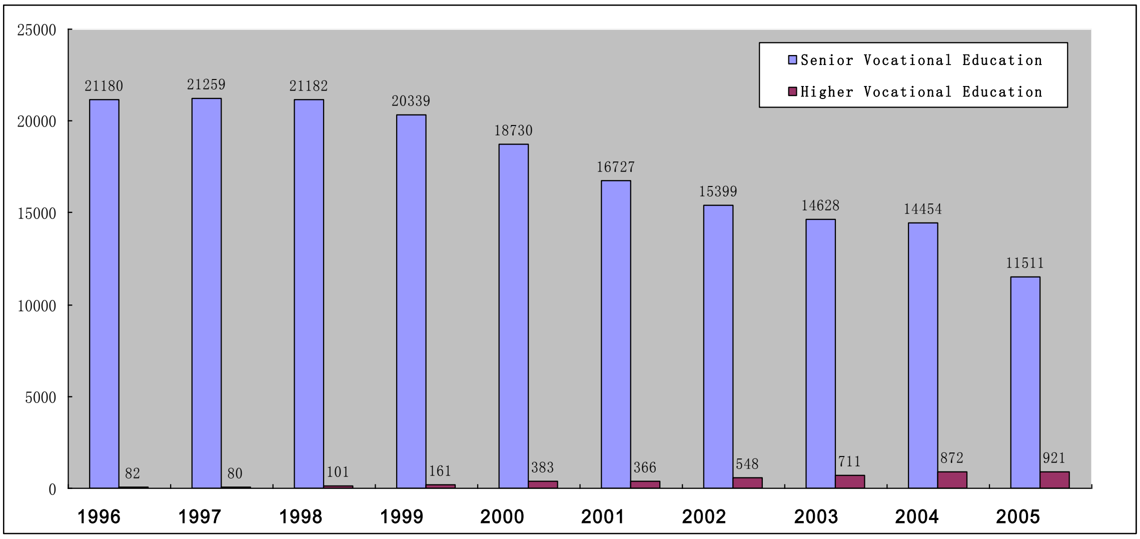


Figure 7.3 Chinese Vocational Educations

Source: China Academy of Science, 2007.

<u>7.2.3.4 Developed basic manufacturers</u>

Chinese shipbuilding developed well on the basic manufacturers. According to data from Chinese Industry Research (2007) (Figure 7.4), the basic manufacturers created the majority of GDP in 2007 at about 600 billion RMB. It evolved a complete industrial system from the energy industry to the processing industry [Li, 2009]. And shipbuilding industry thus could gain support from various suppliers such as steel and machinery manufacturers [Chinese Industry Research, 2007].

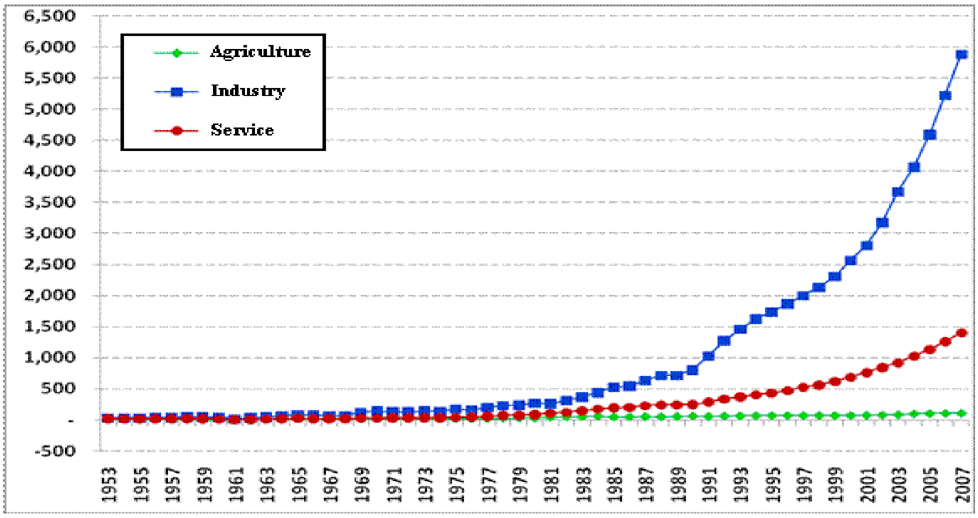


Figure 7.4 Chinese GDP Components (100 Million RMB)

Source: Chinese Industry Research, 2007.

7.2.3.5 Efficient government interventions

The Chinese government effectively supported shipbuilding industry development. In the *"Eleventh Five-Year Plan of Scientific and Technological Development"*, the Chinese government decided to increase the investment in research and development to two percent of the national GDP in 2010 (1.4 percent in 2006). Shipyards thus could have the government's financial support for developing more advanced technologies. With those capital supplies, Chinese shipbuilding thus could also keep expanding its building capacities as well as developing new technologies [Li, 2009].

7.3 Labour Force

7.3.1 *Labour in industrialisation*

Industrialisation stimulated the development of industry to strengthen the power of national economy and politics. In history, as Figure 7.5 and Figure 7.6 showed, the industrialisation in UK and France impacted the industry in 18th century to contribute more to the nation's GDP than the agriculture [Chambers, 1966].

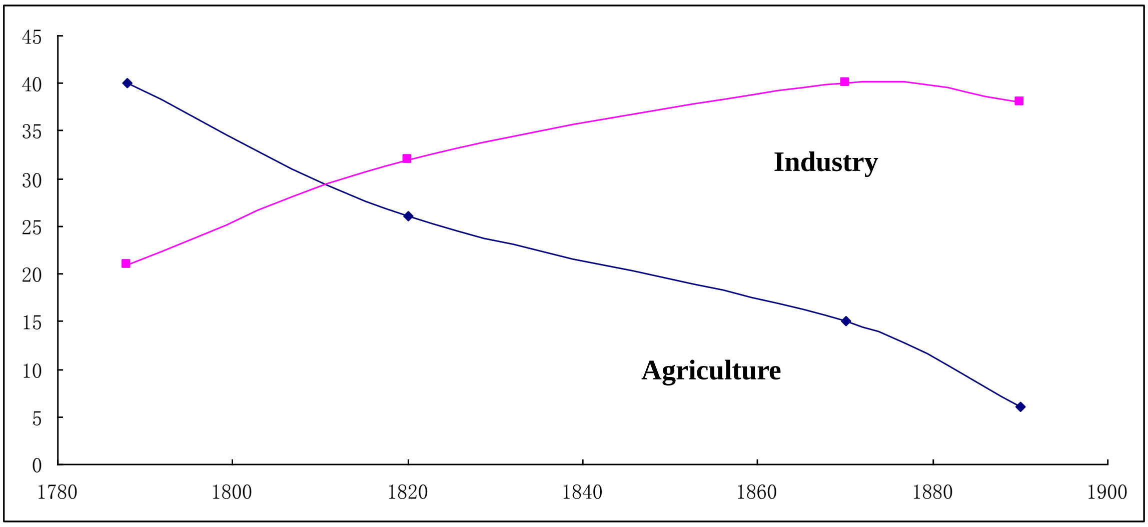


Figure 7.5 British Industries in National Economy 1780 – 1900(%)

Source: Edited based on International Historical Statistics: 1750～1993, Europe.

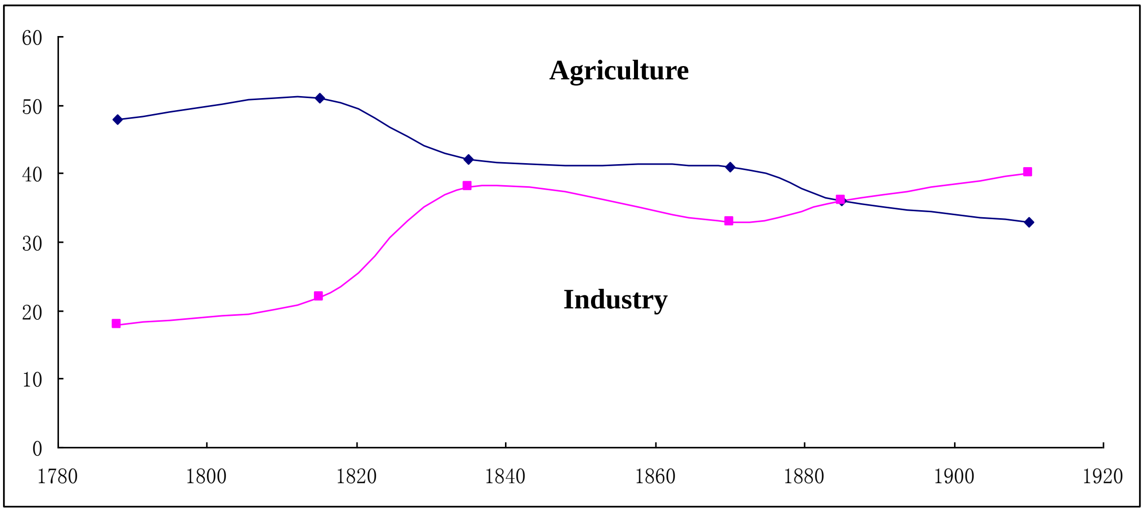


Figure 7.6 French Industries in National Economy 1780 – 1920(%)

Source: Edit based on International Historical Statistics: 1750～1993, Europe.

During industrialisation, industrial departments often had enormous authority, privileges and unequal status in accessing social resources [Chambers, 1966]. One of the most important social resources was labour force. The early industry development had a large consumption of labour force which was usually from agriculture departments [Chambers, 1966]. That labour force was cheap and can then be used to achieve original capital accumulation for future industrial development [Marx, 1848]. Again take the British and French industry development for example, as shows in Figures 7.7 and Figure 7.8, the employments in their industrial system were larger than that in agriculture. The low wages and large quantities was the reason of stimulating their progresses of industrialisation [Sidney, 1982].

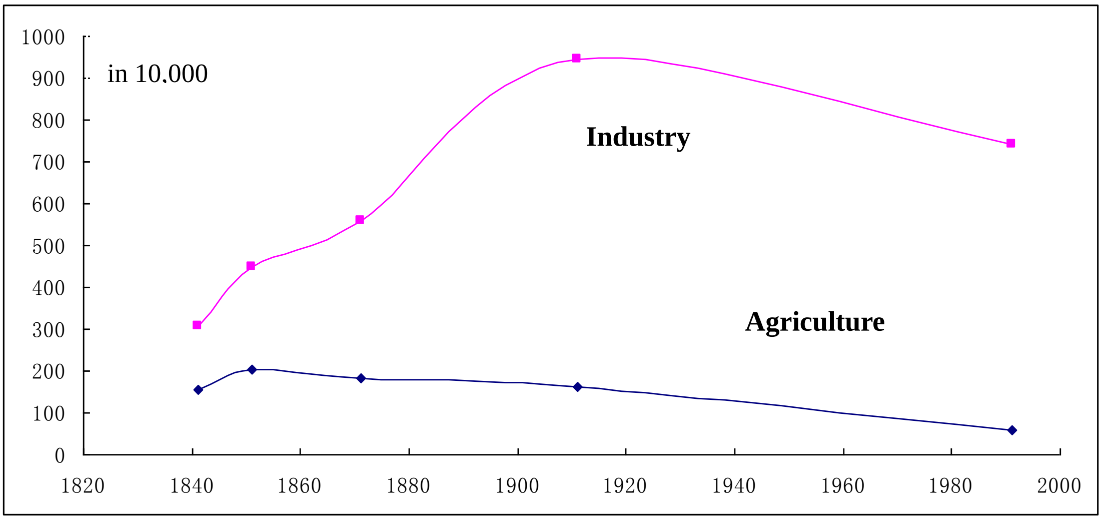


Figure 7.7 Labour Changes in British Industry and Agriculture

Source: Edited based on International Historical Statistics: 1750～1993, Europe.

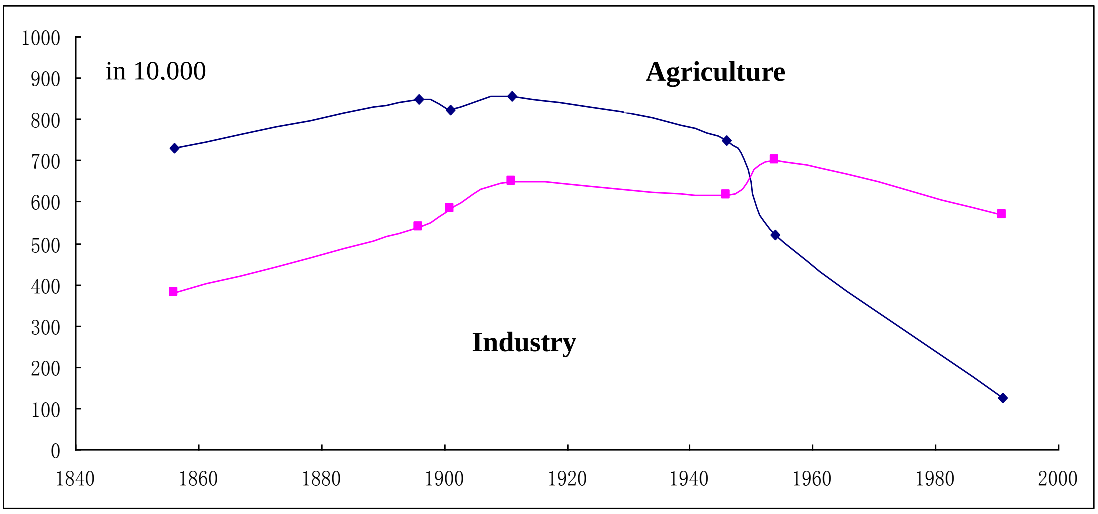


Figure 7.8 Labour Changes in French Industry and Agriculture

Source: Edited based on International Historical Statistic: 1750～1993, Europe.

7.3.2 *The cheap labour force of China*

Similarly in China, industrialization created sufficient labour force for industry development. Xu (2005), Zhang (2006) and Tian (2006) all concluded that the Chinese government extracted resources (mainly the labour force) from agriculture to lay the foundations for industry development in 1950s. Even after the 1970s when the new Chinese government applied the “Reform and Open Policy”, industrialisation still continuously created inexpensive labour force from agriculture departments. This proved sufficient labour for shipbuilding as well as other advanced industry sectors.

China could become the “World’s Factory” was mostly because the massive labour force and low price performance. It was the human resource that could fuel national economic development [Sidney, 1982]. In China, new workers reached at least 15 million in 2005, many of them were from rural areas and universities [CHINAPOP, 2005]. Such a large human resource even brought the imbalance between workers and jobs. It was not the economy crisis that decreasing the employment in China but the surplus supply of labour force [Long, 2002; Zhang, 2006; Cai, 2008]. Therefore, the price (wage) of Chinese labour was very low. It was much cheaper than many other countries. As showed in Figure 7.9: Chinese wage was at only 0.7 dollars per hour, and only increased to 0.9 dollars in 2007, while the Japanese wage and the Korean wage were 30 times and 20 times higher comparatively.

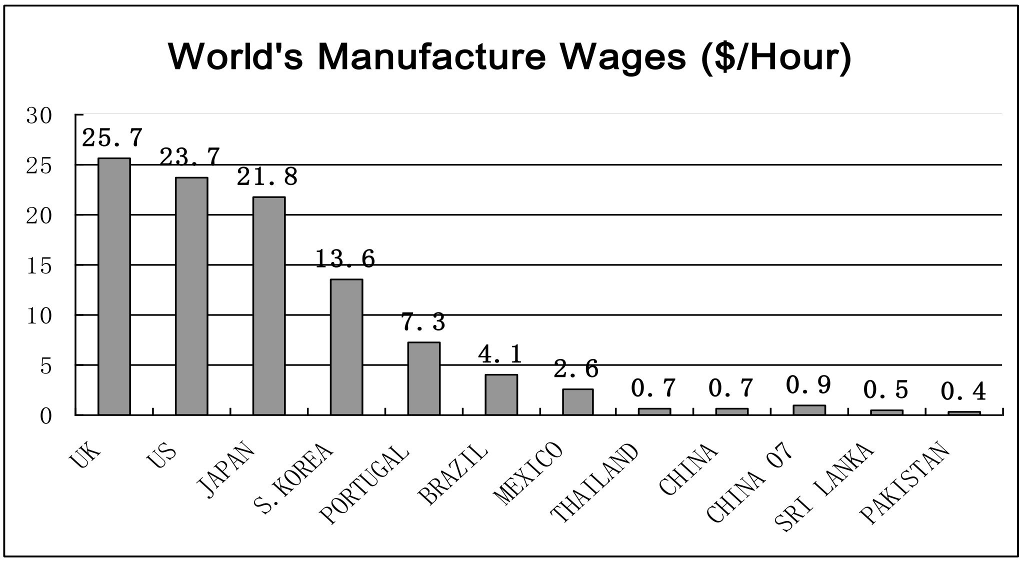


Figure 7.9 World’s Manufacture Wages

Source: International Labour Organization (2009), Chinese Industry Research (2007).

Chinese labour force would keep cheap in the future for a long time. Similar conclusions could be found from the reports from those research institutions such as Hay Group (2006) and the National Bureau of Statistics of China (2008). Chinese wage increased from the year 2000 onwards with the annual growth rate exceeded 10 percent (Figure 7.10). However, to the labour-intensive industries such as shipbuilding, this growth contributed to only a small addition when considered other factors, e.g. the quantity. And the labour force would still be cheap as the worker's productivity was increasing, which could be noted as the Chinese wages was formerly in long-term low-level growth [ILO, 2009].

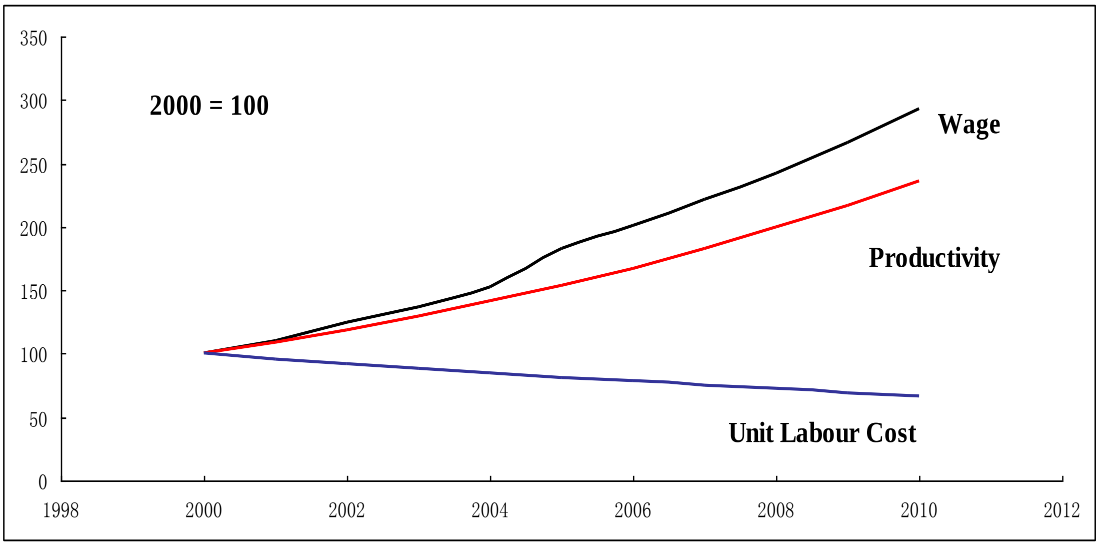


Figure 7.10 Chinese Labour Cost

Source: Created by author based on the statistics from *National Bureau of Statistics of China*, *2008.* The addition of wage was high, but the unit labour cost was decreasing as averaging by the whole population, which also means the gap between rich and poor was enlarging.

7.3.3 *Shipbuilding productivity*

Chinese shipbuilding industry had a larger employment when compared with other countries. According to the Chinese Industry Research (2007), see Figure 7.11, Chinese shipbuilding industry had 840 shipyards (including private small shipyards) with the total employment over 380,000 in 2006; at the same time, the employments in

Japanese shipbuilding industry and Korean shipbuilding industry were 60,000 and 93,400 respectively. Moreover, the new addition of employment was also larger than other countries. As Chinese Industry Research (2007) calculated, since the year 2000, Japanese shipbuilding and Korean shipbuilding had an annual new employment at about 500 and 700 respectively, but it was 1,500 in Chinese shipbuilding.

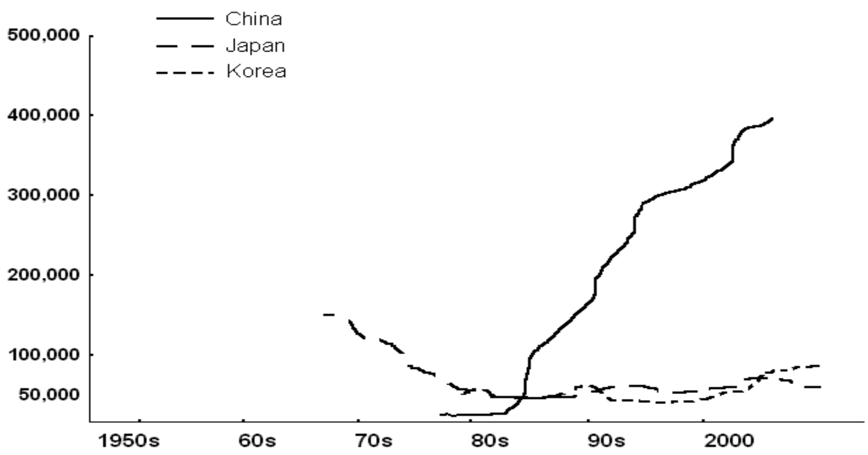


Figure 7.11 Shipbuilding Employees in General

Such a large quantity of manpower might create the problem of low productivity. For example, according to the research in Table 7.2, the average wage per person in Chinese shipyards was about 3,880 dollars in 2006, much lower than that in Japan and Korea (36,237 and 16,684 dollars respectively). However, the productivity of Chinese shipbuilding was much lower than the others', for example:

- Compared by the building time, as Jiang et al. (2006) noted, to the national average level, Japan and Korea could build a VLCC (150,000 DWT) in less than 12 months, but may need 16 months in China;
- Compared by quantity of production, Japan and Korea could build more vessels than China when operating under the same conditions. A Hyundai shipyard maintained the record of building 18 vessels of 1,650,000 DWT in a year but the selected large Chinese shipyard with the same capacity only built 6 vessels of around 500,000 DWT [Chinese Industry Research, 2007].

Table 7.2 The Shipbuilding Productivity in 2006

	Japan	Korea	China
Dollar / man year	36237.6	16684.8	3880.8
CGT/ man year	185.6	123.73	17.54

Source: Data from Institute of Scientific and Technical Information of Shanghai, 2006.

Therefore, the low productivity would become the reason of losing the competitiveness of cheap cost in Chinese shipbuilding. Take the data from the shipbuilding in Japan, Korea and China, and calculated them by simple methods, the results that showed in Table 7.3 and 7.4 (index) highlighted the problem of current low productivity in Chinese shipbuilding. Korea could produce newbuildings nearly at the same volume of Japan but save about one billion dollars, whilst China spent nearly the same amount of money as Korea but only got half of its productions. Regarding to the cost of producing one CGT, Korea was 135 dollars, Japan was 195 dollars, but China needed about 221 dollars.

Table 7.3 The Performance of Shipbuilding Industries 2006

	Japan	Korea	China
Dollar / man year	36,237.6	16,684.8	3,880.8
CGT/ man year	185.6	123.73	17.54
Employment	70,000	93,000	380,000
Dollar/year	2,536,632,000	1,551,686,400	1,474,704,000
CGT/year	12,992,000	11,506,890	6,665,200
Dollar/CGT	195.2	134.8	221.2

Note: the used the equation for calculation were: Production = Employment × CGT/ man year; Cost = Employment × Dollar/ man year; Productivity = Cost / Production (Dollar/CGT).

Table 7.4 The Performance Index of Shipbuilding Industries 2006

	Japan	Korea	China
Dollar / man year	933	430	100
CGT/ man year	1058	705	100
Employment	19	25	100
Dollar/year	172	105	100
CGT/year	194	173	100
Dollar/CGT	88	61	100

7.3.4 *The future trends*

The future trend of shipbuilding in productivity could be induced as that shows in figure 7.2 The Chinese shipbuilding would improve productivity in the future: the cost of labour would slowly increase but the productivity would increase quicker. The slope coefficient of the curve of the Chinese shipbuilding was larger. This was quite different in shipbuilding industry in Korea or Japan whose productivity would slowly increase but the wages would increase quickly. The reasons were: 1) the Chinese labour force was continual growing and keeping cheap, 2) shipyards were aiming to enhance productivity to win more business opportunities.

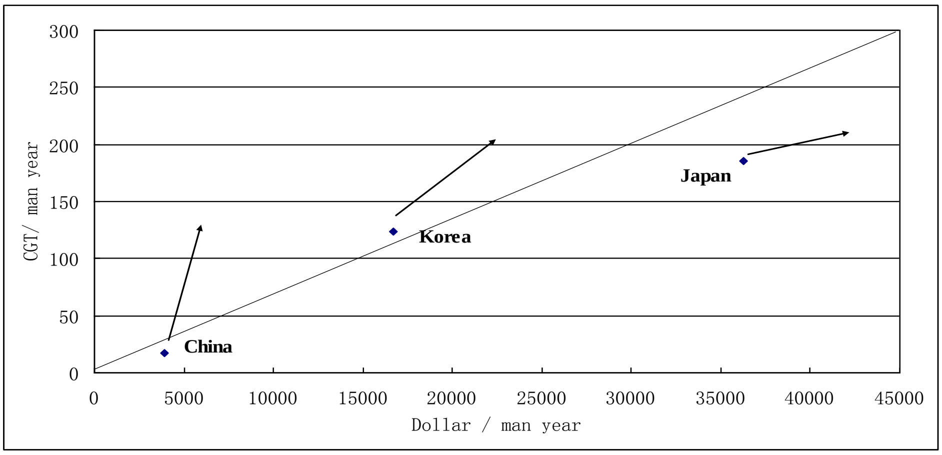


Figure 7.12 Shipbuilding Productivity Trends

Note: the Chinese productivity increases faster than its cost and so its trend line was much vertical.

7.4 Shipbuilding Supply and Demand

7.4.1 *Chinese shipbuilding supply*

In ancient time (before 20th century), Chinese shipyards were mainly located in or near the main ports. Those ports were in the cities near the coastline such as Shanghai and Ningbo [Xi, 2000]. Many of these shipyards still existed in 2000s and contributed to the development of three shipbuilding centers: North East, Yangtze River Delta and Zhujiang River Delta.

These three centers developed different performances of shipbuilding industry. Their detailed characteristics are described in detail in Appendix 2. Those main shipbuilding provinces within these three centers were all carrying out their own development strategies to develop their shipyards in 2000s. However, without an efficient government control, the current Chinese shipbuilding may face the problem of surplus building capacity. As Li (2009) from the China Ministry of Industry and Information Technology noted, the Chinese shipbuilding capacity reached twice of world's total newbuilding demand in 2009. But a potential problem may be lagging the nation's shipbuilding development in future 10 years [Chinese Industry Research, 2007].

7.4.2 *Shipbuilding demand*

The quantity of world's seaborne trade directly impacted world's newbuilding demand. Firstly, the world's industry production could influence the development trend of the seaborne trade. General statistics could also be seen from the Figure 7.13. For example, world's seaborne trade was decreasing during the world's oil crisis in 1970s, and it started increasing again when the world's economy began to rise after 1980s. Secondly, the world's newbuilding demand had a strong relationship with the volume of world's seaborne trade. This could be explained by the statistics data from Lloyd's Register

2008 as shown in Figures 7.14 and 7.15. There were four small cycles of booming newbuilding orders including 1996~1998, 1999~2001, 2002~2004 and 2005~2007. In these cycles, the newbuilding contracts soared at the beginning and dropped at the end, which totally followed the fluctuation of world's seaborne trade in those years. The world's total orderbook was thus rising and decreasing as well.

Chinese shipbuilding industry was developed well in those years when the world's newbuilding demand was rising. The booming period fully followed the world's seaborne trade developments. Shipyards' businesses were booming notably after 1995, as because the world's international trade was booming as well [Jiang, 2006]. Both the foreign and the domestic shipping company who were expanding their fleet in those years provided Chinese shipyards the massive newbuilding orders [Li, 2009].

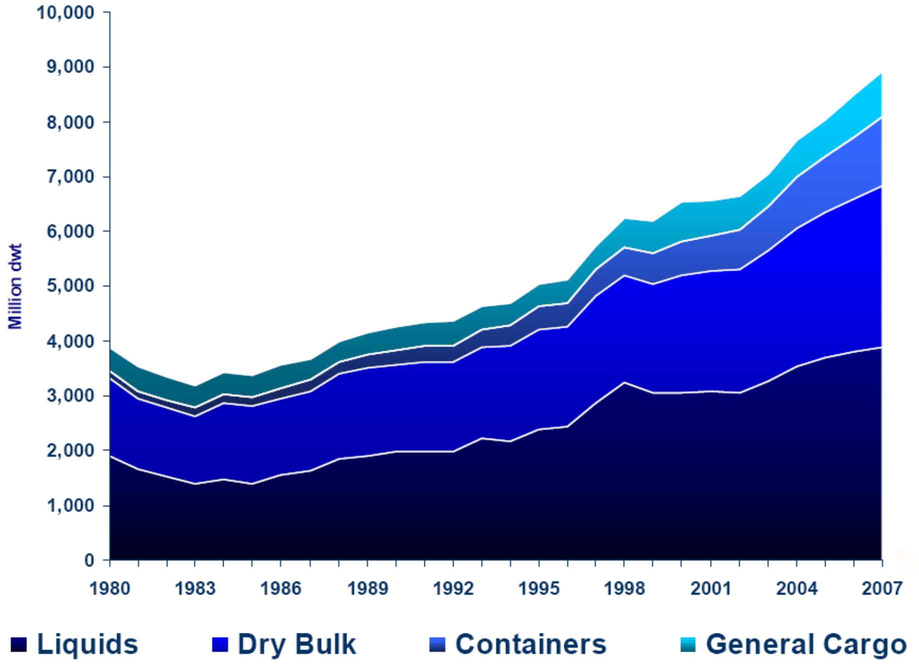


Figure 7.13 The World's Seaborne Trade

Source; Modified based on a report from Lloyd's Register 2008.

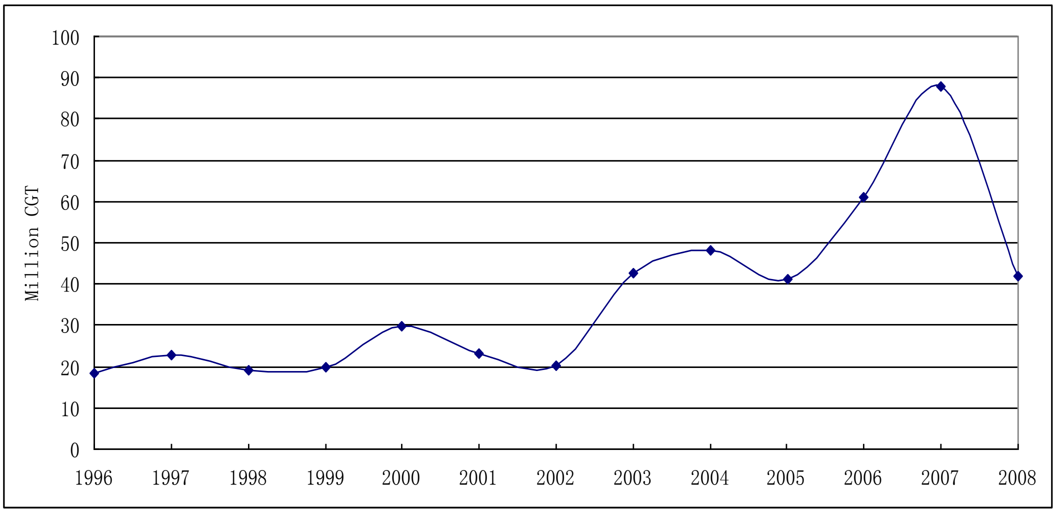


Figure 7.14 The World's Annual Generation of New Orders

Source: Modified based on a report from Royal Lloyd's Register 2008.

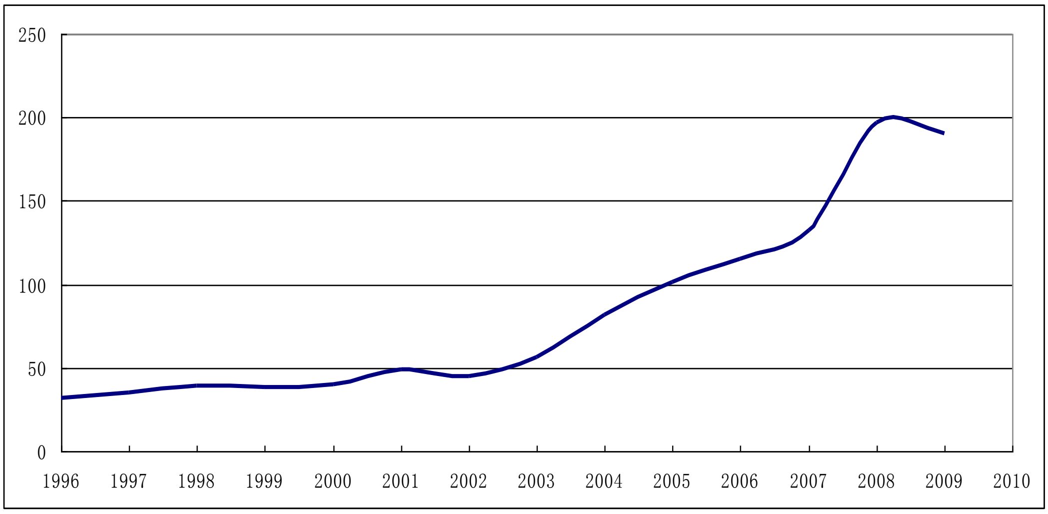


Figure 7.15 World's Annual Shipbuilding Orders in Total

Source: Modified based on report from Lloyd's Register 2008, Index: 2005 = 100.

7.4.3 *Government support shipbuilding on time*

There were also many examples indicated that, under the government's support, shipyards could easily catch the opportunity to boom their businesses. In history, shipyards that obtained governments' support usually invested in decreasing periods of the world's seaborne trade (Figure 7.16), and then kept waiting for the next increasing to win profits. For example, the Korean government invested and reorganized its shipyards in the early 1970s, and then the boomed seaborne trade in later 1970s thus gave Korean shipyards opportunities to win lots of income [Rhee, 1994].

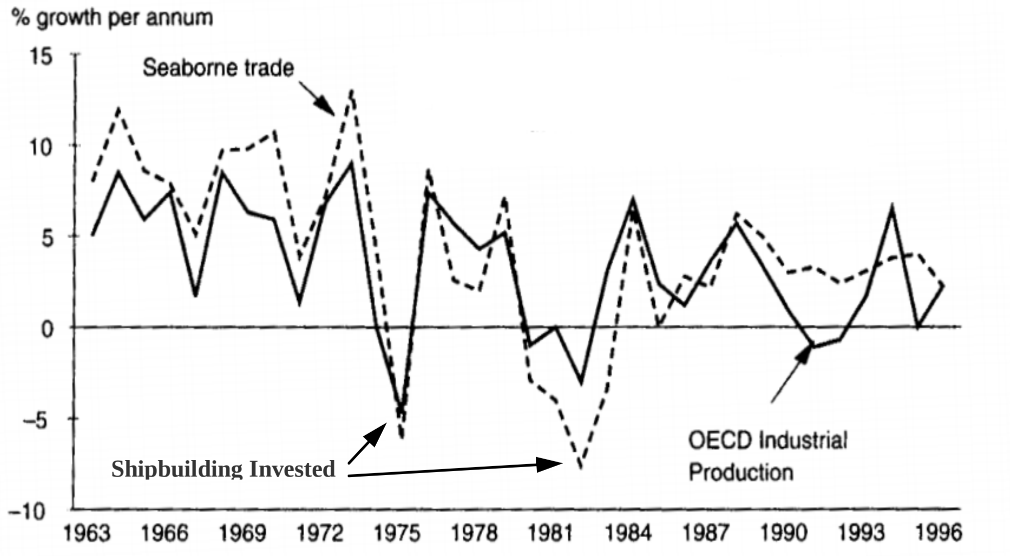


Figure 7.16 The World's Industrial Cycle 1963 – 1996

Source: Stopford (2009), Maritime Economies.

Chinese shipbuilding once won such revenue as well. For example, in 2005, Chinese government made lots of investments to shipyards for expanding their building capacities. The statistics in Figure 7.17 showed an increase in Chinese shipbuilding delivery in 2005, which even exceeded many European countries' newbuilding delivery (Figure 7.18). And the most accurate data was truly found in the year 2005, to say the revenue achieved 119.8 billion RMB (near 20 billion dollars) [Chinaship, 2006].

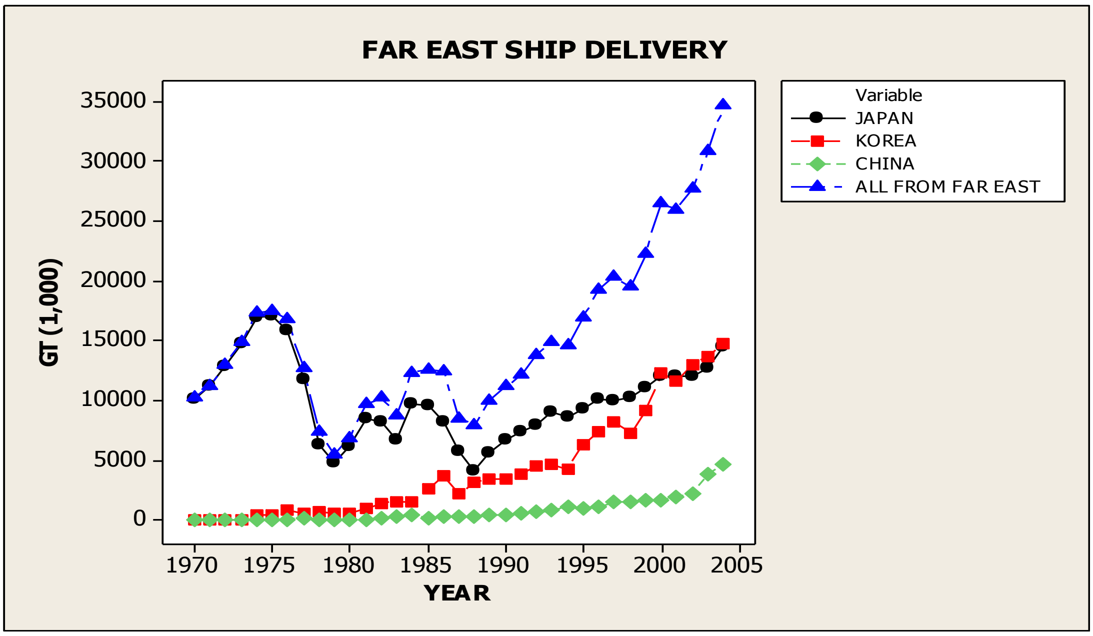


Figure 7.17 Far East Ship Deliveries

Source: Data collected from Clarkson's from 1970 to 2005.

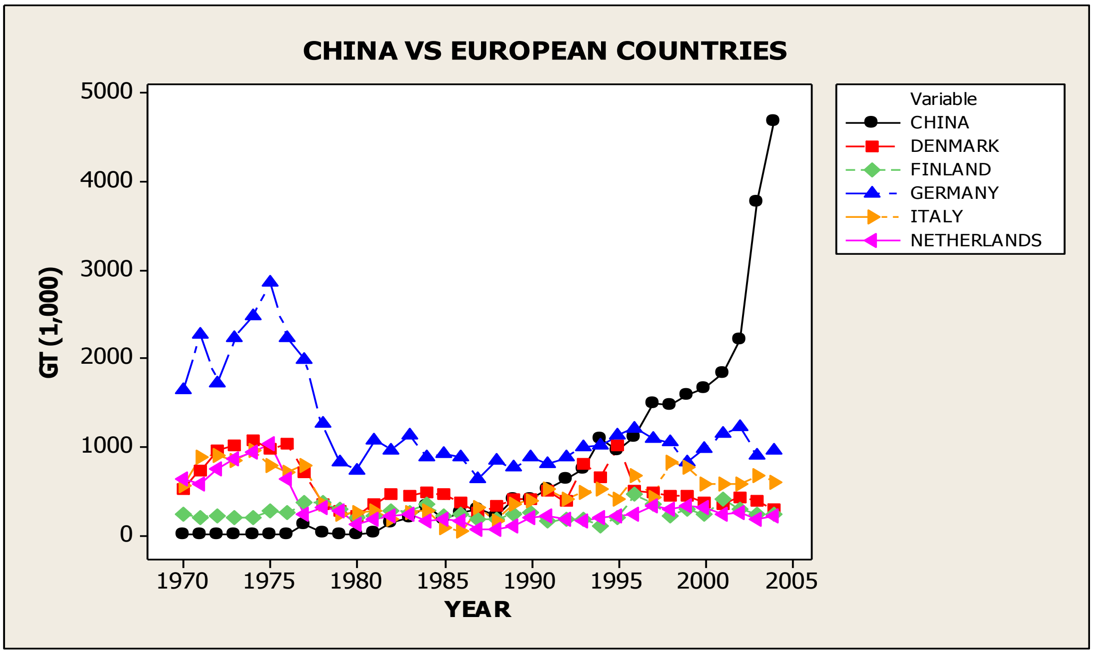


Figure 7.18 China vs. European Countries

Source: Data collected from Clarkson's from 1970 to 2005.

7.5 Summary

The development of shipbuilding industry was based on a developed national economic background. Firstly, shipbuilding industry necessitated building materials and labour force to fulfill the shipyards' production. Secondly, shipbuilding industry developed on the primary manufacturers. Thirdly, shipbuilding industry was capital and technology intensive, and had high productivity. Fourthly, efficient investments would also become a reason of a success.

In this Chapter, it aimed to discuss that the development of Chinese shipbuilding also presented above characters. First of all, shipbuilding industry was capital and technology intensive but still needed the cheap labour force (wage) to develop the most important competitiveness. This was the reason of a successful shipbuilding industry especially like the Chinese shipbuilding in 21st century. On the other hand, shipbuilding industry was developed towards high efficiency and productivity. Chinese surplus labour supply could maintain low wage but also brought low productivity to shipyards. However, it was deduced from government or shipyards' develop plan that Chinese shipbuilding would develop towards high productivity. Last but not least, the imbalance of shipbuilding supply and demand might become a reason of decreasing shipyards' profits. Marketing thus was considered to be an important tool to solve the problems: if shipyards was supported and invested on time.

This Chapter only discussed the reasons of a successful shipbuilding industry in economy aspects. However, the economic background was not the only element in developing shipbuilding industry. There was still another important element of shipbuilding industry which will be discussed in the next Chapter – the technology.

Chapter 8. Shipbuilding Technologies

8.1 Introduction

Technology was another element for shipbuilding industry development. There were many ways that contributed to the improvement of shipbuilding technology. Firstly, the National R&D Investments stimulated the technology development of shipbuilding industry. Secondly, taking the advantage of foreign technologies could also facilitate shipyards' technology developments. Thirdly, there were also "soft technologies" such as establishing industry clusters and improving shipyard's operational management considered as a method for developing shipbuilding technologies.

In this chapter, all the above issues of shipbuilding technology development will be discussed in detail by the instances from Chinese shipbuilding. Chinese shipbuilding industry attempted to develop a world-class technology and strong competitiveness. According to the investigation, the government's R&D investments as well as the introduction of foreign shipbuilding technologies worked effectively in shipyards' technology development. What the current Chinese shipbuilding needed to improve quickly was the operational management which could minimize the shipbuilding costs.

8.2 Investments in Technology Development

8.2.1 *Research and development investments*

8.2.1.1 Increasing R&D investment

The Chinese government had sufficient capital resources to invest the most essential research and development activities (R&D). As the China S&T Statistics (2007) and the China National Bureau of Statistics (2009) noted, from 2001 to 2008, the total value of expenditure on R&D increased from 104.25 billion Yuan to 457 billion Yuan, and the GDP share increased from 0.95 percent to 1.52 percent (Table 8.1). The achievements were as the China National Bureau of Statistics (2009) reported that those investments assisted lots of national technology research projects, many new national engineering research centers and laboratories were established as well. Although the current Chinese R&D investment only occupied a small proportion of GDP compared with many other countries (Table 8.2), the 12th Five Year National Develop Plan had decided to increase it in the near future.

Table 8.1 The Chinese R&D Expenditure

	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
R&D SPEND (Billion Yuan)	104.25	128.76	153.96	196.63	245	300.31	371	457
GERD/GDP (%)	0.95	1.07	1.13	1.23	1.34	1.42	1.49	1.52

Source: China S&T Statistics Data Book 2007; National Bureau of Statistics of China 2009.

Table 8.2 The R&D % Share of GDP

Country/economy	**Share**
All OECD (2004)	2.25
EU-27 (2006)	1.84
Japan (2006)	3.39
South Korea (2005)	3.23
United States (2006)	2.61
Germany (2006)	2.51
France (2005)	2.13
United Kingdom (2004)	1.73
China (2008)	1.52
Ireland (2005)	1.25
Argentina (2005)	0.46
Mexico (2003)	0.43

Source: Science, Technology and Competitiveness key Figures report 2008/2009; National Science Foundation of China, Division of Science Resources Statistics, National Patterns of R&D Resources (annual series 04-06) and OECD, Main Science and Technology Indicators (2008).

8.2.1.2 Investing significantly in industry

Currently, almost all countries allocated a significant part of their R&D investments in industrial departments. As Figure 8.1 showed, the World Factbook (2007) calculated that developed countries spent an average of over 70 percent of their R&D investments in industries, and developing countries like China spent over 80 percent.

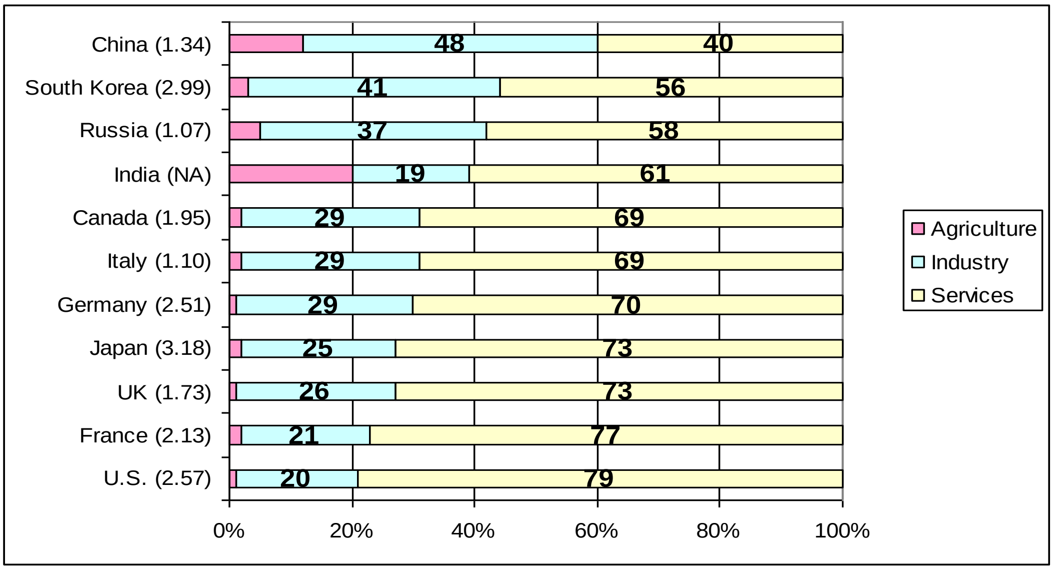


Figure 8.1 GDP and R&D/GDP Ratio for Selected Countries (2005)

Source: Data fron The World Factbook (2007).

Note: India as the developing countries invested more in service, but much smaller in industry.

Countries' R&D investments were decided by their industrialisations. Developed countries had the higher allocation of R&D in services was because their industrialisations highlighted the importance of service departments in their national economy development. But many of them still operated the high technical and capital intensive industries like shipbuilding to capture the core technologies [Balance, 1982]. This could be deduced from their quantity of R&D investment in industry, e.g. even the US had over 20 percent of investment in industry.

In 2000s, China focused on developing technology and capital intensive industries, and so its R&D investments in industry were large in quantity. Chinese R&D investments were enlarged by four times from 2004 to 2008, and in 2006, China became the world's second highest investor in R&D after the United States [OECD, 2008]. The 48 percent of R&D investment in industry helped develop the advanced technologies in more advanced industries [Yang, 2006; Yao, 2004]. Especially in shipbuilding industry, as Li (2009) noted, it was the R&D investment that worked in building up advanced technologies for the domestic shipyards in 2000s [Li, 2009].

8.2.2 *The results of R&D investments*

The R&D investments dedicated to innovations in technology which could be deduced from the production of patents. As the State Intellectual Property Office of China (2009) (Figure 8.2) noted, because of the R&D investments were enlarged by the government, the application of new patents increased from about 480,000 in 2005 to over 820,000 in 2008, the amount of innovations increased from about 180,000 in 2005 to over 290,000 in 2008. And according to the Chinese patent applications (Figure 8.3), about 350,000 applications for patents had been granted in 2007, and about 50,000 of them could be directly applied in production [State Intellectual Property Office of China, 2009].

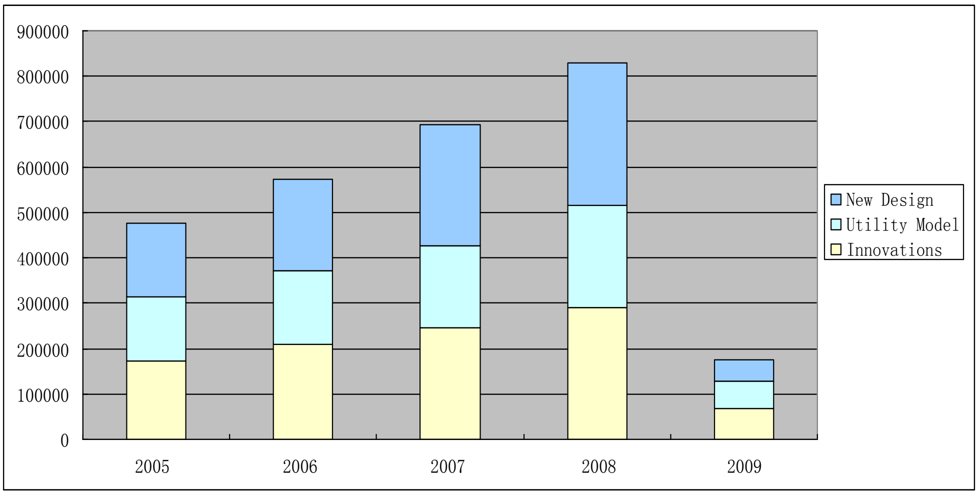


Figure 8.2Chinese Patent Applications

Source: State Intellectual Property Office of China (2009), the data of 2009 was from first season.

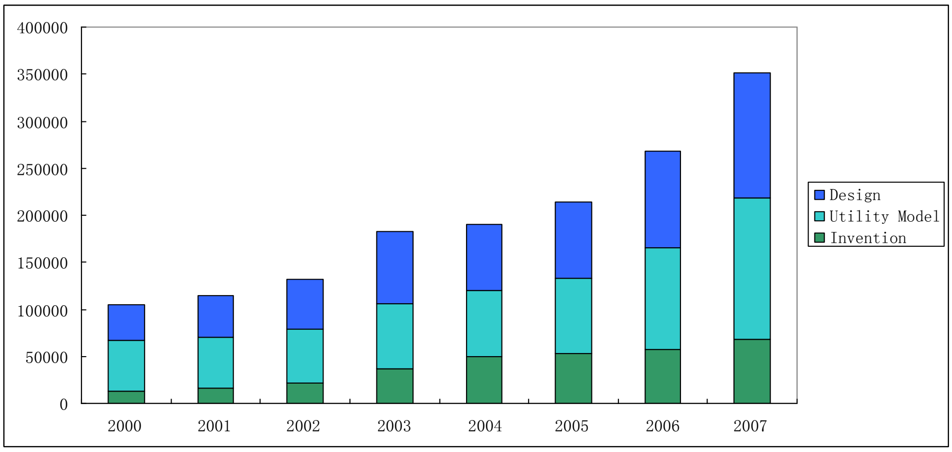


Figure 8.3 Annual Grants for Patents

Source: State Intellectual Property Office of China (2009).

Chinese technology innovation was notable when compared with other countries. State Intellectual Property Office of China (2009) (Figure 8.4) noted the total innovations from Chinese research institutions kept increasing and occupied about 40 percent of the global share in 2007 to become the world's first place. The Chinese shipbuilding industry contributed a large amount of innovations in those years. China Shipbuilding Online (2008) reported that the Chinese new patents of shipbuilding growed by 589 annualy which was the largest in the world (Japan 544, Korea 533 and Europe 290).

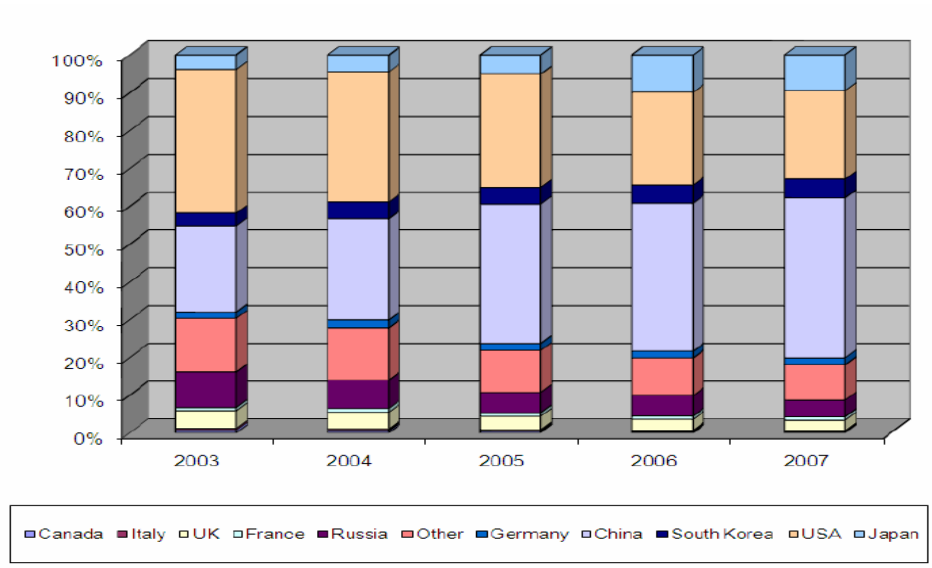


Figure 8.4 World's Innovations

Source: State Intellectual Property Office of China (2009).

8.3 Chinese Shipbuilding Techniques

The Chinese R&D investments had effectively promoted technology development in shipbuilding in the 20th century. Shipyards thus obtained more advanced shipbuilding technologies since the end of the 20th century. The progress of technology development in Chinese shipbuilding industry was represented in two different ways (Figure 8.5): ***Introducing-Learning-Innovation***, and ***Cooperation-Learning-Innovation***. The first one was the most primary stage of technology development, and technologies were introduced (bought) and applied by shipyards directly. The other one was that shipyards made cooperation with foreign companies for learning technologies, and then led to the self-innovation for new technologies.

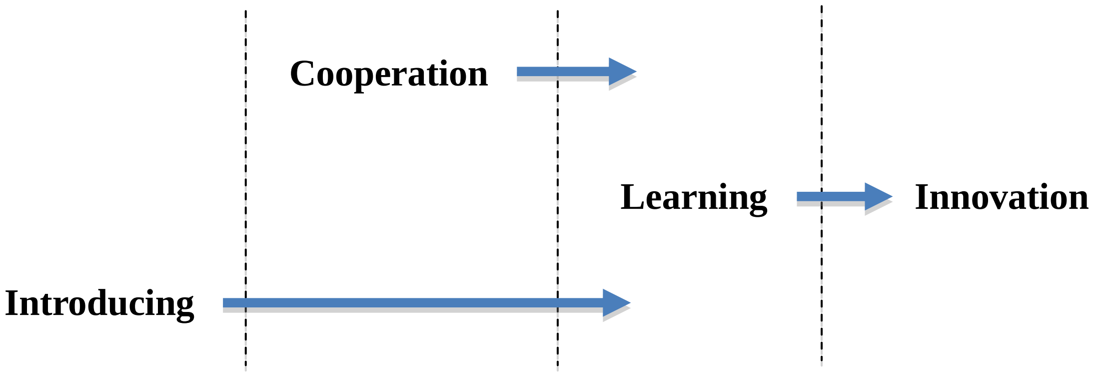


Figure 8.5 Progresses of Chinese Technology Development

8.3.1 *Introducing-Learning-Innovation*

The development of Chinese shipbuilding industry had experienced introducing and directly applying foreign technologies. This became the better way for developing technologies in domestic shipyards in short time at the beginning. In 1950s, Chinese shipbuilding benefited from the Soviet Union for various support including technologies (patents, equipments, and design), direct capital and financial investments, professionals and skilled workers. These newly introduced technologies and facilities were effectively used by Chinese shipyards for both commercial and military shipbuilding in later 1950s. However, for political reasons, the Soviet Union cancelled all of them in later 1960. The shortage of fundamental technologies and skilled workers become the biggest difficulty for Chinese shipbuilding [Dong, 2004].

Therefore, the Chinese government started searching for shipbuilding technologies from other countries. Firstly, the shipbuilding technologies were introduced (bought) from other developed shipbuilding countries. For example, the Chinese shipbuilding industry introduced hull constructing methods from Europe in 1970. And at this time, the domestic shipyards learnt to carry out technical research on these imported technologies and maritime equipments [Tian, 2009]. Those actions helped shipyards build up the capacities of using foreign technologies all by themselves but no need to depend on foreigners [Xi, 2000]. Secondly, many imported technologies for related industries indirectly influenced the development of shipbuilding technologies as well. For example, from 1972 to 1973, there were two national projects of "*Importing 1.7 meters steel plate mill*" and "*Increasing the importation of equipment and enlarging overseas economic communication*" used in steel manufacturers, which indirectly developed the technology of newbuilding by high quality steel plates [Dong, 2004].

8.3.2 *Cooperation-Learning-Innovation*

The way of introducing technologies from foreign countries was changed in 1990s, when the Chinese government gradually released restrictions for foreign investments in Chinese shipbuilding. Since then, cooperation with foreign companies for advanced technologies became the major method of developing domestic shipbuilding technologies. This method was even used more frequently in 2000s. According to the annual report from the Ministry of Commerce of China (2004; 2005), foreign companies contributed to 48 percent of the total production of new technologies in 2004; this even increased to 51 percent in 2005. Moreover, transnational corporations also established many research institutions in China in 2000s for developing shipbuilding technologies. Wang (2006) calculated that 750 foreign-cooperated research institutions were established in China by the end of 2004, for researching shipbuilding technologies, their research funding together exceeded 2 billion dollars which occupied 20 percent of national total in this area.

Cooperating with foreign shipbuilding countries became more and more important in developing shipbuilding technologies. In 2000s, countries such as Korea and Japan directly invested in Chinese shipyards again, this stimulated Chinese shipbuilding technologies more effectively. For example, Samsung Heavy Industry established shipyards in China in 1996 for hull section construction. Even if there were technical barriers, China still learnt from building methods and advanced operational management of shipyards [Wang, 2006]. There was also cooperation with many European countries for producing ship equipments, which enhanced the technologies in those areas as well. Taking the year 2006 for instance (appendix 3), 14 new cooperative marine associated manufacturers were established for ship equipments such as engines (based on Rolls-Royce Marine AS) and ship electric systems (based on Kongsberg Maritime). Then, the Chinese marine associated manufacturers learnt and built up their own abilities to produce new advanced ship equipments.

8.3.3 *The achievements of learning foreign technologies*

8.3.3.1 Shipbuilding methods

By taking the advantage of foreign technologies, Chinese shipbuilding industry developed many advanced shipbuilding methods. First of all, many Chinese shipyards could build large vessels effectively in dry docks. Shipyards learnt from Japan and Korea for developing the advanced hull section construction technology and the hull outfitting technique (Figure 8.6), by which they could build large ships (over 150,000

DWT) with high efficiency [Jiangmen Maritime Safety Administration, 2009]. Shipyards also learnt to establish mechanization and assembly line works to reduce the shipbuilding time. The achievements were as Chen (2009) the director of Chinese National Development and Reform Commission noted, the Dalian shipyard could build a VLCC indoor in about 90 days and, the Shanghai Waigaoqiao Shipyard minimized the building time of a 170,000 DWT bulk carrier in 50 days.

Figure 8.6 Building a Whole Ship

Source: Jiangmen Maritime Safety Administration, 2009.

Figure 8.7 Section Constructing Method in Nanyang Shipyard

Source: Jiangmen Maritime Safety Administration, 2009.

On the other hand, the Computer-Assisted Design (Figure 8.12) was developed in Chinese shipyards for constructing more complicated vessels. For example, by learning the Computer-Assisted Design systems from foreign shipbuilding countries, Chinese shipyards then could design the FPSO and the LNG Carrier all by themselves. With the advanced design techniques, the Chinese shipyards were then able to accept newbuilding orders for a LNG Carrier at 147,000m^3 and for a FPSO at 300,000 DWT in 2006 [Tian, 2009]. Some of those design techniques were even much advanced than that used in building war ships in China [Chinese Industry Research, 2007].

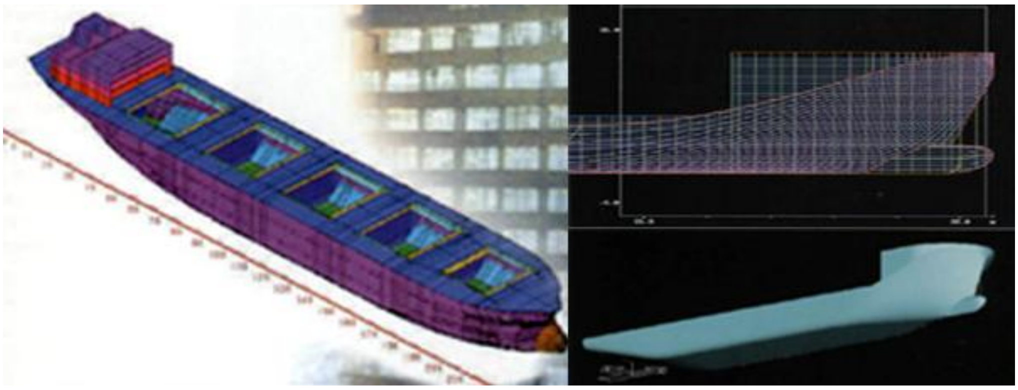


Figure 8.8 Computer-assisted Design

Source: China Shipbuilding Industry Corporation (2007).

It was those advanced shipbuilding technologies that helped Chinese shipbuilding industry become much powerful in world’s market in 2000s. However, the problem was these two modern shipbuilding methods had not been applied by shipyards in the national wide. Many small–middle sized Chinese shipyards were insufficient in financial resources for developing those shipbuilding methods. This became the reason why Chinese shipbuilding was still weaker than Japan and Korea.

8.3.3.2 Ship equipment

China had developed a series of manufacturers for producing ship equipments. The four diesel engine manufacturers in China achieved an annual production of 2 million horsepower in 2006 and were expected to reach 5 million by 2015 [China Report, 2008]. Many new manufacturers were planned to be established for increasing the productions. For example, the CSSC, WARTSILA and Mitsubishi cooperated in setting up a large engine manufacturer in China, the expected annual production would reach 3.5 million horsepower [China Report, 2008].

However, to some parts of the core technologies, those associated manufacturers still relied on foreign supports. Again, take the engine manufacturer for instance. Many Chinese domestic manufacturers were weak in core technologies in constructing some kind of diesel engine and were producing replicas of foreign models. China still did not have a professional engine manufacturer that could construct engines all by itself [Chinese Industry Research, 2007]. Therefore, Chinese shipyards still need to import many ship equipments to fulfill their shipbuilding business (Appendix 4).

8.3.3.3 Ship designs

Chinese shipbuilding had developed the ability of designing many advanced ships. Since the beginning of the 21st century, China has learnt numerous design techniques such as the ship performance forecast and optimization. These skills helped shipyards in designing new ships and enhancing abilities for self-innovation. The achievements were as Tian (2009) noted, from 1998 to 2008, Chinese shipbuilding designed and constructed about 297 different new ships including 47 capesize bulk carriers and 49 post-panamax container ships. Many of these new design ships such as RORO and bulk carriers were preferred by shipowners worldwide [Chen, 2008].

However, Chinese ship design was still weaker than that in Japan and Korea. Firstly, the quantity of Chinese ship design production was small. Chinese shipbuilding industry did not like the shipbuilding industries in Japan and Korea who could produce 20 new-designed ships annually [Xie, 2006]. On the other hand, the Chinese ship design was weak in designing more advanced ships. Shipyards still lack of core technologies in designing ships such as LNG and drilling vessels [Xie, 2006].

8.3.4 *Problems in self-innovations*

The Chinese shipbuilding industry tried to develop the ability of self-innovation. In 2000s, China developed and obtained the cabilities of self-innovation in building tankers, bulk carriers and container vessels. Some shipyards gradually developed the capacities in buidling high value-added vessels such as the LNG Carriers. As Zhang (2007) noted:

> "*China could independently design many advanced ships such as the 300,000 DWT tanker, 8000 TEU container carrier……and LNG carriers……*"

But compared with Japan and Korea, the current Chinese shipyards had many problems in self-innovation. Firstly, Chinese shipbuilding still relied on some foreign techniques to design and construct ships. Some shipyards did not positively carry on the learning, researching and inventing for new ships but easily "copy" from foreign countries [Xue, 2006]. Secondly, shipyards relied on importing ship equipments. As some of the productions of domestic ship equipment manufacturers were low in quality, many shipyards choose to import those equipments to fulfill shipbuilding requirements [Tian, 2009]. This was the reason why Chinese shipyards still needed to import about 80 percent of ship equipments for constructing newbuildings in 2000s. And so the newbuilding cost was increasing much more than that in Korea and Japan who can self-supply 80 percent of ship equipment [Chen, 2008].

8.4 Shipbuilding Industry Cluster

8.4.1 *The conceived shipbuilding industry cluster*

Shipbuilding industry needed various industrial supplies such as human resources, land, energy resources and transport facilities for development. Shipbuilding countries could supply industrial accessories to establish shipyards, but this was various in characters because of their different national competitiveness [Porter, 1998]. For example, developed countries could supply manufacturers more advanced technologies than developing countries.

When a factory (shipyard) was established, its primary production should be a "whole production" which produced each part of the production all by itself without outside help [Balance et al. 1982; Baumohl, 2007]. A concrete example was the US shipbuilding industry, when the wooden shipwrights produced ships as well as ship components and equipments all by themselves. Later, small related manufacturers developed to supply shipwrights by making various ship equipments, but again those productions were all "whole production". And such a whole system works together in the "chain" to stimulate shipyards' efficiency and productivity.

Accordingly, the shipbuilding industry cluster should focus on promoting efficiency and productivity of shipyards. And the proposed four large-scale subsystems including *Supply Procurement System, Production System, Business System and Reverse System* were focusing on the whole production's (ship) life cycle.

8.4.2 *The current Chinese shipbuilding industry cluster*

To establish the industry cluster was very important in developing shipbuilding industry. The current Chinese shipbuilding industry connected with more than 97 related manufacturers [GOV, 2005]. Those manufacturers were developed from 1990s, when it was stimulated by the booming shipbuilding. According to the data from the Chinese Industry Research (2007), about 252 new marine associated manufacturers were established up to 2006, with the total production value reached about 3.2 billion dollars at that time, which all aimed to supply shipyards firstly.

In order to develop the shipbuilding industry, the Chinese government attempted to organize and relocate the existed associated manufacturers as well as shipyards. Many shipyards and marine manufacturers joined such a shipbuilding industry clusters in various ways under the promotion of the local governments. For example, the established cluster in Dalian in 2007 is represented in Figure 8.9: a) Dalian Shipbuilding Heavy Industry was in the first-level; b) this was supported by three associated manufacturers in second-level including Dalian Maritime Diesel Engine Company, Dalian Maritime Propeller Company and Dalian Maritime Valve Company which were established by CSIC from 1980s and; c) another 120 sub-factories, 37 ship repair yards and 15 maritime logistics companies were set up for directly supplying the second-level manufacturers.

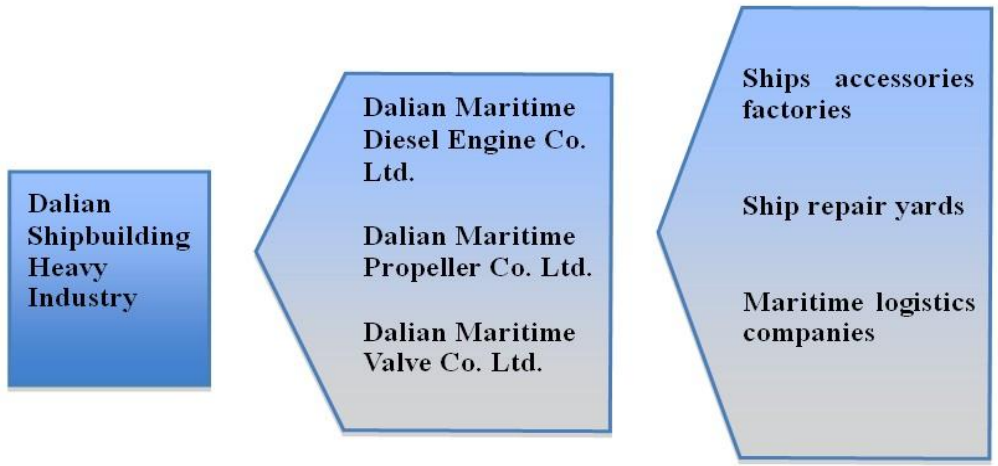


Figure 8.9 The Dalian Shipbuilding Industry Cluster

Another example was the shipbuilding industry cluster in Nanjing. As shown in Figure 8.10, all those marine associated manufacturers were set to directly support shipyards. Such a kind of industry cluster was small in size but could tie shipyards much closer to associated manufacturers. And those marine associated manufacturers had more businesses opportunities from shipyards. Such an industry cluster developed those marine associated manufacturers a total production value of 8 billion RMB annually [Nanjing Municipal Economic Commission, 2007].

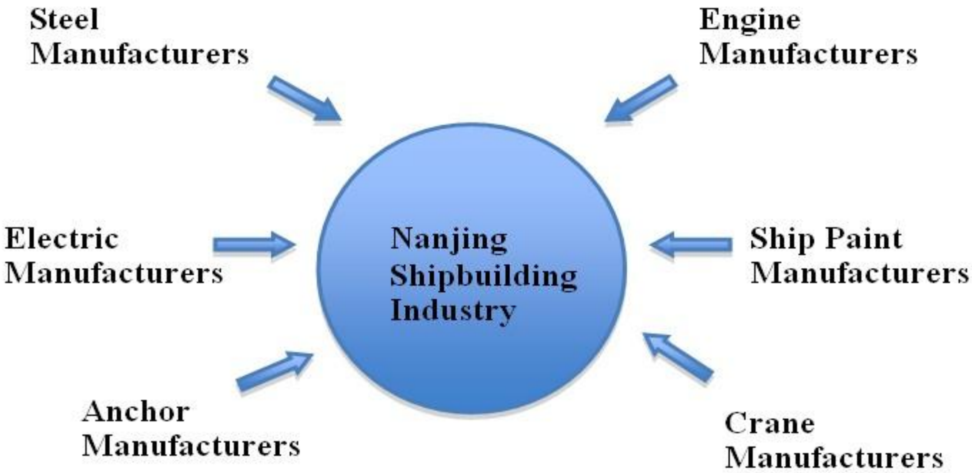


Figure 8.10 Nanjing Shipbuilding Industry Cluster

8.4.3 *Promoting the current industry cluster*

The Chinese shipbuilding industry still had problems in developing industry clusters. Investigating in different provinces, lacking an efficient operation management became the most serious problem. To solve this problem in long-term, as the *"National Eleventh Five-year Plan 2007"* stated:

> *"… a) Should promote modern logistics managerial techniques…… b) should realize the enterprises' serialized operation in acquisition of materials, organizing production, sales and recycling renewable resources…… c) should cultivate specialized and professional industries' cluster system as well as new technologies…… d) should strengthen the logistics infrastructures to construct large-scale distribution system and regional cooperation."*

It was believed that the current Chinese shipbuilding industry cluster should promote at least four things in short-term.

8.4.3.1 Purchase

Shipyards needed raw materials from steel manufacturers. The newbuilding costs would increase as long as material prices were increasing. At the end of the 1990s, Chinese shipbuilding faced problems from the rising raw material price. As Liu once (1994) noted, the increasing raw material price combined with high transport cost made a higher “landed cost” for China importing shipbuilding materials. And Chinese shipyards had to choose to accept the additional costs and transfer them into newbuilding price. According to the National Development and Reform Commission of China (2008), when the material price was rising in some months of 2008, for building a large VLCC which needed 40,000 tons of steel plates, the average building price increased by 10 million dollars.

To the Chinese shipyards, establishing the cooperation with material manufacturers would solve the above question. And if the shipyards could control the raw material prices, it would be more efficiently and actively in managing the newbuilding costs [Baumohl, 2007]. First of all, the upstream integration could help the shipbuilding industry effectively minimize newbuilding cost. For example, as Bunker (2007) noted, Mitsubishi acquired 51 percent of stocks in India’s biggest private iron ore supplier SesaGoa, with the subsequent control of materials, shipyards then could reduce newbuilding cost by at least 10 percent by cheap raw materials [Bunker, 2007]. On the other hand, establishing an efficient material transport system could also decrease newbuilding costs. As Johnson (1995) once noted, reducing the transport time and optimizing inventory could avoid many extra costs when building ships.

8.4.3.2 Production

The internal operation management was very important for shipyards’ newbuilding production. Currently, many shipyards in China still required an advanced operation management. Issues were rising to say that shipyards could have many methods to promote their internal production system. Firstly, shipyards could take the advantage of those associated manufacturers which were close to them. For example, in China, shipyards in Nanjing benefited from local industry cluster for ship components, this helped shipyards save purchasing cost and time [Wang, 2004]. On the other hand, the scientific operation management and production management should be used to eliminate redundant work. This could help shipyards carry out accurate and efficient shipbuilding businesses. Moreover, the Chinese shipyards necessitated the establishment of an accurate information system to assemble and analyse the data, and feedback through the whole production process [Xie, 2006]. The computer-aided engineering (Figure 8.11) could be used to construct such a systemic internal operation.

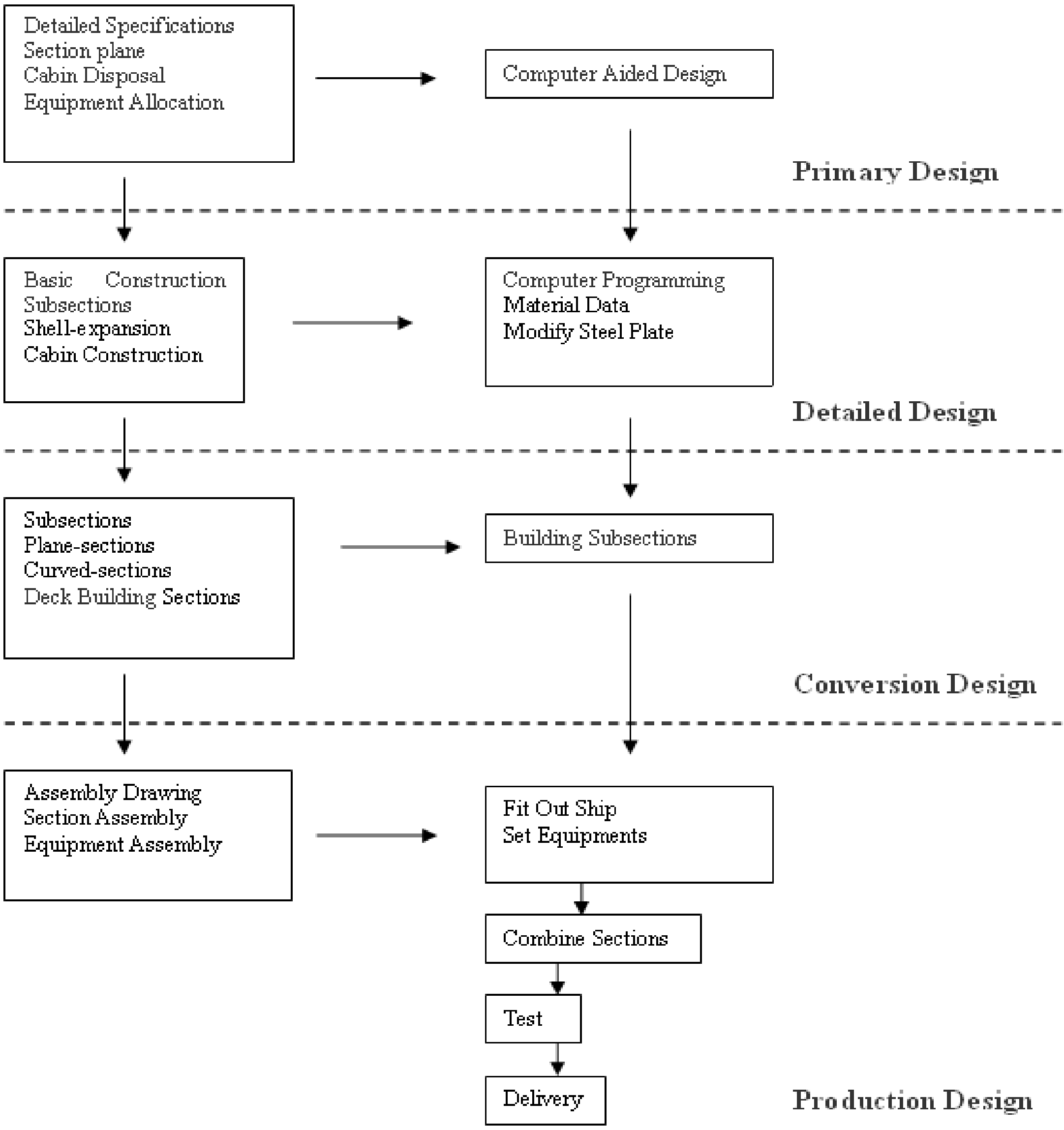


Figure 8.11 Computer Aided Design

Source: Chinese Industry Research, 2007.

8.4.3.3 Services

The services existed in every part of a product's value chain and life cycle. This was a kind of competitiveness as the competitions in the market were not only for product's performance but also for added value such as service [Porter, 1998]. In shipbuilding industry, there were many concrete examples showed this principle. For example, the Hyundai Shipbuilding promoted a special information system called SCAS (Shipowner & Class Assistance System) in 2003, and it became Hyundai's competitiveness of service. The shipowners and classification societies were more likely to obtain the information of the ships during constructing, they could ask for new requirements whenever they want to [Xie, 2006].

Chinese shipbuilding had not established such professional customer services. Then, no "joint guarantee" was obtained by shipowners once their ships met problems [Xie, 2006]. Currently, many Chinese shipyards were still facing problems when trying to establish the customer services. For example, poorly designed docks, low quality materials and inefficient operational management lagged the development of shipyards' customer services [Yao, 2004].

Chinese shipyards could establish customer services according to the practical conditions of shipyards themselves. There were still many simple ways of customer services could be developed quickly in the current shipyards. Firstly, during construction, shipyards could keep providing required information to the shipowner and classification society as Hyundai did. Secondly, shipyards could track a ship's condition and immediately solve problems. This could be achieved by dispatching professionals and engineers directly to shipowners. Thirdly, shipyards could also communicate with ship equipment manufacturers in order to guarantee prompt and right actions in solving malfunctions.

8.4.3.4 Reverse logistics

Shipyards created material scraps during shipbuilding which could be reasonably recycled for reducing shipbuilding costs. According to the data from the US Bureau of Labor Statistics (2009), raw materials accounted for an average of 40 percent of total shipbuilding costs in world's shipbuilding industries. As steel materials occupied such large amount percentages of shipbuilding cost, James (2005) stated that the rising steel material price definitely bring extra costs for using it. For example, as Fei (2008) noted, for building a 50,000 DWT bulk carrier, about 15 percent of total used steel plates became steel scrap which could be reused; Dwivedi and Crisp (2003) noted that for building a VLCC at least 10 percent of the total steel materials became the steel scrap and could be reused. Those costs could be saved if shipyards use regenerated materials, as to buy scrapped and recycled steel plate was 70 percent cheaper than that of new produced ones [Zhang, 2003]. But, all these necessitate a reverse logistics.

Currently, many Chinese shipyards applied a very simply reverse logistics:

STEP 1 Shipyards *sell* steel scraps to small workshops;

STEP 2 Small workshops *resell* steel scraps to large recycling company;

STEP 3 Large recycling companies *resell* steel scraps to steel manufacturers;

STEP 4 Resource department regenerated steel scraps and *sell* to the market.

The very benefit of the current system was that the shipyards released their burdens of handling scraps and focused more on shipbuilding. However, hindrances still existed and led to some problems. The small workshops and the large recycling companies only cared about resell prices and were not concerned with helping the shipbuilding save material. Those were because their ambitions were sell the material scraps back to resource departments and, as Zhang (2007) noted, "…merely for finishing governmental performance measure of handle scraps." This could not reduce shipyards' newbuilding costs by cheap recycled materials.

The current research proposed shipbuilding reverse logistics system for Chinese shipyards. A new partner called “Shipbuilding Reverse Logistics Center” (SRLC) was introduced to replace the small scraps’ workshops and large recycling companies. The construction of this new reverse logistics was:

STEP 1 SRLC buy steel scraps from shipyards;

STEP 2 SRLC resell steel scraps to steel manufacturers;

STEP 3 SRLC buy regenerated steel plates from steel manufacturers.

Such a shipbuilding reverse logistics system was simple but more efficient for current Chinese shipyards. Firstly, to the operation time aspect, the proposed reverse logistics combined all the middle sectors into the SRLC which saved the transfer time. Secondly, the SRLC did not add additional costs to material recycling and so the price of recycled materials could be minimized. Thirdly, acting as a “Channel Captain”, the SRLC could positively promote supplying shipyards the regenerated building materials to reduce their building cost.

8.5 Summary

Technology was considered as another vital element for shipbuilding industry development. This was represented by the R&D investment, developing new technologies and industry cluster. According to current research:

- The Chinese government distributed massive R&D investment to develop shipbuilding new technologies. A significant investment in manufacturers could create more technology for industrial development. It suited to the current progress of Chinese industrialization, i.e. mainly develop technology and capital intensive industries like shipbuilding.
- The Chinese shipbuilding industry benefited from foreign technologies to develop domestic shipbuilding technologies. This was achieved by the two ways of introducing (buying) foreign technologies and cooperating to develop new technologies. The remained weaknesses were inefficiency in learning from new

technologies and a continuing poor performance of self-innovation.

- The Chinese shipbuilding industry had many accessory manufacturers to produce ship components. But there was still 80 percent of ship components need to be imported because of the complex technical requirements. Shipyards should be located into the shipbuilding industry clusters. And an efficient operation of industry clusters was considered to be a very effective technique to help reduce shipbuilding cost.

Moreover, it was also realized from the above discussion that all those technology development should be processed under the administration of government. This will be discussed next.

9. Government Management

9.1 Introduction

Efficient government managements were considered as another stimulator of shipbuilding industry development. Those managements included managing ownerships, establishing a legal system and financial support. Firstly, government managed the ownerships between private and public to develop industries. Those could be deduced from the nationalizations of shipbuilding in countries like France and Poland, and the privatizations in Japan. Secondly, government took effective strategies to develop shipyards. The more recent examples could be found from Japan and Korea who provided financial support to their shipyards. Thirdly, countries all had a fundamentally legal system for shipbuilding industry development. This could be found especially in countries like the US, Japan and Korea.

In this chapter, how the Chinese government managed shipbuilding industry would be discussed. Chinese shipyards were both organized by two ownerships to gain both advantages. State-ownership assured strong governmental support, while Private-ownership gave more commercial freedom. On the other hand, Chinese government set developing shipbuilding industry as one of the most important national development strategies. These aimed to work in financial and industry construction aspects to help shipbuilding industry. As to the legal system, China had not established such a professional legal system for shipbuilding industry. This would be a big weakness when the government making policies for developing shipyards.

9.2 State Ownership versus Private Ownership

9.2.1 *State ownership*

The “State ownership” was the same as “Government ownership”, which had many advantages in developing national economy. Firstly, while the assets were owned by government, the stated-owned enterprises could develop national economy more effectively. Secondly, their productions were mainly focused on raw materials and energy which were natural monopoly goods. Their productions occupied a crucial position in the national economy or even national safety [Fagan, 1960]. Thirdly, for political reasons, state ownership was better than private ownership. Government made financial support to protect, continuously, production from commercial, environmental or other external pressures [Fagan, 1960]. And they became a predominant function in key areas of the national development and safety such as transportation [Pryke, 1971; Ramamurti, 1991].

However, state ownership also presented many problems. First of all, as the world’s soaring price of energy and raw materials, state-owned enterprises met the problem of increasing costs for operating [Grant, 1994]. The original management by political methods was inefficiency in doing international businesses. Moreover, state ownership was weak when facing new competitive and unpredictable economical environments. Their wages would not be changed no matter whether the company gained profit or not, which led to a high management cost but low productivity and efficiency [Lv, 2008].

9.2.2 *Private ownership*

Private ownership was commonly connected with “privatization”, which means the process of transferring state ownership to private ownership. This was usually by the way of selling shares to the stock market or directly to non-governmental investors

[Ramamurti, 1991]. Compared with state ownership, the most important characteristics of the private ownership were strong incentives to innovate and maintain operational costs [Shleifer, 1998].

Privatization was developed at the end of 1980s. With the advantages of efficiency and profitability, the private ownership was rising and replacing the state ownership in many industrial areas. For example, privatization helped UK government gain at least 45 billion pounds in 1970s in transport industry, and helped reduce at least 1 billion pounds of the burden of annual subsidy [Vernon, 1981]. Similarly, as Einaudi (1955) and Caron (1979) noted, the French government applied privatization to stimulate the development of enterprises such as the national transport company, which enhanced their efficiency and productivity, and also reduced the financial pressure.

9.2.3 *Chinese industry system*

Countries' industry developments presented different characteristics. For example, the UK and the US had the free marketing economics. Countries like France and Germany applied the "Rhineland model" which means governments made social welfare and security as an important part of industry development [Vernon and Aharoni 1981].

As to the development of Chinese industry, there were two notable characteristics. Firstly, Chinese industry development took the advantage of Foreign Direct Investment (FDI). The annual FDI investment has kept growing since 1979 (Figure 9.1), which made a massive contribution to developing capital and technical intensive industries [China FDI Department, 2007]. Although the debt increased from only about 20 billion dollars in 1986 to about 300 billion dollars in 2007 (Figure 9.2), government could use FDI effectively in investing industrial productions to create revenues for paying back [Xinhua News, 2008].

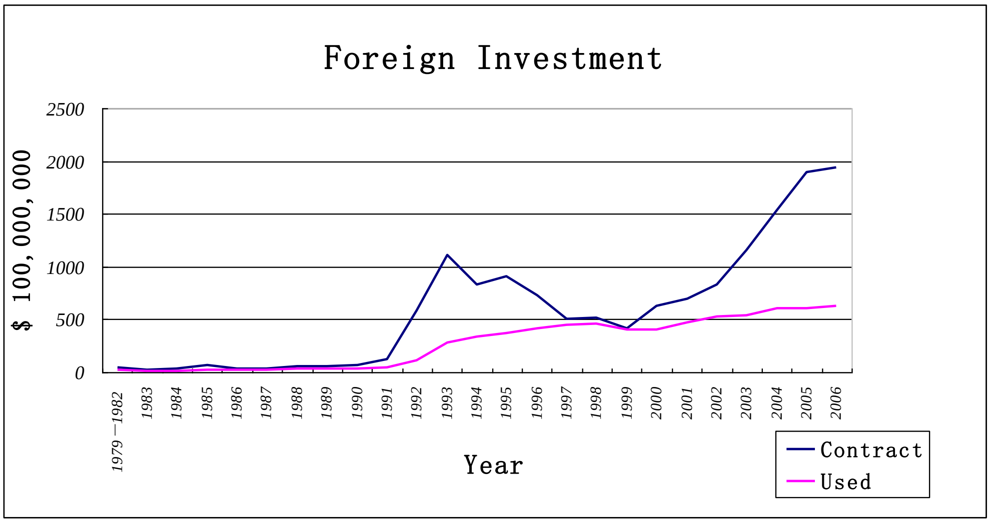


Figure 9.1 Chinese Foreign Investment

Source: China FDI Department, 2007.

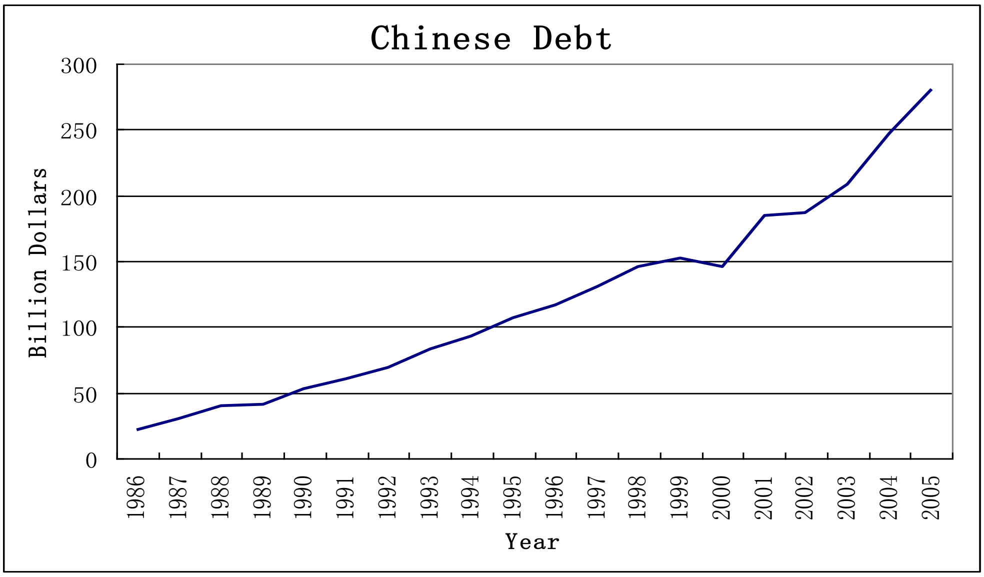


Figure 9.2 Chinese Debts

Source: Data collected from China State Administration of Foreign Exchange, 2007.

Secondly, the Chinese government kept controlling industries. The five-year national development plans from 1953 kept guiding Chinese industry development till 2000s. The highly centralized state power and national development planning effectively concentrated resources for industry development [Zhang, 2006]. The rate of state ownership enterprises in total national industries increased to over 90 percent in 2005, and made a large contribution to national economy development [China Governmental News, 2005]. Even if private enterprise raised and made considerably larger contributions to the growth of the national economy in 2000s, state-owned enterprises were still the most important contributor to GDP development [National Bureau of Statistics of China, 2004].

9.2.4 *The ownership of Chinese shipbuilding industry*

Since the 1970s, Chinese government carried out a series of programs to reform national industries, especially in shipbuilding industry. Those included:

1. "Release Rights and Enlarge Profit";
2. "Divide Management from Proprietorship";
3. "Enhance the Ability of Self-determination";
4. "Build up Modern Company Systems".

By this reformation, the current ownership of Chinese shipbuilding industry was developed between state ownership and private ownership. Before the 1980s, the transport ministry directly controlled the Chinese shipbuilding industry for planned productions [Zhang, 2007]. And the China Shipbuilding Industry Company was organized to directly control shipyards' newbuilding productions [The Central People's Government, 1982]. But this was not suitable in the coming decades as the state ownership presented inefficiency and low productivity. Therefore, in 1999, the China Shipbuilding Industry Company was deregulated and divided into two groups called China State Shipbuilding Cooperation (CSSC) and China Shipbuilding Industry Cooperation (CSIC). They were supported by the central government but obtained independent rights to do business (as those private enterprises did). The remaining government managements were mainly in helping to formulate development strategies, promote technology development and implement surveillance [Zhang, 2007].

This kind of industrial reformation in Chinese shipbuilding industry presented many advantages in 2000s. Firstly, shipyards obtained independent authorities in operation rather than been fully controlled by government. And so shipyards could make business decisions and arrange production more quickly and effectively [Zhang, 2007]. Secondly, the domestic shipyards could flexibly cooperate with foreign shipyards. Except for developing shipbuilding technologies, shipyards could more independently judge shipbuilding prices, contract foreign projects, or even export skilled workers and professionals according to world's market situations [Zhang, 2007]. Thirdly, taking self-responsibility during operations assumed shipyards the responsibility for business. This stimulated shipyards to enhance efficiency and productivity to win profits.

9.3 Efficient Government Interventions

9.3.1 *Effective interventions*

No matter what kind of ownership the Chinese shipbuilding industry adopted, it needed government's efficient interventions i.e. support, guide and control. Since 1980s, the Chinese government took various actions such as enacted policies to develop domestic shipyards. These were: 1) policies for developing shipping industries to create business for shipyards; 2) policies to develop heavy industries such as steel industry to supply shipyards; 3) policies for introducing foreign investments to create domestic shipyards extra financial supports; 4) policies for stimulating national export to give shipyards preferential privileges in selling ships overseas.

9.3.2 *New project for shipbuilding industry*

In 2000s, Chinese shipbuilding kept booming until early 2009 when the world's economy crisis happened. In 2009, China received few new construction orders and many shipyards were out of business. This situation also highlighted many potential risks in the Chinese shipbuilding industry. For example, as Chen (2009) noted, weak of advanced technologies and over supply was decreasing shipyards' productivity and efficiency. Therefore, in later 2009, the Chinese government carried out a policy called "Adjusting and Developing Shipbuilding Industry" for managing shipyards.

9.3.2.1 Increasing Financial Support

The world's economy crisis in 2008 affected the shipbuilding industry much more in financing. At the beginning of 2009, over 20 percent of the world's total newbuilding orders faced financial problems and were cancelled [BRS, 2009]. However, many shipowners (both foreign and domestic) looked for financial support in China, which was because China was considered more reliable in finance [Chen, 2009]. The current "Project" thus caught this opportunity to develop shipbuilding by:

- Calling capital from financial departments. The domestic banks such as *China Bank of Import and Export* guaranteed floating capital for shipyards' daily operations and processing valid contracts on time [Huang, 2009]. Banks were also enforced to cooperate with shipyards to provide reasonable loan extensions, which indirectly gave shipowners more time to arrange payment.
- Stimulating new construction orders. The project attempted to stimulate Chinese shipowner and shipping companies to purchase new ships from domestic shipyards [Huang, 2009]. Government gave the domestic shipping company subsidy (a new kind of bank loan) at 17 percent of the total newbuilding cost, and the rest could be borrowed from certain banks by a three-year low interest loan.
- Expending shipyards' business. Shipyards were enforced to expand their business into other related areas such as repairing, scrapping and maritime equipment. This would help shipyards to create capital resources to support newbuildings.

9.3.2.2 Reorganising shipyards' building capacities

By the end of 2008, China Investment Consulting (2008) declared that China had over 5,000 shipyards with the total shipbuilding capacity already exceeded 60 million DWT.

This would undoubtedly lead to over supply in the near future. The project thus attempted to reorganise existing shipbuilding capacities. Firstly, Chinese shipyards were reorganized and located into "two Leading enterprises" (CSSC and CSIC) and "three shipbuilding centers" (North East, Changjiang delta and Zhujiang delta) to avoid unsuitable expanding. Secondly, instead of establishing new yards, shipyards were encouraged by integrating with upstream or downstream manufacturers or cooperating with foreign shipbuilding. Thirdly, through this project, government stimulated shipyards' technology development to develop shipyards' abilities in building more advanced ships such as LNG. This aimed to enlarge the existing shipyards' business areas in world's market.

9.4 Shipbuilding Law System

9.4.1 *The condition of Chinese legal system*

Laws worked for protecting and guiding the development of shipbuilding industry. This had been discussed in the previous chapter. To build Chinese shipbuilding industry a professional legal system, several problems should be solved.

9.4.1.1 Ideological confrontation

China had more than 2000 years' feudal history. Those laws prescribed in history were almost all used for protecting imperial authority rather than developing economy. So the people's legal awareness was weak and the disaffection lasted for a long time [Tang, 2002]. The weak legal awareness brought many problems to economy development. Firstly, even if the government made laws and used in various aspects of Chinese life, the society seemed to ignore it as if it used the fast economy development as a substitute for legal liability. Secondly, the current Chinese legal system presented a low efficiency in strengthening legal regime constructions [Liu, 2001]. And thus industries still needed to wait for a long time to be well protected. Thirdly, government had not changed people's mind with the legal sense of responsibility to develop national industries. The result was as Liu (2001) noted, some laws were difficult in using as the people in industries always attempted to escape from the regulations.

9.4.1.2 Different economic regime: socialism & capitalism

The current Chinese legislative system was established on the socialist market economy, which was different from other countries (capitalism). As Friedman (1975) and Malleson (2007) noted, a country's legal system could only be established in a multi-party political system and private ownership. However, China developed its market economy on state ownership and was the first time that the state ownership coexisted with the market economy [Tang, 2002]. How to establish the legal regime based on socialism and let it coexist with state ownership became a big challenge.

Moreover, the Chinese government had taken many actions to enforce party politics in enterprises. The target was paying special attention to the enterprise's party spirit construction and combating corruption at work. To the shipbuilding industry, the responsibility of internal party organization was in the transmission of instruction from central authorities to implement the surveillance function for the government. But many issues have suggested that such a political party organization should not participate in these enterprise' daily works. As Riegel (1944) noted, the enterprises' operation and development would not successful on political party's participation.

9.4.1.3 Central government and local governments

Chinese central government always coordinated the relationships between national authority and local authorities. The powerful central authority aimed to implement strict macroeconomic regulations to guide local developments. However, the raised localism created serious problems for the country in the long term. Those problems were including: 1) the local authorities might twist or negatively apply macroeconomic regulations from central government; 2) the local authorities were competing against each other for better representation nationwide, which built redundant projects to enlarge development or expand extra-budgetary constructions; 3) the local authorities enacted their own policies for the sake of regional protectionism, which artificially blockaded and separated the market; 4) localism made the Chinese government unable to carry out the reform of industry restructures and establishment of national legal systems. As Liu (2001) noted, the localism affected in establishing an efficient shipbuilding industry and, did more harm than good in developing regulations.

9.4.2 *Laws for the Chinese shipbuilding industry*

9.4.2.1 Laws in industry's life cycle

Chinese shipbuilding industry needed a professional legal system for development. Even if policies such as *"The Shipbuilding Industry Admittance Rule"* had enacted to manage shipyards, they did not have the universal and long-term effective binding forces to promote shipbuilding industry. Therefore, a new legal system should be established to effectively manage or protect the shipbuilding industry in their four parts of life cycle (Figure 9.3).

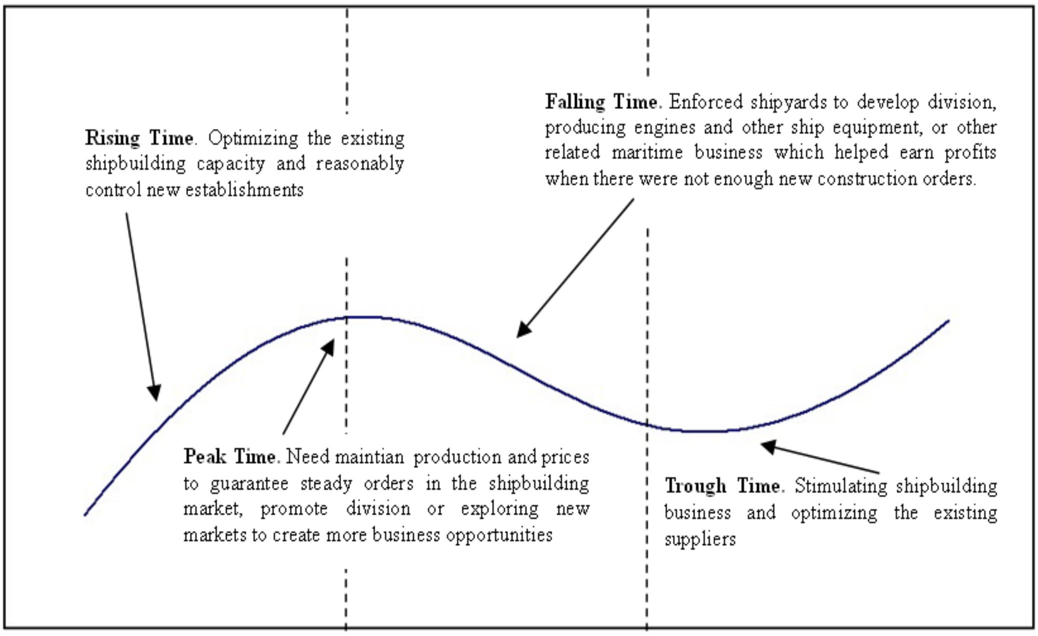


Figure 9.3 Shipbuilding Industry's Life Cycle

a) Trough time

It was difficult to maintain orders during a trough time as the market was over supplied. Laws thus could be used for stimulating business and optimizing the existing shipbuilding capacities. Just as the Japanese government did in the 20th century, *"Shipping Law"* or *"Marine Transportation Promotion Law"* was enacted to stimulated shipbuilding business and reorganize shipyards' building capacities.

b) Rising time

Shipbuilding industry would face a boom when world's seaborne trade was rising. The ambition of policies should be changed towards guiding shipyards' development. Countries such as the UK, Japan and Korea all adopted *"Shipbuilding Law"* to optimize their existed shipbuilding capacity and control new establishments during this time. This could also help maintain the rising time for lasting for a long time.

c) Peak time

Peak time came when the preliminary mass productions and the stacked newbuilding orders reached a balance. It was important that adjusting the shipbuilding industry structure and maintain orders at this time, or the blind competition (unreasonably reducing newbuilding price) would appear between shipyards. European countries and Japan solved this problem by using *"Shipbuilding Industry Law"* to promote division for more business opportunities.

d) Falling time

In the falling time, there were not so many newbuilding orders and so shipyards needed to develop new businesses besides shipbuilding. Countries such as Japan and Korea all used laws to force their shipyards to explore new businesses such as developing associated manufacturers. These could help shipyards earn profits from other business to balance losses in shipbuilding if they had.

9.4.2.2 Law performer promoter

Shipbuilding industry also needed law promoters to play as a vital role in carrying out government's development policies. In the 1930s, the Japanese government organized the *Shipowner Association Research* to promote government policies in developing shipyards' productivity and technology. Similarly, many countries' organizations such as the US *"American Shipbuilding Association"* and British *"Shipbuilders and Ship Repairers Association"* all actively assisted shipbuilding by researching and promoting policies.

Unfortunately, the Chinese shipbuilding industry did not have such an expert organizations to promote marine policies. The recent established organizations such as *"China Shipowner Association"* and *"China Shipbuilding Industry Association"* had not participated in executing laws for the shipbuilding industry. They only participated in fields such as market research, coordination and surveillance of the existed shipyards [Chen, 2008]. They lacked the independent rights to promote policies, and with few or no responsibility in building the legal system for shipbuilding industry. The result was, as Chen (2008) noted, no one would positively manage the policies but try to get the task off their hands.

Accordingly, China needed such professional organizations or associations to promote the establishment of shipbuilding industry's legal systems. The Chinese government should encourage the establishing of other professional organizations as well as stimulate and enhance the existing ones such as the *"Shipowner Association"* and the *"Shipbuilding Industry Association"*. These could be like *"Shipbuilding Industry Law Research Organization"* and *"Shipbuilding Industry Management and Promotion Organization"* that were established in UK, Japan and many European countries. Their ambitions should be focused on developing policies in the construction and development of shipbuilding industry to prevent the "redundant management" and the renewal of legal frameworks.

9.5 Summary

The government management was another element supported and developed shipbuilding. Those government managements were presented in changing ownerships, establishing a legal system and controlling shipyards' business in different market situations. History showed countries all managed ownerships by nationalization and privatization to develop shipyards, and a comprehensive legal system contributed to a successful shipbuilding industry.

The Chinese government did very well in managing shipyards' ownerships. The ownership of the shipbuilding industry was balanced between public ownership and private ownership. The state-ownership assured shipyards strong financial and political support and private-ownership provided shipyards more freedom in doing business. The most important thing that Chinese government needed to do immediately was establishing for the shipbuilding industry a professional legal system.

PART FOUR

RESULTS

- This part outlined the conclusions to the research and recommendations.
- In the conclusion, it firstly used the generated theory to compare and analyze two different shipbuilding countries: Korea and China. The economic background, technology development and government administration were used to explain their different performances and possible future trends.
- A recommendation for further research is generated at the end of this part. All those research and discussions were established on the selected research methodology - *Phenomenology*. A further research was recommended in using other research methods such as quantitative analysis.

Chapter 10. Shipbuilding Development Model

10.1 Introduction

According to the current research, different countries showed similar principles in developing their shipbuilding industries. Shipbuilding industry evolved in industrialisation and was affected by countries' economic background, technology development and government management. Countries' different progress of these three elements led to the different performances of shipbuilding industries.

In this chapter, a model of shipbuilding industry development trends was created for discussion. Countries' shipbuilding industry developed from low cost and low efficiency to high cost and high efficiency, and this would appear in the developing shipbuilding countries. Flourish and depression were unavoidable, but shipbuilding countries could learn from previous experiences to extend the cycle time as far as they could. Shipbuilding industry development in South Korea and China is also discussed in this chapter to reveal the future trend for new shipbuilding countries.

10.2 A Model of Shipbuilding Industry Development

A model of shipbuilding industry development was created based on the research of world's shipbuilding industries. As Figure 10.1 shows: 1) this model is divided into three stages including ***Boom***, ***Mature*** and ***Even***; 2) the vertical line shows the power of shipbuilding efficiency which is measured by the shipbuilding productivity showed in Chapter Seven; 3) the horizontal line shows the cost of shipbuilding which is increasing from left to right side; 4) the develop trend of shipbuilding industry is generally following the blue curve and; 5) the develop elements can be described as:

> *Shipbuilding industry is booming quickly by the advantages of economic background, maturing and dominating market by the technology development, then developing evenly to maintain market share.*

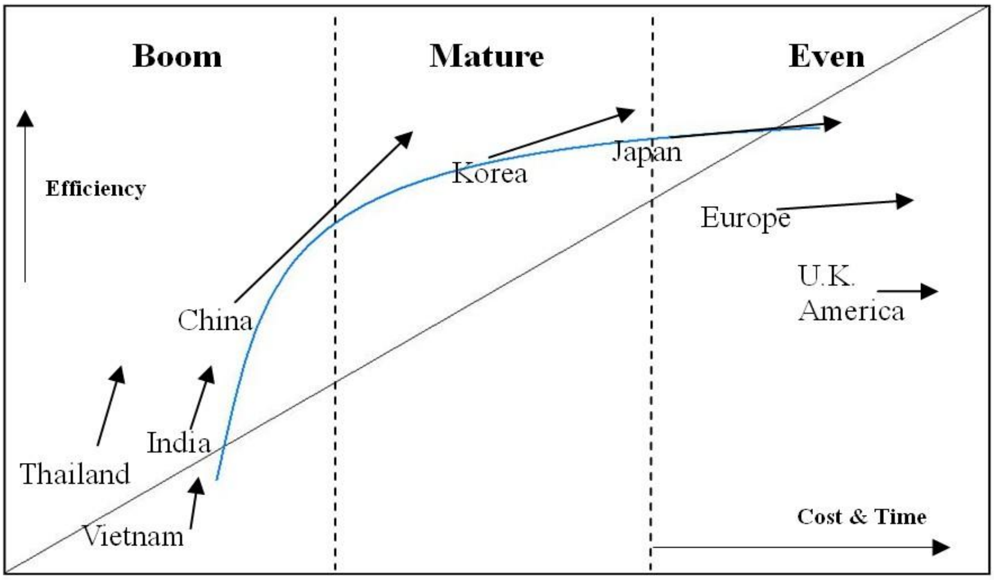


Figure 10.1 A Model of Shipbuilding Development

Note: Countries in this figure were mainly those who acting or still acting in shipbuilding in 2010. This diagram represents the current position in this thesis of these countries right now, the significance of the slope of the line accompanying each country' shipbuilding develop trend, this is going to be explained in the following phases.

10.2.1 *Boom*

Shipbuilding industry was booming after the development of national economy. Countries such as China whose shipbuilding industries were in the primary level were located in the *Boom* stage. Shipbuilding was labour intensive at this time and the cheap building cost was the most useful competitiveness. A concrete example was from the development of Chinese shipbuilding in 2000s. The cheap labour forces attracted extra newbuilding orders and investments, and the Chinese shipbuilding boomed quickly to become a compatible player in the world market [Chinese Industry Research, 2007].

The shipbuilding technology at this time was low and could not be bracketed with other developed shipbuilding countries' in the next stages. However, the economic backgrounds identified the certain positions in technology development. Shipbuilding in India, Thailand and Vietnam were less technological than that in China, and so they were in much left-lower corner in this model. As the economy development created sufficient labour force, primary manufacturers and national financial supports etc, the Chinese shipbuilding was thus developed with much competitiveness.

But by obtaining the cheaper labour force, the future trends of shipbuilding industries in the bottom three countries (i.e. India and Vietnam.) were more quickly than that in China. This was represented by their larger slope coefficients of trend lines in this model. This means that their shipbuilding costs were increasing slowly but they would build shipyards advanced technologies as well as efficiency and productivity easily.

10.2.2 *Mature*

Since 2000s, Chinese shipbuilding was developing from boom towards mature. It still fell behind countries in mature stage such as Korea, whose shipbuilding had been developed for over half century. Shipbuilding in countries such as Korea could still dominate the global market for long time. This was because they still obtained and led the development of shipbuilding technologies. Their matured industrial system contributed to the competitiveness of high productivity and efficiency.

Compared with countries in boom stage, Korea had lost the competitiveness in minimizing shipbuilding price. The most weakness and uncompetitiveness were from the developed national economy with appreciated wages increased the newbuilding costs [Lee, 2003]. Therefore, in the mature stage, countries developed shipbuilding more evenly than the countries in booming stage, as they had a smaller slope coefficient of trend line. In another words, their efficiency (productivity) was high, but developed slower as the shipbuilding costs were rising noticeably.

10.2.3 *Even*

Countries in the last stage of this model had a long history of developing shipbuilding. America and United Kingdom had experienced booming, dominating global market and losing significant competitiveness, but might still obtain a little efficiency in shipbuilding. As Vernon (1966) noted, their efficiency was high at their time, but could not meet the new world's requirements which were higher than before. The trend lines had the smallest slope coefficient - tending to a horizontal line. This indicated that their efficiency (productivity) would be maintained no matter how shipbuilding costs were increasing.

This model would make it much easier to research shipbuilding countries by locating them in the certain stages. Shipbuilding countries that located in this model would develop from left-low corner to right high corner, i.e. develop from cheap and low efficiency to expensive and high efficiency. The only difference between shipbuilding countries was represented by their different location in this model: a) new developed shipbuilding industry was in boom stage with a high-speed development of efficiency; b) the older was in mature or even stage with a high-speed development of cost.

10.3 Comparing China with Korea

10.3.1 *The similar economic background*

The shipbuilding industry in China and Korea both had similar economic backgrounds. They were promoted by the fast booming national economy. Firstly, as illustrated in Figure 10.2, Korean GDP and Chinese GDP kept growing from the 1960s to 1990s.

Korean real GNP expanded by an average of more than 8 percent annually, from US$33 billion in 1962 to US$204 billion in 1989 [Encyclopedia of the Nations, 2009]. Similarly in China during 1970s to 1990s, the GNP developed by the average growth rate of over 9 percent, from US$91.6 billion in 1970 to US$691.3 billion in 1995 [China Academy of Social Science, 1994; Chinese Industry Research, 2007].

Secondly, their primary industry sectors such as machinery manufacturers and steel manufacturers grew noticeably in those times. The number of Korean manufacturers grew by over 40 percent in the 1980s [Encyclopedia of the Nations, 2009], while the Chinese manufacturers were increased by over 50 percent from the 1970s to the 1990s [China Academy of Social Science, 1994]. The shipbuilding industry that needed various support of primary manufacturers thus was raised during those times.

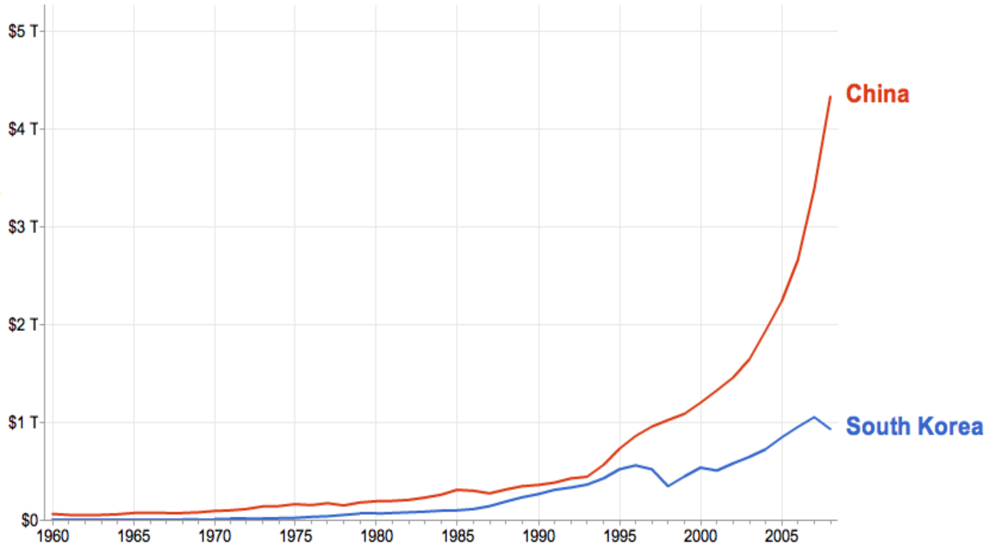


Figure 10.2 GDP of China and Korea, 1960-2005 (Trillion Dollars)

Source: World Bank, World Development Indicators, 2009.

Thirdly, the developing national economy also stimulated the investments in expanding shipbuilding capacities. Both in Korea and China, shipbuilding centers were built in coast areas where were developed with many primary manufacturers. The world-class ports such as Ulsan and Shanghai both provided excellent commercial environments for developing shipyards. As China Marine Economic (2008) noted: Korea developed five large shipbuilding groups in south coastal which occupied 95 percent of national share, and almost all Chinese shipbuilding enterprises were built in east coastal ports such as Dalian and Shanghai.

Moreover, the booming economy facilitated international businesses, which then stimulated the development of shipbuilding industry in both Korea and China. Korea and China followed the rapid growth of international trade to flourish their national economy (GDP) in the 1980s and 1990s respectively. The statistics from Encyclopedia of the Nations in 2009 showed the Korean principle export was increased from only about 835 million dollars in 1970 to over 65,000 million in 1990 (Figure 10.3), and the Chinese Industry Research (2007) calculated that the Chinese export rocketed from about 300 billion RMB in 1990 to over 2200 billion RMB in 2000 (Figure 10.4). And previous research showed that their shipbuilding industries were rising noticeably in those time periods: Korea was in 1983 and China was in 1995.

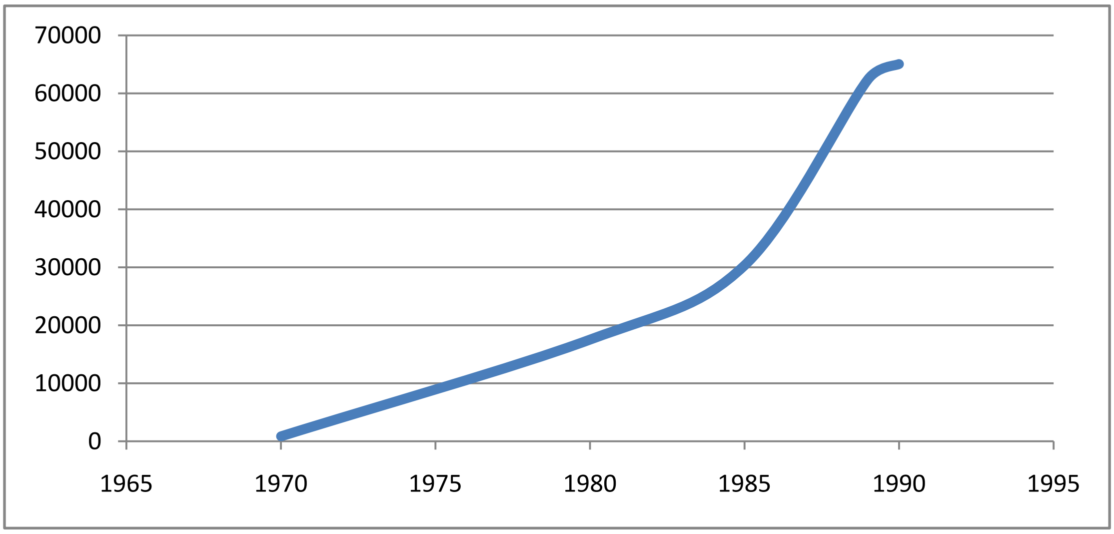


Figure 10.3 Korean Principal Exports (Million Dollars)

Source: Data from Encyclopedia of the Nations, 2009.

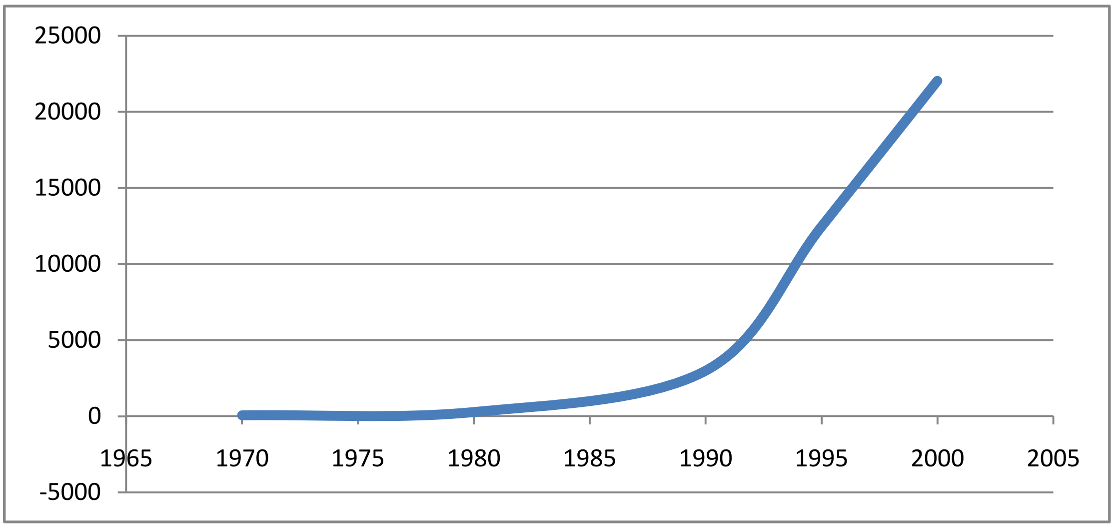


Figure 10.4 Chinese Export Value (100 Million RMB)

Source: Data from Chinese Industry Research, 2007.

10.3.2 *The differences in technology development*

Chinese shipbuilding industry fell behind Korea was because of the technology development. Those factors could be:

a) Evolving core technologies

Korean shipbuilding developed many "technological innovations" by various methods. These were: 1) direct paid for absorptions of foreign technologies through joint ventures [Hassink, 2005]; 2) a non-trade-type foreign technology transfer, i.e. sending personnel abroad for training or academic research; 3) obtaining technologies by the form of foreign cooperation; 4) establishing overseas technology-based enterprises or research centers. Korea imported those advanced technologies for building shipyards core technologies. The most notable ones were: the introduction of advanced technology developed the new shipbuilding standards, and an authority in building special ships [Vernon, 1966; Lee, 2003].

Chinese shipbuilding lagged behind Korean shipbuilding because of weakness in core technologies as showed in Table 10.1. One reason was because political reasons affected shipyards' technology development. China once benefited from the Soviet Union by shipbuilding facilities and professional workers, but this was not lasting for long as to the political conflicts. Moreover, the *Chinese Culture Revolution* in 1970s (during Chairman Mao) again blocked the domestic shipyards to learn advanced foreign technologies. And so China was weak in technologies when compared with Korea by the end of 20th century, the affections even lasted in 2000s [Chen, 2008].

Table 10.1 The Differences in Shipbuilding Technologies

	Korea	China
Using foreign shipbuilding technologies	Using and learning from foreign technologies since 1960s, evolving own technologies.	For political reasons, the process of technology development was at a standstill until the end of 1970s.
The life-cycle of introduced technologies	Introduced foreign technologies which were in researching or developing stage.	Almost the matured technologies or the equipments that already in standard production.
Research organizations	Domestic research. Set overseas research branches, took the advantage of foreign resource, and brought back the invented technologies.	Domestic research institution, mainly from state-owned shipbuilding enterprises, and some from certain universities.
Results	• 130 shipyards occupied over 40 percent global shares. • Self-supply over 85 percent of ship equipment. • Able to build high technical content ships like LNG, LPG all by themselves. • Can research and create new computer assistant design system. • Inventing new shipbuilding technologies.	• 3000 shipyards occupied 29 percent global share. • Self-supply about 40 percent ship equipments. • Lack of technologies in building high technical content vessels. • Using computer assistant design system from foreign countries. • Can invent new technologies but also need learn from foreign technologies.

b) Shipbuilding productivity

Chinese shipbuilding industry had sufficient cheap labor force, which was the main reason that flourished Chinese shipbuilding by the end of the 20th century. The employment of Chinese shipbuilding reached about 400,000 in 2008 while Korea was only about 93,000, but the average wages in China were less than one third of that in Korea (Figure 10.5). And the rising labor costs in Korea (Figure 10.6) made the Chinese advantage of cheap labour force become more competitive. As China Shipbuilding Industry Cooperation (2008) reported, in 2008, Chinese shipyards paid an average annual wage at 3,800 U.S. dollars while that in Korea exceeded 16,000 dollars.

However, such a cheap labour force was low productivity. As Chinese Industry Research (2007) calculated, till 2007, China needed about 50 man-hours for producing one DWT while Korean was less than 20. Chinese shipyards also need to introduce foreign engineers to fulfill the lack of technical professionals, which increased the shipbuilding time and extra costs.

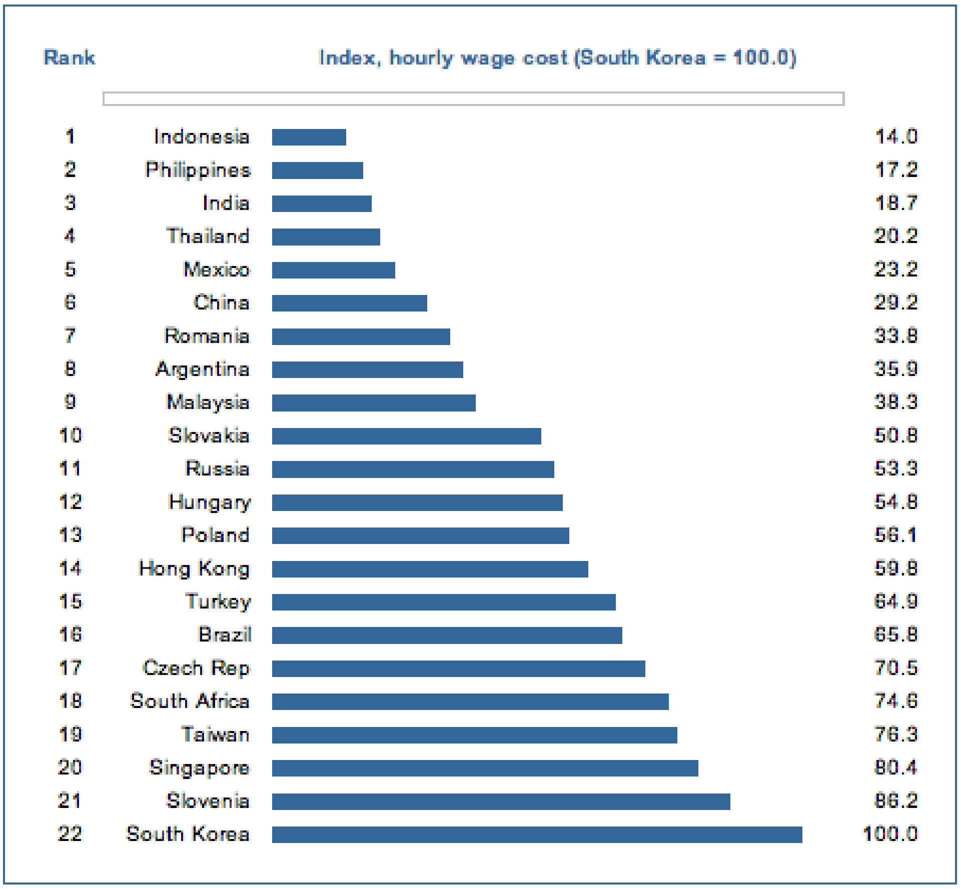


Figure 10.5 Labour Cost Index Compared with Korea, 2008 keep

Source: Abele, 2008.

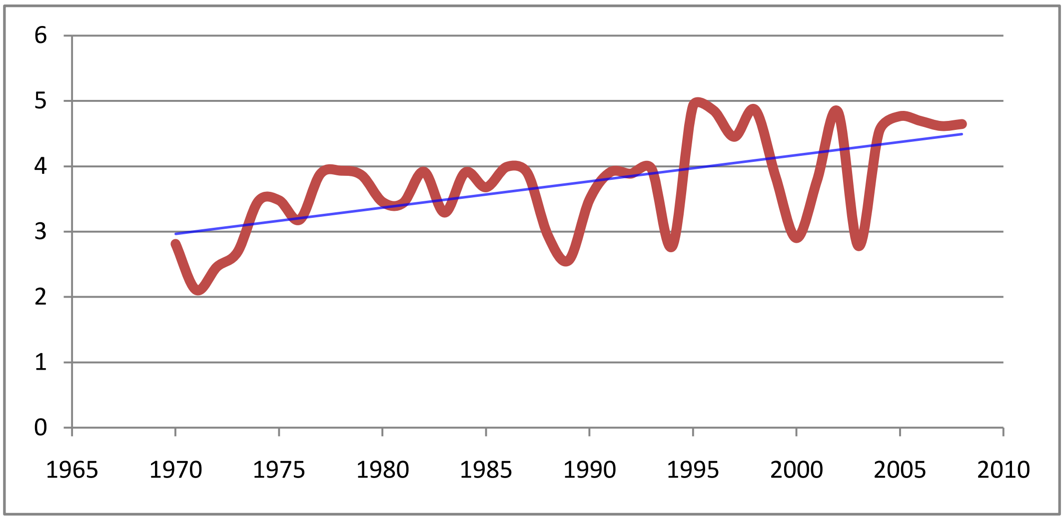


Figure 10.6 Korean Unit Labour Cost Index (in Log_{10})

Source: Data was colleted from Korean Natioanl Statistics, the original unit was in dollars per year, calculated by logarithms to minimize its fluctuation.

According to the model, Chinese shipbuilding industry would catch up with Korea by developing shipbuilding technologies and increasing productivity. This needed a comparatively long time. However, it was easy for the current Chinese shipyards to improve workers' performance. The high-quality and efficient workforce could maximize the price advantage by cheap wage and high productivity [Chen, 2008].

10.3.3 *The government interventions*

Korea had taken many actions to promote shipbuilding industry. Firstly, shipbuilding was developed as one of the main strategic export industries in Korea. The Korean government provided various support to build shipyard' building capacities and advanced technologies. Secondly, Korean government attempted to enhance shipyards' productivity. This had been achieved by increasing implementation of the automated machinery and computer-aided system in ship design and construction.

Similarly, actions were taken by Chinese government to develop shipbuilding industry.

The *"Adjusting and Developing Shipbuilding Industry"* in 2009 had clearly prescribed the main development strategies for government to develop shipbuilding was giving financial support, researching advanced technology and enforcing productivity. Those similar government interventions could also be found in Korean shipbuilding industry development.

10.4 Discussion within the Model

Korea shipbuilding and Chinese shipbuilding both experienced boom stage. It was their economic background – cheap labour that stimulated the booming of shipbuilding industry. As Ravenhill (1995) noted, Korean shipbuilding boomed in the 1960s with the global share rose so quickly was because the competitiveness of cheap labour minimized shipbuilding cost. And Chen (2008) also noted that Chinese shipbuilding relied on cheap labour force to boom and win the global shares in 1990s. They both developed their shipbuilding industry as one of the most important suppliers in the world's market in merely 20 years time. And they had the same develop trends in boom stage in this model- a large slope coefficient of trend lines.

Korean shipbuilding entered into the mature stage because of the development of advanced technology. The economic globalization entailed the convergence of corporate procurement costs and the national economic development, which would increase the wages. Korean shipbuilding faced this by the end of 20th century and thus turned the shipbuilding competitiveness into advanced technology and productivity. This also indicated the characteristics of shipbuilding industry in mature stage. Although Chinese labour force was cheap, the technology and productivity were still lagged. In 2000s, Chinese government started optimizing the industrial structure and operational management to improve efficiency. It was believed that the Chinese shipbuilding would enter the mature stage as well, and the slope coefficient of trend line would become more even.

10.5 Summary

The development of shipbuilding industry in different countries followed a common trend. This chapter created a model to explain shipbuilding industry development comprising three stages including boom, mature and even. Developing through the three stages in a diagonal, i.e. from the left low corner to right high corner in this model, shipbuilding industry would experience: 1) the development speed gradually decreased; 2) booming to occupy large market shares then losing to the new players; 3) the slope coefficient of trend line changed from large (almost vertical) to small (almost horizontal); 4) a development from cheap and low efficiency to expensive and high efficiency.

Investigating in shipbuilding industries in both Korea and China, their previous development could be explained by this model. They both experienced the first stage of booming shipbuilding industry by cheap labour cost. And they would unavoidably develop advanced technology and high productivity then entered into mature stage. They did not totally copy development strategies from each other, but was naturally following the common trend of development respectively.

Chapter 11. Conclusion and Recommendation

The current thesis was based on the research which traced the development of shipbuilding industries around the world over the last three hundred years until now. Lots of previous research had already been conducted across the world on the development of the shipbuilding industry in countries such as the US, the UK, Japan and Korea among others. They attempted to describe how shipbuilding developed in certain countries at certain times by the way of analyzing market trends and so on. But many of them only presented the practical factors (the phenomena) concerned in shipbuilding rather than formulating a general theory. So they could not answer why the shipbuilding industry developed and flourished in this country but not in the other.

The idea of generating a general theory to explain the relationship between shipbuilding and the national economy became the objective of this thesis. Such a theory was considered as could be adapted for guiding the future development of world's shipbuilding industry.

11.1 Efficient Using the Methodology

Phenomenology was adopted as the main paradigm and methodology of this research. The phenomenology used in this thesis was subscribed to the three-step methodology, which, as Husserl (1859~1938) named *Epoché*, *Eidetic Reduction* and *Transcendental Reduction*. The ambition was applying objective reality without any incongruent prejudices to prove that pure elements existed before the phenomenon and experience. The relationship between the shipbuilding industry and national economy development was such a pure element that was inherent and unchangeable and could cause all possible phenomena and experiences.

According to the methodology of phenomenology, the current research was progressed in five stages:

- *Knowing, understanding and summarising;*
- *Understanding the relationships of factors;*
- *Generating the idea;*
- *Eliminating the unproductive and maintaining the useful;*
- *Promoting the Theory.*

Across these five stages, the research materials such as books, published articles, journals, market reports and official documents were classified to clarify the relations between factors. And they covered politics, industrialisation and economics within the main shipbuilding countries such as the U.S., the U.K., European countries, Japan and South Korea. All those aimed to show that economic background, technological development and government intervention were the core factors in developing the shipbuilding industry.

11.2 The Three Elements of Shipbuilding Industry

Shipbuilding industry evolved and developed within the special environment created by industrialisation. Industrialisation was the process whereby a country transfers from pre-industrial to industrial modes of production, i.e. from agriculture to industry and from industry to services (Figure 11.1). The shipbuilding industry evolved in the second stage of industrialization when industries were developing from labour intensive to more capital and technology intensive. Countries such as the UK, Japan and Korea all developed their shipbuilding industry within such a common environment during industrialisation. They depended on sufficient cheap labour forces for a quick boom and then developed more advanced shipbuilding technologies to keep their competitiveness.

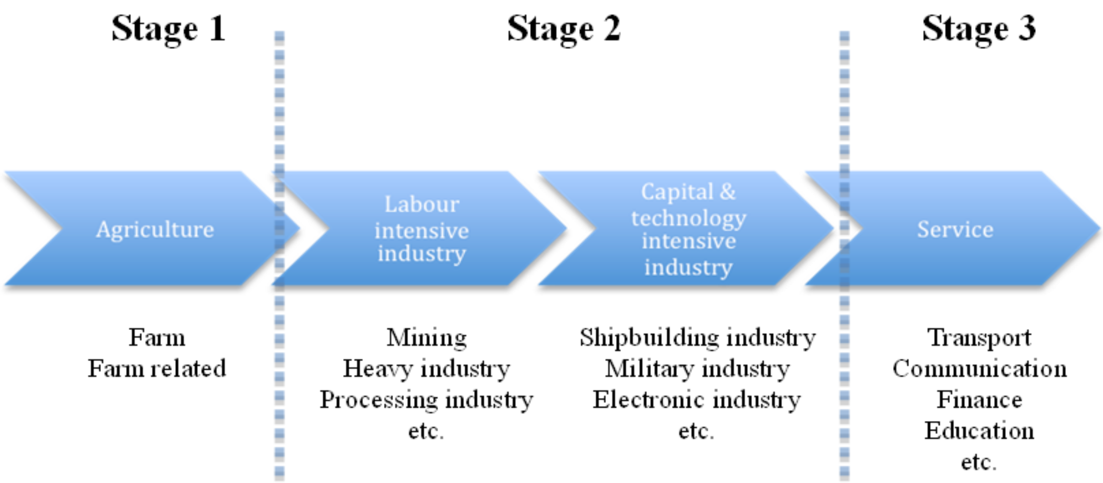


Figure 11.1 Industrialisation Process

Industrialization created a strong environment for developing the shipbuilding industry. The current research concluded the relationship between the shipbuilding industry and the national economy as (Figure 11.2):

> *Shipbuilding is created and developed under a systemic organization and concentration of a well-performing economic background, technological development and government intervention.*

The research in world's shipbuilding history showed that shipbuilding was almost developed based on the above principle. And the better the management of these three, the more successful the shipbuilding industry would be.

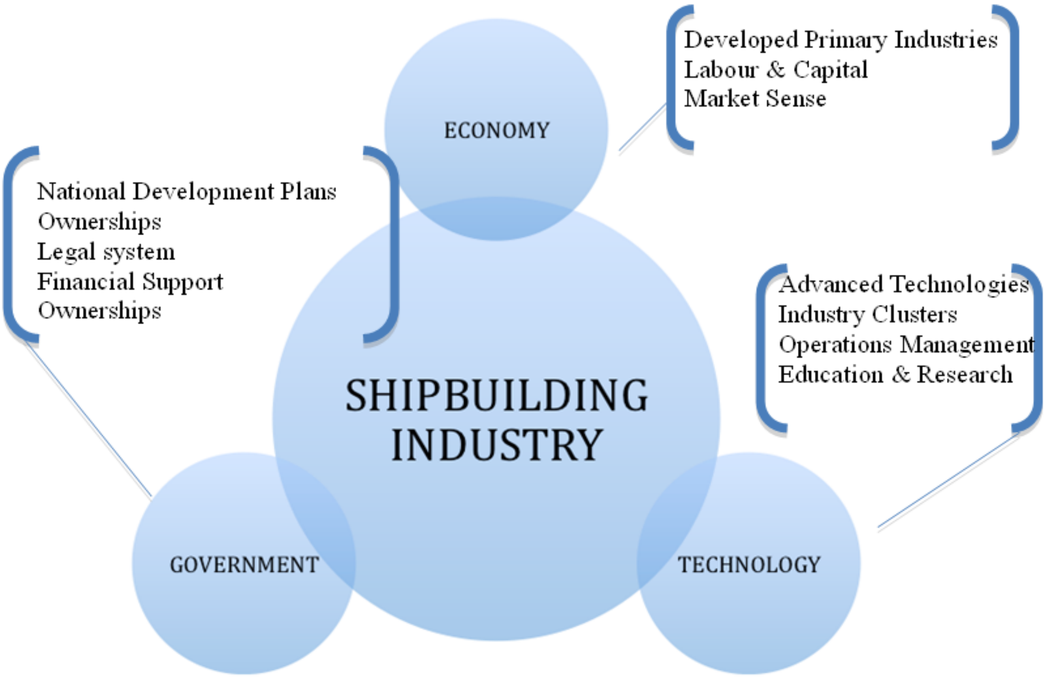


Figure 11.2 The Three Elements for the Shipbuilding Industry

a) Economic Background

Shipbuilding industry was a high capital and technology-intensive industry needed sufficient support from national economy development. These supports included sufficient material resources, developed primary manufacturers, massive cheap labour forces and basic industrial technologies etc.

b) Technological Development

Shipbuilding industry needs advanced technologies to gain competitiveness. Domestic research and introducing foreign advanced technologies was two methods to develop shipbuilding technology. Technology development was also represented by the developed industry cluster and, shipyards' scientific business operation such as integration and division to enhance efficiency and productivity.

c) Government Intervention

Government intervention was an indispensable tool for guiding and supervising the development of shipbuilding industry. History proved that shipbuilding industries in different countries necessitated their governments' managements. These were managing ownerships, establishing a legal framework, enacting policies and giving capital supports.

11.3 Researching Chinese shipbuilding

In the current research, the Chinese shipbuilding was used to discuss the theory in more detail and with more reliability. The previous research in world's shipbuilding history was the process of generating the pure theory as the *Epoché* and the *Eidetic Reduction* in phenomenology. The approach of using the most recent Chinese shipbuilding development as a case study then was considered as the *Transcendental Reduction*. And by researching the Chinese shipbuilding industry, the three elements acted in the whole development process.

11.3.1 *Economic background of Chinese shipbuilding industry*

Shipbuilding industry necessitated the economic background such as material resources and the developed primary manufacturers for development. Firstly, the current Chinese shipbuilding industry had the sufficient supply of building resources including materials and labour forces to minimize newbuilding cost. This became the Chinese shipyards' notable competitiveness. China had developed a substantial steel supply system for shipbuilding industry. Except for the domestic productions, steel plates could also be easily imported from Japan and Korea for the special technological requirements. On the other hand, China still maintained a sustainable supply of cheap but skilled labour force. Chinese industrialisation created massive labour forces from agriculture to industry which reduced the shipbuilding cost noticeably. The formal education and vocational education were implanting them with splendid technical skills as well.

Secondly, the Chinese industrialisation developed various primary manufacturers which can fully support shipbuilding industry by materials and machine equipments. China achieved the industrial conversion from agriculture to industry in the early 1970s. Since then, a great number of machinery manufacturers and processing manufacturers were developed which made China become the largest “World’s Factory”. Therefore, shipbuilding industry was booming quickly in China by various fundamental supports such as skilled works and basic mechanical technologies from those primary manufacturers.

Moreover, the good market responsiveness was also promoting the development of Chinese shipbuilding industry. The Chinese shipyards were mainly located in the three economy zones i.e. Bohai Bay, Yangtze Delta and Pearl River Delta to introduce massive business opportunities. The shipbuilding demands both from home market and foreign market flourished shipyards’ newbuilding orders. Shipyards also made investments at the right time, by which they won lots of revenues when the shipbuilding market was booming.

11.3.2 *Technological development of Chinese shipbuilding industry*

Technological development was another important element in promoting Chinese shipbuilding industry. China had applied two approaches to develop shipbuilding technologies: domestic research and learning advanced technologies from foreign countries. First of all, the domestic research for shipbuilding technologies was supported by government’s R&D investments. The Chinese government distributed lots of R&D investments for technological development, and the significant investments in industry sector stimulated the creation of advanced technologies in shipbuilding industry. On the other hand, China also used the foreign advanced technologies to effectively develop domestic shipyards. These were mainly from directly introducing (buying) foreign technologies and cooperating with foreign shipyards for evolving new technologies. Chinese shipyards thus could quickly catch up with the advanced international standards of shipbuilding.

Technological development was also represented in developing the scientific operations management. China had already promoted the shipyard's operation by establishing industry clusters. Such a shipbuilding industry cluster facilitated the development of marine industries (shipbuilding, shipping, shiprepairing etc), associated manufacturers, marine technologies and many other related areas. The Chinese shipyards also developed internal operations management which focused on *Purchase*, *Production*, *Service* and *Reverse Logistics* to facilitate a more efficient and scientific business operation. These could also be learnt by other shipbuilding countries to develop a more scientific shipbuilding industrial system.

11.3.3 *Government intervention of Chinese shipbuilding industry*

The government interventions to shipbuilding industry were represented in managing shipyards' ownerships (nationalization or privatization), establishing legal system and enacting efficient policies. Chinese government had taken the advantages of those government interventions to develop shipbuilding industry. Firstly, the Chinese government set the ownership of shipbuilding industry between state-ownership and private-ownership to obtain the advantages from both of them. These were: 1) the state-ownership assured shipyards the reliable financial and political support from government and; 2) the private-ownership gave shipyards more vitality in doing business. Moreover, the Chinese government also started building a professional legal system for the domestic shipbuilding industry at the beginning of the 21^{st} century. A scientific and complete legal system could make policies or regulations effectively to supervise shipyards' development. The policies for maintaining shipbuilding in 2009 (world's financial crisis) as well as the enacted *"Project of Adjusting and Fostering Shipbuilding Industry"* were protecting and developing the shipbuilding industry a better performance (e.g. optimized building capacities etc).

11.4 The Prediction of Chinese shipbuilding

Different countries' shipbuilding industry development followed a common trend as shown in the model of shipbuilding development. Shipbuilding industry had a life time cycle that could be divided into three stages i.e. Boom, Mature and Even. Shipbuilding is commonly developing from cheap and low efficiency to expensive and high efficiency. Chinese shipbuilding is located in the boom stage, and would unavoidably develop towards high efficiency and productivity in this model.

By using this model, the potential problems of Chinese shipbuilding development can also be discovered. Firstly, to the economic background aspect, although was supported well by the primary manufacturers and cheap labour forces, the Chinese shipyards are still low in efficiency and productivity. The current appreciation of wages would add the costs for newbuildings. A solution should be carried out to enforce the efficiency, productivity and quality of workers before their wages were truly soaring. Secondly, Chinese shipyards need to develop the core technologies for creating competitiveness. Chinese government still needs to adopt the two approaches (i.e. domestic research and introducing foreign technologies) to develop the most advanced technologies. This will bring lots of technology improvements and promote the ability of self-innovation, but still needs a long way to catch up with developed countries. Thirdly, the Chinese government needs to distribute more interventions to shipbuilding. The current Chinese shipbuilding needs a complete legal system for developing various policies. But this is discouraged by many contradictions such as the conflicts between central government and local governments. Chinese shipbuilding necessitates laws for promotion, supervision and guiding the future development within the market cycle. The enacted *"Project of Adjusting and Fostering Shipbuilding Industry"* in 2009 was a good example of developing such a complete and scientific legal system.

11.5 Recommendations for Further Research

By investigating historical data and the most recent Chinese shipbuilding industry, the current research applied a phenomenological methodology to explain the relationship between shipbuilding industry and national economy development. The generated theory and model could be used in further research in the development forecast and feasibility analysis of developing the shipbuilding industry in particular countries. For example, when discussing the shipbuilding industry in India, reasons would be concluded: 1) India had not experienced the complete development of industry (the second stage) within industrialisation and so there was an unsuitable basic economic background for the shipbuilding industry; 2) the current India still had an underdeveloped primary manufacture system and thus was insufficient in supplying shipyards the necessary basic technologies; 3) India had a weak industrial legal system which could not guide and protect its shipbuilding industry.

However, further research in different shipbuilding counties in more detail is required in order to fulfill the generated theory and model. First of all, this research was carried out on the selected shipbuilding countries. Few considerations were taken for researching those small developing countries in the contemporary world which had their own shipbuilding industry. And so the generated theory and model might not be fully suitable for explaining their special situations. One the other hand, this thesis did not apply mathematical modeling or quantitative research method to present the relationship between shipbuilding and the national economy. Therefore, a further research would be recommended to forward the theory and model by subjecting them by other research methods such as quantitative analysis.

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APPENDIX

Appendix 1 Chinese Shipbuilding History

China is one of the oldest shipbuilding nations in the world. According to the archeological research, Chinese people could already build canoes and use oars before 4500 BC [I Ching, 11^{th} BC]. When China was in the period of a slave society, the developed national economy helped ship transportations to flourish, which contributed to the development of shipbuilding as well [Zhu, 2005]. The canoe shows many weak points such as its small carrying capacity and low navigation speed, thus it prompted the development of building simple wooden boats (about 2500 B.C.).

After 770 BC, China entered into the “Spring and Autumn Period” and “Warring States Time”, during which wars stimulated the development of shipbuilding technologies, and a large number of warships were developed from the commercial ships. For example, the earliest “River War” in Chinese history occurred around 510 BC between two countries called “Wu” and “Yue”, and the large battle vessel called “Da Yi” was already over 20 meters long and 2.7 meters in width. It was built to accommodate 26 warriors and, with 50 rowing workers together with other operators, the vessel could carry over 90 people [Li, 977].

From 220 BC, the Chinese wooden shipbuilding was becoming in technologies, which made vessels larger and stronger and offered new capacities. In the Qin dynasty (221 BC - 206 BC), ships could be built over 30 meters long, with the carrying capacity reaching about 60,000 kilograms, and could be navigated on the sea near the coast line by applying sails. The Han dynasty (since 206 BC) showed further progression in shipbuilding. A classic battle ship at that time was called the "Towered Ship", shown in the following Figure, which was over 10 feet high and had a tower on the deck. With the help of anchor, rudder, sails and wooden or stone defensive walls on board, such a ship was competent for sea-wars as well.

Towered Ship of Han Dynasty

Source: Quanzhou Maritime Museum, 2002.

After the 7th century, Chinese shipbuilding flourished due to the use of several shipbuilding methods. One of the most noticeable was in the Tang Dynasty (since 618). Tang's shipbuilding was developed under a strong economic background and the enhanced shipbuilding technologies [Chu, 2007]. One of the notable innovations was applying rivets to enhance hull strength. This building technology was more advanced than European shipbuilding which still connected the deck by ropes at that time. It also constructed watertight bulkheads to protect and ensure that they were not easily sunk.

Recovered Tang's Watertight Bulkhead

Source: The Ships Museum of Shanghai Jiao Tong University, 2002.

In the 10th century, China entered into the Song dynasty when was more professional in building large ships. Shipwrights of the Song dynasty specialized in building different kinds of vessels for different purposes. Ships could be built with a loading capacity over 200 tons and wash bulkheads to avoid sinking when striking on a rock. To improve the navigation speed, on the other hand, ships were constructed with a maximum of ten masts and adjustable sails that were carefully styled for maximum utilization of the wind. The compass was also applied for more precise navigation as well. Such the Chinese ancient shipbuilding and navigation technologies were in the leading position in the world at that time. This was well known by the ancient world for their large carrying capacity, and reputation for being fast, strong, safe and reliable [Tan, 2008]. These techniques helped Chinese shipbuilding to build large ocean ships, which were very famous in Southeast Asia.

At the start of the 15th century, the sailing ships that were built in China became the world's biggest, the most reliable and superior in seaworthy terms. During the Ming dynasty, in 1405, Zheng He travelled seven times to the western world by the ships exceeded 140 meters long and 60 meters wide. This was far bigger than Columbus used for travelling to the Americas. The whole fleet reached 200 boats, some of them ranging on voyages as far as Somalia and Kenya on the East African coast. Ming's shipbuilding technology had mounted a crest in ancient shipbuilding history, and this great achievement received long time praise from various countries.

Zheng He's ship compared with Columbus's

Source: Wikimedia, 2006.

In the later 15th century, however, the Ming government changed to implement the maritime restriction policies to prohibit international trade. In this case, the shipbuilding industry started to change to the direction of developing river navigation and coastal defense. At this time, Chinese shipbuilding developed certain shipbuilding centers. For example, Yangzi River's shipbuilding center mainly served the inland water transport, and Zhu Jiang River's shipbuilding center mainly built ships for official and military usage. In addition, the Ming's shipbuilding industry also developed some primary accessory manufacturers to process spare parts like sails, ropes and nails. It appears that with the scientific management of inventory, material supply systems and shipbuilding payments, a more advanced shipbuilding industry system was established

Appendix 2

The Selected Chinese Shipyards' Locations and Productions

The Northeast Shipbuilding Center

Province	Name	Location	Building capacity (DWT/annually)	Productions
Liao Ning	**Dalian Shipbuilding**	Dalian	2,660,000 (08)	Tanker, container ships, bulker carriers, chemical ships, ro-ro, marine engineering.
	Dalian New -Ship Heavy Industries	Dalian	2,400,000 (09)	VLCC, container ships, offshore drilling platform and marine engineering product.
	Bohai Shipbuilding Heavy Industry	Huludao	2,000,000 (08)	VLCC, capsize bulk carrier, container ships.
	Liaoning Marine & Offshore Industry	Yingkou	150,000 (08)	Chemical ships, LPG and Cruise ship.
Shang Dong	**Qingdao Beihai Shipbuilding**	Qingdao	3,000,000 DWT (09)	Tanker, bulk carrier, LPG, container ships, FPSO and floating dry dock.
	Huanhai Shipbuilding	Shidao	100,000 DWT (09)	All types of ships under 30,000 DWT.
	Shandong Weihai Shipyard	Weihai	1,000,000 DWT (09)	Bulk carrier under 30,000 DWT, multi-purpose container ships, tankers.
	Daewoo Shipbuilding Shandong company	Yantai	100,000 DWT (09)	Container, tanker, car carriers, LNG, LPG and passenger vessels in block or section fabrication.
	Samsung Heavy Industry Shandong Company	Rongcheng	100,000 DWT (09)	Container, tanker, LNG and passenger vessels in block or section fabrication.
	Penglai Jinglu Ship Industry	Penglai	1,000,000 DWT (09)	Container ships, bulk carriers and special ships.
	Shanghaiguan Shipbuilding Industry Co. Ltd	Qinhuangdao	100,000 DWT (08)	Bulker carriers under 30,000 DWT, container ships under 3,00 TEU, floating dock, semi-submergible barges, repairing, and offshore production.

The Yangtze River Delta Shipbuilding Center

Province	Name	Location	Building capacity (annually)	Productions
Jiang Su	**New Century Shipbuilding**	Jingjiang	1,500,000 DWT (09)	Tankers in 70,000 DWT and 110,000 DWT, container ships from 4,000 to 6,000 TEU, and bulker ships in 35,000 DWT, 52,300 DWT and 175,000 DWT.
	Jiangsu Yangzi Jiang Shipbuilding	Jiangyin	200,000 DWT (08)	Multipurpose vessels and bulk cargo vessels all under 50,000 DWT, chemical ships and engineering ships.
	China Changjiang National Shipping Corporation, Nanjing Jinling shipyard	Nanjing	580,000 DWT (09)	RO-RO vessels round 10,000 DWT, special purpose vessels, chemical tanks form 10,000 DWT to 40,000 DWT, container ships under 1100 TEU.
	Nantong COSCO KHI Ship Engineering Co., Ltd	Nantong	700,000 DWT (08)	VLCC round 300,000 DWT, container ships round 5,500 TEU, bulk vessels at 55,000 DWT and RO-RO at 5,000 DWT.
Shang Hai	**Jiangnan Shipyard**	Jingjiang	4,500,000 DWT (09)	Tankers, LNG, bulk carriers and chemical ships.
	Hudong-Zhonghua Shipyard	Pudong	2,000,000 DWT (09)	Container ships under 8350 TEU, LNG ships round 150,000 m^3 , car carrier, bulk vessels around 75,000 DWT, tankers round 70,000 DWT, passenger ships.
	Shanghai Waigaoqiao Shipbuilding Co., Ltd	Taizhou	2,600,000 DWT (09)	Bulk carrier of 175,000 DWT and 177,000 DWT, 105,000 DWT aframax tanker, 150,000 DWT, 170,000 DWT and 300,000 DWT FPSO, 300,000 DWT VLCC, drilling platform, large container ships.
Zhe Jiang	**Ouhua Shipbuilding Industry Co., Ltd**	Zhoushan	350,000 DWT (06)	All kinds of ships from 10,000 DWT to 100,000 DWT.
	Zhejiang Hongguan Ship Industry	Taizhou	150,000 DWT (08)	Oil production tankers, bulk carriers and chemical ships between 10,000 DWT and 30,000 DWT.
	China Dong Fang Shipbuilding Co., Ltd	Wenzhou	200,000 DWT (08)	Container ships, bulk carriers, chemical ships, multi-purpose vessels and clean tanks, under 30,000 DWT.

The Zhujiang River Delta Shipbuilding Center

Province	Name	Location	Building capacity (annually)	Productions
Fu Jian	**Fujian Southeast Shipyard Co., Ltd**	Mawei		Cargo vessel, multiple purpose container cargo ship, fishing ship, barge, engineering ship, travel ship, all under 5,000 DWT.
	Fujian Mawei Shipbuilding Co., Ltd	Mawei		All kinds of ships under 35,000 DWT.
	Fujian Quanzhou Shipbuilding Co., Ltd	Quanzhou	1,480,000 DWT (09)	All kinds of ships mainly over 100,000 DWT, especially bulk and tankers at 100,000 DWT and 170,000 DWT, and container ships round 8,000 TEU.
	Fujian Guanhai Shipbuilding Co., Ltd	Fuzhou	100,000 DWT (08)	Container ships between 700 and 2,500 TEU, other cargo vessels from 10,000 DWT to 80,000 DWT include tank.
Guang Dong	**Guangzhou Shipyard International Company Co., Ltd**	Guangzhou	380,000 DWT (08)	RORO, Chemical ships, tankers for oil productions and other kinds of vessels at handy size, ship repairing.
	Guangzhou Wenchong Shipyard Co., Ltd	Guangzhou	300,000 DWT (08)	Container ships under 1,700 TEU, bulk cargo vessels and multi-purpose ships under 30,000 DWT, engineering ships and ship repairing.
	Afai Southern Shipyard (Panyu Guangzhou) Co., Ltd	Guangzhou	100,000 DWT (08)	Passenger vessels.
	Guangdong Haitong Shipyard Co., Ltd	Shantou	230,000 DWT (08)	Container ships and bulk cargo vessels from 10,000 DWT to 30,000 DWT.
	Dongguan Juxing Shipyard Company Co., Ltd	Dongguan		Custom yacht.
	Youlian Dockyards Co., Ltd	Shenzhen		Largest ship repairing and reconstruction company in south China, can operated with ships over 300,000 DWT.

Shipyards' Building Capacities in Inland Provinces

Province	Name	Location	Building capacity (annually)	Productions
Hu Bei	**Hubei Qingshan**	Wuhan	300,000 DWT (09)	Container ships over 10,000 DWT, chemical ships from 5,000 DWT to 20,000DWT, LNG and bulk carriers.
	CSIC Wuchang	Wuhan	230,000 DWT (08)	All kinds of commercial ships and some special function vessels below 8,000 DWT.
	Jiangbei Yuanhan Shipbuilding Industry	Huanggang	100,000 DWT (08)	Bulk carriers and container ships round 10,000 DWT for coastal line, chemical ship and other engineering ships.
	CSC Yichang Shipyard	Yichang	80,000 DWT (08)	All kinds of ships for river or costal navigation, less than 10,000 DWT.
Jiang Xi	**Jiangxi Jiujiang Yinxing Ship Heavy Industry Group**	Jiujiang	200,000 DWT (08)	All kinds of ships especially the oil product tanks under 50,000 DWT.
	Jiujiang Xiangsheng Shipbuilding Co., Ltd	Jiujiang	300,000 DWT (08)	Ships under 20,000 DWT especially oil products tanks and chemical tanks.
	Jiangzhou Union Shipbuilding Co., Ltd	Ruichang	200,000 DWT (08)	All kinds of ships under 20,000 DWT.
An Hui	**Wuhu Dajiang Shipyard**	Wuhu	20,000 DWT (08)	Container ships , bulk cargo ships from 100 DWT to 3,000 DWT, passenger ships, barge and engineering vessels.
	Wuhu Xinlian Shipbuilding Co., Ltd	Wuhu	500,000 DWT (09)	Bulk carriers at 30,000 DWT, RORO for about 3,000 cars, chemical ships under 50,000 DWT, engineering ships from 10,000 DWT to 30,000 DWT and yacht.
Chong Qing	**Chuandong Shipbuilding Industry**	Chongqing	30,000 DWT (08)	All kinds of ships under 8,000 DWT, especially chemical ships.
	Chongqing Dongfeng Shipbuilding Co., Ltd	Chongqing	200,000 DWT (09)	All kinds of ships under 8,000 DWT.
	Shenxi Shipbuilding	Chongqing	60,000 DWT (08)	Passenger ships under 10,000 DWT, container ships and LNG for coastal lines.

Appendix 3

The Examples of Foreign Cooperation in China, 2006

Time	Locations	Productions	Foreign cooperation companies
2006/1	Chongqing	ABB turbo.	Switzerland ABB company
2006/3	Changzhou	Steam generator, pressure vessel, offshore platform.	Kangrim Industries Co., LTD. Korea (Foreign-Funded only)
2006/5	Shanghai	Ship equipment, generators.	WARTSILA cooperate with CSIC
2006/6	Wuxi	Lateral thruster.	WARTSILA (Foreign-Funded only)
2006/6	Suzhou	MTU 2000 series diesel engine.	MTU (Foreign-Funded only)
2006/6	Wuhan	Shipping-matched equipment (research, production and sell).	Changjiang National Shipping Group (50%), Wuhan East Lake High Technology Group (25%) and IMSK (25%).
2006/8	Anqing	Diesel engine and other related metal attachment.	Japan DAIHATSU CO., LTD, produces DK-20, DK-26, DK-28 series marine generator (50%).
2006/9	Shanghai	Diesel engine.	Mitsubishi, CSSC and Hudong heavy industry.
2006/10	Zhenjiang	Propeller.	WARTSILA and CSSC.
2006/10	Qindao	Diesel engine.	CSIC、WARTSILA and Mitsubishi.
2006/11	Shanghai	High Voltage Electromotor.	Switzerland ABB company.
2006/11	Dalian	Components for large marine engine.	DOOSAN (Foreign-Funded only)
2006/12	Wuhan	Ship's auxiliary machinery (control system, fire protection system, etc.).	JASON company, UK and another four German companies.
2006/12	Dalian	Diesel engine and engine’s crank.	STX

Appendix 4

A Selected List of Chinese Ship Component Import, 2008

Code	Name	IT P / G %	ET %	VAT %	CT %	Quantity Ship Needed No.			
						B	C	L	S
Propulsion machinery									
84081000	Engines	5.0 / 11.0	0.0	17.0	0.0	1	1	1	
85371010	Monitoring plant of main engine	5.0~8.4/14.0~50.0	0.0	17.0	0.0		1	1	
85015300	Electric motor	12.0 / 35.0	0.0	17.0	0.0				
85372090	Switchboard	8.4 / 50.0	0.0	17.0	0.0				
85044090	Transducer	10.0 / 30.0	0.0	17.0	0.0				
85043400	Transformer	14.0 / 50.0	0.0	17.0	0.0				
84851000	Propeller or thrusters	6.0 / 14.0	0.0	17.0	0.0				
90141000	Electric gyrocompass	2.0 / 8.0	0.0	17.0	0.0				
Shafting system									
84833000	Shafting bearing, amortisseur	6.0 / 30.0	0.0	17.0	0.0	1	1	1	
84842000	Shaft gland	8.0 / 30.0	0.0	17.0	0.0	1	1	1	
Side thrust system									
84851000	Side equipments	6.0 / 14.0	0.0	17.0	0.0				
85371090	Control system	8.4 / 50.0	0.0	17.0	0.0				
Electric generating set									
85021200	D-fuel generating (75KVA ~ 375KVA)	10.0 / 45.0	0.0	17.0	0.0	1	1	1	
85021310	D-fuel generating (375KVA ~ 2MVA)	10.0 / 45.0	0.0	17.0	0.0				
85021320	D-fuel generating (< 2MVA)	10.0 / 30.0	0.0	17.0	0.0	3	4	3	
85016410	Alternator (750KVA ~ 350MVA)	10.0 / 30.0	0.0	17.0	0.0				
85016300	Axle generator (375750KVA)	12.0 / 30.0	0.0	17.0	0.0	1	1	1	
Marine pump									
84137010	Water pump	8.0 / 40.0	0.0	17.0	0.0	1	1	1	
84133090	Oil pump	3.0 / 30.0	0.0	17.0	0.0	1	1	1	
84211990	Oil separator	10.0 / 30.0	0.0	17.0	0.0	5	7	5	
84212190	Water oil separator	5.0 / 50.0	0.0	17.0	0.0	1	1	1	
Boiler									
84021200	Heating boiler a	5.0 / 35.0	0.0	17.0	0.0	1		3	

84162090	Boiler combustion equipments	10.5 / 35.0	0.0	17.0	0.0	1	1	1	
General navigation facility									
90141000	Induction compass, rudder setter	2.0 / 8.0	0.0	17.0	0.0	2	2	2	
84798990	Wiper, snow & rain disposal	0.0 / 30.0	0.0	17.0	0.0	1	1	1	
91040000	Primary-secondary clock	10.0 / 100.0	0.0	17.0	0.0	1	1	1	
Radio aid to navigation and radio communication equipment									
85269190	Satellite navigation equipment	2.0 / 8.0	0.0	17.0	0.0	1	1	1	
85261010	Radar	2.0 / 8.0	0.0	17.0	0.0	1	1	1	
85269190	Emergency position-indication	2.0 / 8.0	0.0	17.0	0.0	1	1	1	
85291090	community antenna	2.0 / 20.0	0.0	17.0	0.0	1	1	1	
Automation equipment									
85371010	Monitored control equipments	8.4 / 50.0	0.0	17.0	0.0	2	2	2	
90328900	Tank remote stand	7.0 / 17.0	0.0	17.0	0.0	1	1	1	
90328900	Stowage and balance control	7.0 / 17.0	0.0	17.0	0.0		1		
Tank system									
85311090	Combustible gas monitoring	10.0 / 40.0	0.0	17.0	0.0			1	
90251910	Tank temperature control	8.4 / 20.0	0.0	17.0	0.0			1	
84248999	Auto ejector device	0.0 / 30.0	0.0	17.0	0.0		1	1	
90261000	Oil-water boundary instruments	0.0 / 17.0	0.0	17.0	0.0			1	
84122990	Hydraulic controller	14.0 / 35.0	0.0	17.0	0.0			1	
90271000	Combustible gas detector	7.0 / 17.0	0.0	17.0	0.0			1	
Special valve									
84818019	Temperature-sensing valve	7.0 / 30.0	0.0	17.0	0.0	1	1	1	
84818019	Remote-operated valve	7.0 / 30.0	0.0	17.0	0.0	1	1	1	
84818019	Blankoff flange valve	7.0 / 30.0	0.0	17.0	0.0			1	
Large marine deck machinery									
84253100	Mooring winch, anchor windlass	5.0 / 30.0	0.0	17.0	0.0	1	1	1	
84798910	Steering engine	0.0 / 14.0	0.0	17.0	0.0	1	1	1	
85371090	Bi-control controlswitch	8.4 / 50.0	0.0	17.0	0.0				1
84138100	Bow hydraulic pump aggregate	8.0 / 40.0	0.0	17.0	0.0				1
For engine using									
84812020	Exhaust valve stem	6.0 / 30.0	0.0	17.0	0.0				1
90328900	Electron speed regulator	7.0 / 17.0	0.0	17.0	0.0				1
90268000	Oil mist monitor	0.0 / 17.0	0.0	17.0	0.0				1

IT P/G: Import Tariff, preferential/general
ET: Export Tariff
VAT: Value Added Tax
CT: Consumption tax
B- Bulk Carrier
C- Container ships
L- Liquid carriers include tankers
S- Special ships

Source: ***http://www.ykds.gov.cn/zcfg/Article/ShowArticle.asp?ArticleID=528***
http://tariff.sol.com.cn/list.asp

Appendix 5

Statistical Communiqué of the P.R.China

National Bureau of Statistics of China, February 26, 2009

IX. Education, Science and Technology

In 2008, the post-graduate education enrolment was 1.283 million. The general tertiary education enrolment was 20.210 million students with 6.077 million new students and 5.120 million graduates. Vocational secondary schools of various types had 20.563 million enrolled students, including 8.100 million new entrants, and 5.706 million graduates. Senior secondary schools had 24.763 million enrolled students, including 8.370 million new entrants, and 8.361 million graduates. Students enrolled in junior secondary schools totalled 55.742 million. The country had a primary education enrolment of 103.315 million, including 16.957 million new entrants. There were 417 thousand students enrolled in special education schools, with 62 thousand new entrants. Kindergartens accommodated 24.750 million children.

The amount of expenditures on research and development activities (R&D) was worth 457.0 billion Yuan in 2008, up 23.2 percent over 2007, accounting for 1.52 percent of GDP. Of this, 20.0 billion Yuan was appropriated for fundamental research programs. A total number of 922 projects under the National Key Technology Research and Development Program and 1,205 projects under the Hi-tech Research and Development Program (the 863 Program) were implemented.

The year 2008 saw the establishment of seven new national engineering research centres and 51 national engineering laboratories. The number of state validated enterprise technical centres reached 575 by the end of the year. The technical centres at the provincial level numbered 4,886. Some 828 thousand patent applications were accepted from home and abroad, of which 717 thousand were domestic applications, accounting for 86.6 percent of the total. A total number of 290 thousand patent applications for new inventions were accepted, of which 195 thousand were from domestic applicants or 67.1 percent of the total. A total of 412 thousand patents were authorized in 2008, of which 352 thousand were domestic patents, accounting for 85.5 percent of the total. A total of 94 thousand patents for new inventions were authorized, of which 47 thousand were domestic ones, accounting for 49.7 percent.

Till the end of year 2008, the number of patents in force was 1.195 million, of which 925 thousand patents were domestic ones, accounting for 77.4 percent; the number of patents in force for inventions was 337 thousand, of which 128 thousand was domestic ones, accounting for 37.9 percent. A total of 226 thousand technology transfer contracts were signed, representing 266.5 billion Yuan in value, up 19.7 percent over the previous year. The year 2008 saw 11 successful launches of satellites and Shenzhou-7 manned spacecraft was launched successfully.

By the end of 2008, there were altogether 24,300 laboratories for product inspection, including 376 national inspection centres. There were 170 organizations for product certification and management system certification, which accumulatively certified products in 38 thousand enterprises. A total of 3,701 authorized measurement institutions enforced compulsory inspection on 41.90 million measurement instruments in the year. A total of 6,373 national standards were developed or revised in the year. There were 1,314 seismological monitor stations and 31 seismological remote monitor network stations. The numbers of oceanic observation stations were 67 and oceanic monitor spots reached 9,200. Mapping departments published 1,834 maps and 309 mapping books.

Appendix 6

The Interviews of Three Chinese Shipyards

From January 2007 to March 2008, three Chinese shipyards were chosen to interview:

- ***Zhejiang Shipbuilding Company*** was established in 1969 and belonged to provincial government (Zhejiang) until 1984, when it was transferred to Ningbo government (a prefecture-level city lower than the provincial level city, i.e. the capital of province), however it is still a state-owned shipyards;
- ***Samsung Heavy Industry (Ningbo) Co., Ltd.,*** is a sole corporation and was established by Korean Samsung Heavy Industry in Ningbo in 1995, it represents the foreign shipbuilding companies who set up branches in China;
- ***Rui'an Jiangnan Shipbuilding Company*** was established in 1996, it is one of the two largest private shipbuilding companies in Rui'an (a town in Wenzhou), and owned by local Chinese investors.

The results shows, many Chinese shipyards had forwarded their scrap steels to recycle, but these regenerated steel materials were sold for common usages and less support shipyards. In other words, the material recycle system could not supply shipyards cheap materials. Recycle jobs were done by third-party companies, but they were not maritime based recycling sectors which could not help reduce shipbuilding cost.

Shipyards even seem unwilling to accept those regenerated materials because it did not reach the technical standards for ship construction. Chinese shipbuilding industry needs an improved recycling system, which should be specified for shipbuilding only and with the main objective of reducing their material costs. Unfortunately, this had not been found during the interviews to the three shipyards in Zhejiang province of China.