2012

Governance role for maintaining competitiveness of Korean shipbuilding industry

Dong Hwang Hwang
World Maritime University

WORLD MARITIME UNIVERSITY
Malmö, Sweden

GOVERNANCE ROLE FOR MAINTAINING COMPETITIVENESS OF KOREAN SHIPBUILDING INDUSTRY

while strengthening global environmental regulation toward sustainable growth

By

HWANG, DONG HWANG
Republic of Korea

A dissertation submitted to the World Maritime University in partial fulfillment of the requirements for the award of the degree of

MASTER OF SCIENCE

In

MARITIME AFFAIRS

(MARITIME SAFETY AND ENVIRONMENTAL ADMINISTRATION)

2012

DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

Signature: HWANG, Donghwang

Date: 22 October 2012

Supervised by: **Aykut I. Ö lçer**
World Maritime University

Assessor: **Seong-Hyeok Moon**
World Maritime University

Co-assessor: **Şebnem Helvacioğlu**
Istanbul Technical University

ABSTRACT

Title of Dissertation: **Governance role for maintaining competitiveness of Korean shipbuilding industry while strengthening global environmental regulation toward sustainable growth**

Degree: **MSc**

Although the global shipbuilding market faces a severe recession due to the shrinkage of international trade, the shipbuilding industry in Korea has contributed to economic growth and employment. Influences of government on the shipbuilding industry have dimmed and every stakeholder manages their own way without direction from the perspective of national interest.

On the other hand, the mandatory reduction of CO_2 emissions from ships was adopted by IMO in 2011. All possible technologies for energy efficient ships would be considered and major shipbuilding countries have invested in relevant R&D activities. Korean giant shipbuilders have some key technologies for improving fuel efficiency while small and medium firms lack the technologies. Furthermore, the gaps between dual groups are widening in the global recession.

Historically, major shipbuilders have taken different strategies. Considering Korea's status in the industry life cycle, Korea should apply both differentiation strategy and cost leadership simultaneously in order to escape from the China's pursuit and maintain its present status as a global leader

For the purpose of maintaining the status of global leader in the shipbuilding sector, good governance for the shipbuilding industry is necessary. Through good governance for stakeholders in the shipbuilding industry, a different R&D strategy

using Open Innovation should be considered. Giant shipyards should be allocated high risk taking R&D grants and assist other small scale firms on the basis of market mechanism. There should be more consideration of R&D grants for small and medium sized shipbuilders and marine equipment manufacturers.

KEY WORDS: Korean Shipbuilding Industry, Industrial Policy, Governance, Open Innovation, Competitive Strategy, Energy Efficiency Design Index (EEDI), Greenhouse Gas (GHG)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

CCS	Cargo Containment System
CGT	Compensated Gross Tonnage
CMTD	Components & Materials Technology Development
COP	Conference of the Parties
CSSC	China Shipping and Shipbuilding Corporation
DSME	Daewoo Shipbuilding Marine Engineering Co., Ltd.
EEDI	Energy Efficiency Design Index
EEOI	Energy Efficiency Operational Indicator
GATT	General Agreement on Tariffs and Trade
GHG	Greenhouse Gas
GTT	Gaztransport and Technigaz
HHI	Hyundai Heavy Industries Co., Ltd.
IMD	International Institute for Management Development
IMO	International Maritime Organization
INC	Intergovernmental Negotiating Committee for a Framework Convention on Climate Change
IPCC	International Panel on Climate Change
ISTD	Industrial Strategic Technology Development
KEIT	Korea Evaluation Institute of Industrial Technology
KRW	Korean Won
LIFE	Financial Instrument for the Environment
LNG	Liquefied Natural Gas

M&A	Merger and Acquisition
MARINTEK	Norwegian Marine Technology Research Institute
MARPOL	International Convention for the Prevention of Pollution from Ships
MBM	Market Based Measure
MEPC	Marine Environmental Protection Committee
MKE	Ministry of Knowledge Economy
MLTM	Ministry of Land, Transport and Maritime affairs
OECD	Organization for Economic Cooperation and Development
PR	Public Relations
R&D	Research and Development
SCM	WTO agreement on Subsides and Countervailing Measurements
SEEMP	Ship Energy Efficiency Management Plan
SHI	Samsung Heavy Industries Co., Ltd.
SM	Small and Medium
TEES	Tools for Environmental Efficient Ship design
TRESHIP	Technologies for Reduced Environmental Impact from Ships
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
WHRS	Waste Heat Recovery System
WMO	World Metrological Organization
WTO	World Trade Organization
ZEM	Zero Emission

1. Introduction

1.1 Background

In an August 2012 California court jury verdict, Apple defeated Samsung Electronics in a dispute about intellectual property concerning the smartphone and Samsung Electronics was ordered to pay Apple 1 billion USD in damages. Steve Jobs pointed out that Samsung's Galaxy S is a copycat of Apple's iPhone. That criticism can be interpreted according to dual aspects: one is whether a company has an original innovative idea and the other is the protective policy of an advanced state. The Shipbuilding industry of Korea faces the same situation. Many naval architects and marine engineers in Korea are skeptical about the question of whether Korean shipbuilders have original key technology in shipbuilding and offshore industry. Also protective market policy in the recession can raise an issue of disputes in the shipbuilding sector as it did in 1990s.

The Shipbuilding and offshore industry can be defined as a knowledge based complex industry which contains a series of processes of research and development, design and construction of various types of ships and offshore plants including relevant marine equipment. The shipbuilding and offshore industry is one of the major industries which can affect other downstream industries and be affected by other upstream industries as well. For instance, shipping, energy, fisheries and defense sectors play the parts of buyers for shipbuilding and offshore industries. Also, machinery, steel, chemical and electronics industries take part in the contributing industries. Therefore, the shipbuilding and offshore industry is linked with massive ripple effects of economics including employment, technology and capital markets.

Today, lots of advanced countries are striving to maintain their competitiveness in shipbuilding and offshore industries and governments are directly or indirectly supporting their shipbuilding industries. Although the Korean government had played a critical role in promoting major industries since 1970s, government

influence towards the industry has been decreasing as a result of relaxation of regulation and democratization. Thus, the paradigm shift of such deregulation of government leads the need to create a governance concept.

On the other hand, one of the major issues in global society is protecting our environment and reducing greenhouse gases. Also the shipbuilding industry is deeply linked to those concerns. Thus, it can be assumed that whether a country has potential in the field of reducing greenhouse gases can impact its future competitiveness. Moreover, successful achievement of technology needs largely depends on R&D investment and systems. Therefore it is necessary to seek a good governance model for a national R&D investment system while dimming the government role and strengthening global environmental regulations for the sake of maintaining long term competitiveness.

1.2 Research objectives and methodologies

1.2.1 Scope of the research

The spatial scope of this research is mainly focused on Korean shipbuilding and offshore industry including the field of related marine equipment. This thesis will suggest comparisons with other rival countries' policies and strategies. The temporal scope will be limited until 2020 because most references and bibliographies deal with those time constraints.

On the other hand, Open Innovation and Governance concepts will be examined to seek an effective model of a R&D system from the point of view of the contents of this research. Moreover, the renowned strategy and competitiveness theory of Michael E. Porter will be explained to analyze the competitiveness of the Korean shipbuilding industry. Among numerous marine environmental issues, the recent international regulations on greenhouse gas emissions by ships will be mainly

discussed since it is one of the hot issues regardless of industrial sectors in the global economy.

1.2.2 Objectives and methodologies

The main objective of this research is to sustain the competitiveness of the shipbuilding industry in Korea. A paradigm shift for a low carbon economy is a hot issue and the shipbuilding industry is not exceptional. On the other hand, the conventional government role could not be as significant as previous decades and there is not enough direct assistance to be used by governments due to the leveling of the international trade environment. It is necessary to shed light on a new scheme for innovation.

At first, the dissertation will review the importance of the shipbuilding industry of Korea from the perspective of domestic economic status and global shipping and shipbuilding market interaction. Next, the thesis will analyze the as-is competitiveness factor which affects the shipbuilding industry based on the theory of competitiveness strategy and governance role for the national research and development system. Then, this thesis will illustrate the recent trend of environmental regulation on mitigation of CO_2 emissions except for other air pollutants from ships such as nitrogen oxides (NO_x) or sulfur oxides (SO_x). Finally, this research will suggest a good governance role for maintaining the competitiveness of the Korean shipbuilding industry from the point of view of a co-relationship between environmental regulation and technology.

Most of the research information is composed of various statistics and chronological industrial policy. Industrial policy was acquired from the Ministry of Knowledge of Korea, which is mainly charged with the promotion of industries, and shipbuilding statistics are supported by Clarkson Research Services, which is famous for global shipping and shipbuilding market analysis. On the other hand, management strategies of major shipbuilding countries will be illustrated and examined through

analyses reports from research institutes such as Korea Institute for Industrial Economics and Trade (KIET). Also, a theory of competitiveness strategy by MIT professor, Michael E. Porter, will be used for the competitive analysis. Furthermore, updated global regulation documents by the IMO or other international organizations will be used in the research.

2. Governance and shipbuilding industry

Compared with previous decades, the Korean economy is led by a market based system. In the 1960s and 1970s, government officials had planned long-term economic programs and many heavy industries including the shipbuilding industry followed the government policy. As a successful result of the economic promotion plan, heavy industries in Korea have gained competitiveness in the global market and many direct grant programs from the government have been abolished due to the establishment of World Trade Organization (WTO).

The WTO had effects on industrial policies and the shipbuilding industry was not exceptional. The influence of the WTO and the growth of the private sector diminish the power of government. Currently, the giant shipbuilder's voice has jumped over domestic territory and the role of the Korean government in the shipbuilding industry has been slashed. On the other hand, with government support, Korean shipbuilders occupy the largest portion of the global market share and their performance makes a great contribution to the domestic economy.

Therefore, the governance concept is substituted for conventional government. This chapter, firstly, reviews the role of government and governance for the purpose of considering proper policy tools. Then, it examines the various stakeholders in the Korean shipbuilding industry. Furthermore, the features and importance of the shipbuilding industry are discussed for the analysis of policy feedback and tools to be used.

2.1 The role of government

Although the status of government is not as primary as in previous decades, the role of government cannot be negligible. The scale of government activity is important, but there are broader questions involved in what the government does, as it affects the industry and economy as a whole.

An instrument of government is its way of conducting activities. Most government intervention can occur through 4 available economic instruments: (i) provision, where the government provides goods or services through the budget; (ii) subsidy, which is really a sub category of provision and is where the government assists someone in the private economy to provide government desired goods or services; (iii) production, where governments produce goods and services in the market and (iv) regulation, which involves using the forced powers of the state to allow or prohibit certain activities in the domestic economy. The use of these has varied over time and according to the particular function. With regard to their application to the shipbuilding industry, those four major instruments will be discussed.

Among all the instruments, provision and production are related with the infra-structure of a nation. The clear distinction between provision and production is as follows. Unlike provision, production takes places away from the government budget. For example, like other industrial sectors, the shipbuilding industry uses employees and electricity. Employees trained in public schools, which are operated through the government budget, could be regarded as a kind of government provision. On the other hand, recently, some large shipbuilders have been training people in their own training centers. However, electricity is produced by a government operated company. Therefore, electricity is a kind of government production.

A subsidy is a kind of assistance from the government. In prior decades the Korean government provided ship yards with direct and indirect subsidies. One of the representative subsidies for the shipbuilding sector could be financial assistance for contracting new order such as government supported export credits for ships. Another representative example of subsidies for the shipbuilding industry could be R&D grants. There are international legal frameworks for the limitation of government interventions. WTO regulations regarding R&D grants will be discussed in Chapter 4 and export credit will not be examined because the topic of this thesis is confined to technology innovations related to CO_2 emissions.

The last but not least instrument of government might be regulation. Regulation means using the power of the law for an economic purpose. Regulation essentially involves allowing or prohibiting activities in the economy through the legal system such as granting licenses or permits to operate a shipyard. There was a regulation for an entry into the shipbuilding business before the abolishment of the shipbuilding promotion law in 1986. However, there is no direct regulation for the shipbuilders in Korea except for the laws regarding safety of ships or protection of the marine environment.

2.2 Overview of the Governance

There has been a paradigm shift in the management of the public sectors of advanced countries since the mid-1980s. The rigid, hierarchical, bureaucratic form of public administration, which had been prevalent for most of the 20th century, has been transformed to a flexible, market-based form of public management. This is not simply a matter of reform or a minor change in management style, but a variation in the role of government in society and relationship between government and private sector (Hughes, 1998). Therefore, the traditional public administration has been discredited and the adoption of governance means the emergence of transformation encompassing both public and private sectors.

2.2.1 Definition of Governance

Today, the concept of governance is being popularly used instead of conventional government system itself. The background of introducing the governance concept might be mainly due to mitigating strict regulations rather than blasting specific policy goals according to laws. Also, decentralization in public administration and democratic process in various sectors helps to develop the term of governance.

According to the United Nations Development Program, governance is defined as "the exercise of economic, political and administrative authority to manage a

country's affairs at all levels. It comprises the mechanisms, processes and institutions, through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their difference" (Administration, 2006).

Also, according to Jon Pierre, "governance refers to sustaining coordination and coherence among a wide variety of actors with different purposes and objectives" (Pierre, 2000). This means governance encompasses all stakeholders who are inside and outside in the process of policy making.

Therefore, public policy including industrial policy tends to congregate various opinions from government to policy customers like companies or associations. In other words, all stakeholders participate in the process and feedback procedure of a policy. Furthermore, each entity can often negotiate in processes of policy making, not just policy takers. Like other sectors, each player's role in the Korean shipbuilding industry is more important than in previous decades.

2.2.2 Aspects of Korean governance on the shipbuilding industry

2.2.2.1 Government: Central and Regional

The Central government had played a vital role in promoting the shipbuilding industry since the 1960s. At the initial stage of industrialization, the central government fed direct capital or loan guarantees to the shipbuilding industry and supported many aspects such as reducing taxes, land and labor. However, the voice of the government is being phased out with the advancement of the shipbuilding industry, while the giant shipbuilders are having a significant influence in the formulation of industrial policies. Also, democratization of multilateral sectors in the 1980s in Korea played a role in loosening or abolishing the regulations.

Currently, the Ministry of Knowledge Economy (MKE) is mainly in charge of facilitating and promoting the shipbuilding industry while the Ministry of Land, Transport and Maritime affairs (MLTM) is responsible for all other maritime affairs such as safety and environmental protection in the marine industry. In other words,

MLTM has the laws regarding regulations on ships while MKE is mainly in charge of promotion of industries. Therefore, there is no direct regulative legal framework for the shipbuilding industry in MKE but MLTM has a number of laws for the safety of ships. For example, MKE operates many R&D programs for upgrading industries and MLTM controls the safety of ships and protects the marine environment. Therefore, those two ministries sometimes conflict because of their roles in regulation and promotion. For example, there are few collaborative works for preparing IMO agendas between MKE and MLTM. As a result, many issues from shipbuilders are not effectively transmitted to the delegates in IMO.

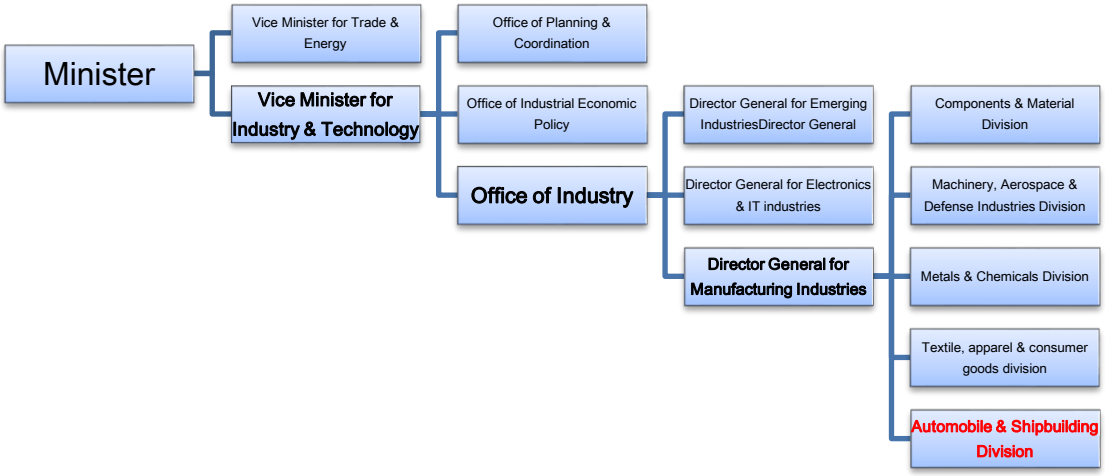


Figure 1 Organization of shipbuilding industry in MKE
Source: http://www.mke.go.kr/language/eng/about/organ01.jsp

As shown in Figure 1, the automobile and shipbuilding industry division is mainly in charge of matters in the shipbuilding industry. There are usually 2 of the total 10 staff members dedicated to shipbuilding matters. Considering the matrix organization of MKE, the workforce scale is too small to concentrate on various issues. In contrast to the shipbuilding oriented workforce of MKE, MLTM has a larger organization for the safety of ships. They have more than 50 people in their maritime safety bureau and there are 4 divisions in the bureau. Therefore, MKE's

capacity with regard to the shipbuilding industry could be relatively inferior to that of MLTM.

On the other hand each local government[1] has divisions regarding the shipbuilding industry. However, their roles are largely focused on promoting medium and small sized shipbuilders because currently regional economies are damaged by the policy of decreasing the number of fishing vessels due to the recession of fisheries. Therefore, during the shipping and shipbuilding boom season, around 2007, they appealed to the central government to assist with building more shipyards. As a result, many of the new yards are now facing recession harshly.

2.2.2.2 Shipbuilders and marine equipment manufactures

There are four giant shipbuilding conglomerates and many other medium and small sized shipbuilders in Korea. The level of technology gap between the giants and others is so wide and cannot be easily overcome. Therefore, their interests are different and it is not easy to build a cooperative system.

The four big players are Hyundai, Samsung, Daewoo and STX groups which represent the world ranking and domestic ranking of shipyards as well. They are actively participating in the policy making process and receiving honors and awards from the government. However, most small and medium (SM) sized shipbuilders rarely have enough opportunities to have a meaningful influence towards policy makers. Recently, the SM sized shipbuilders have been undergoing restructuring with the recession of the global economy and national policy of reducing fishing vessels.

Generally, Korean marine equipment firms are small or medium scale compared with shipbuilders' scales. Therefore, their residual fund has not enough room to invest in the development of innovative items. Also, they rarely have high technologies such

[1] Korea has a local self-governing system and a local government is elected by people.

as Waste Heat Recovery System (WHRS) and usually manufacture low added value products compared with Japanese and European firms.

2.2.2.3 Institutes and Associations

The representative association for the giant shipbuilders is the Korea Shipbuilders Association which has a membership of nine shipyards and the association usually does not accept other SM sized shipyards newly entered in the shipbuilding business for the purpose of maintaining their own vested interests. As a result, a new association for the SM sized shipbuilders was founded in 2007.

On the other hand, institutions for research and development in the shipbuilding industry also exist. The representative research institute of technology is the Ship and Ocean Plant Research Center which is a subsidiary of Korea Institute of Ocean Science and Technology (KIOST). Also a Research Institute of Medium and Small Shipbuilding (RIMS) was founded to support the SM sized shipbuilders.

Moreover, as a policy and economic research institute for the shipbuilding sector, the Korea institute for Industrial Economics and Trade (KIET) and Korea Maritime Institute (KMI) play an important role in building backgrounds for decision making processes.

Conclusively, those entities are founded and operated for the purpose of each foundation's objectives. However, it is important to build up a cooperative process to make a synergy effect from the point of view of national interests. Sometimes, the central government is criticized because of losing leadership in policy formation but from the perspective of governance, the industrial policy is collaborated on through the gathering of various opinions.

2.3 Characteristics and trends of shipbuilding industry

The world shipbuilding industry is in charge of the largest portion (90%) of global transportation. Although there are some other forces dominating the industry, the main dominating force is economic growth because the main route of trade is the seas. The environment of the world shipbuilding industry can be expressed as system dynamics loops as shown in Figure 2. The development of the world economy enhances shipbuilding capacity; however, overcapacity can often make the shipbuilding capacity shrink (Sung, 2009).

In this section, firstly, the main features of the global shipbuilding industry, including recent market analysis, will be examined. Then, the status and the economic contribution of the Korean shipbuilding industry will be discussed through various indexes for giving a salience to the importance of the industry. Through the analysis of each index the importance of the shipbuilding industry will be reaffirmed.

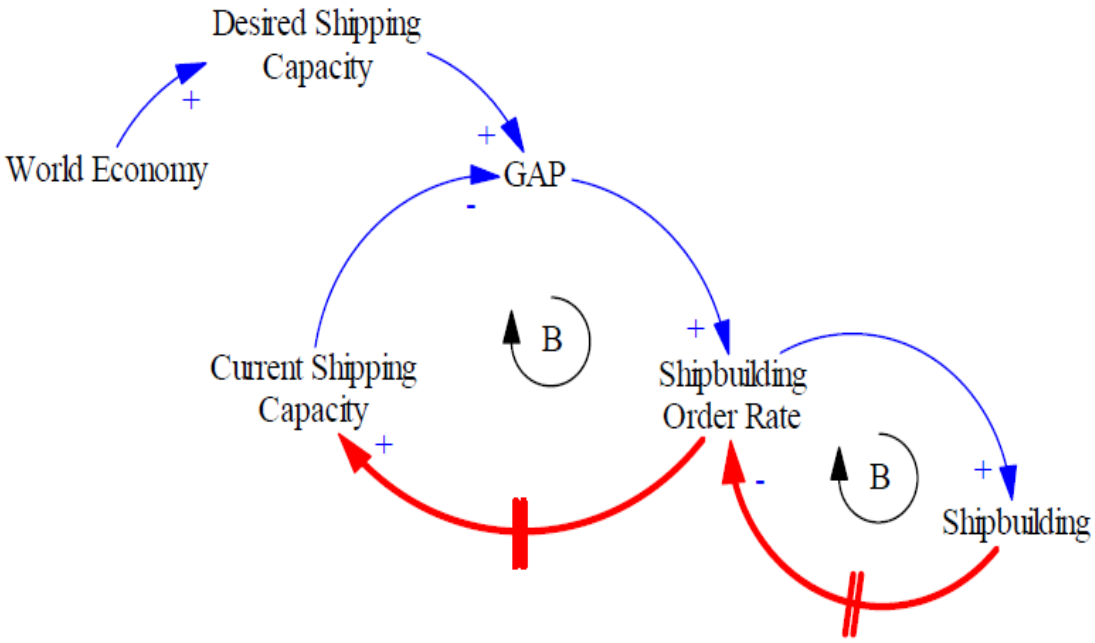


Figure 2 Economic conditions and their influence on the shipbuilding industry
Source: Anh Nam Sung, (Nov., 2009) Competition in the shipbuilding industry

2.3.1 Global shipbuilding industry

2.3.1.1 Global market structure and recent trends

Shipbuilding is a long term cyclic business. Construction of ships takes several years to deliver and they are operated in service for 25~30 years once built. The pace of the market situation in shipbuilding demand is slow because turnover rate of merchant ships is just a few percent a year. Usually trends develop over decades rather than years. When it comes to considering changing trends of market shares in terms of countries, major shipyard transitions can clearly understood.

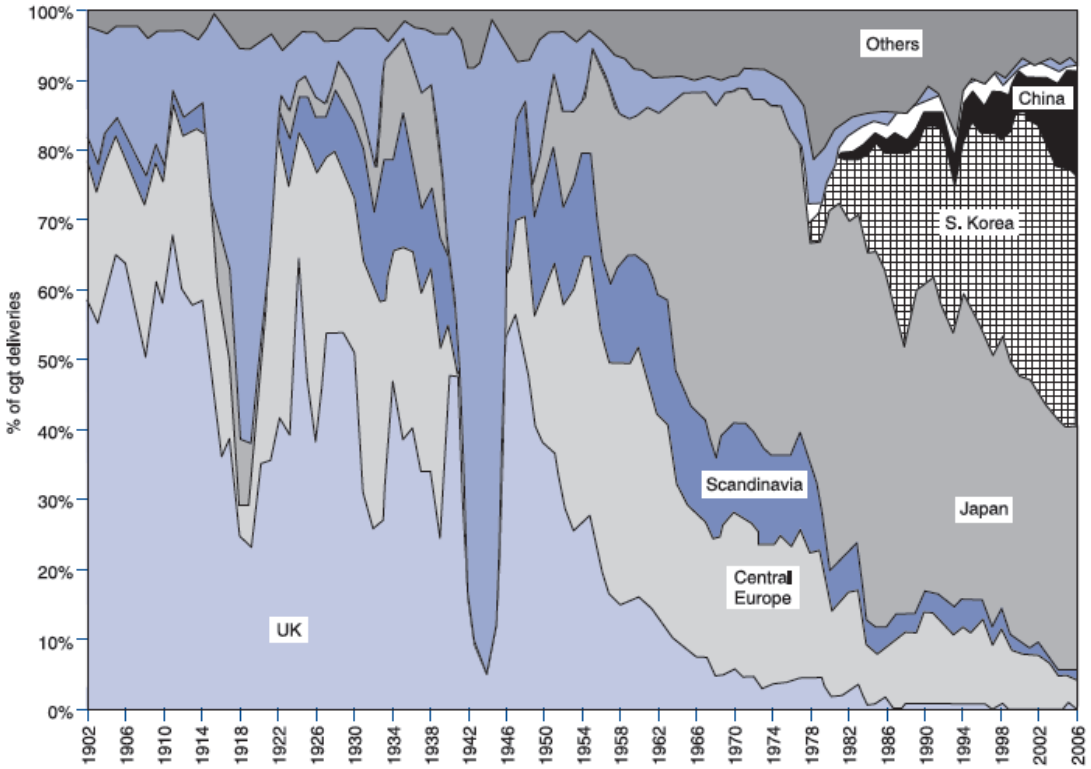


Figure 3 Shipbuilding waves of competition, 1902–2006

Source: Martin Stopford (2009), Maritime economics

More than a century ago, the United Kingdom dominated the shipbuilding industry as can be seen in Figure 3. Slowly, Continental and Nordic Europe suppressed Britain's share down to 40%. Then Japan overtook Europe, gaining a world delivery record of 50% in 1969. In the 1980s, Korean shipbuilding capacity had expanded rapidly, challenging Japan's dominant portion and finally establishing the Far East

region as the center of world shipbuilding. As the pie chart in Figure 3 shows, China aggressively threatens the status of Korean occupation, achieving a 34% of new building market share in the first half year 2012.

This can be analyzed by dual approaches in terms of the global shipbuilding market. One is stationary analysis by new order and the other is dynamic analysis by order book. As illustrated in Figure 4, Korea occupied over one third of the whole new order in terms of compensated gross tonnage and the contracting amount by Korean yards was recorded as nearly half of the whole amount in the first half of 2012.

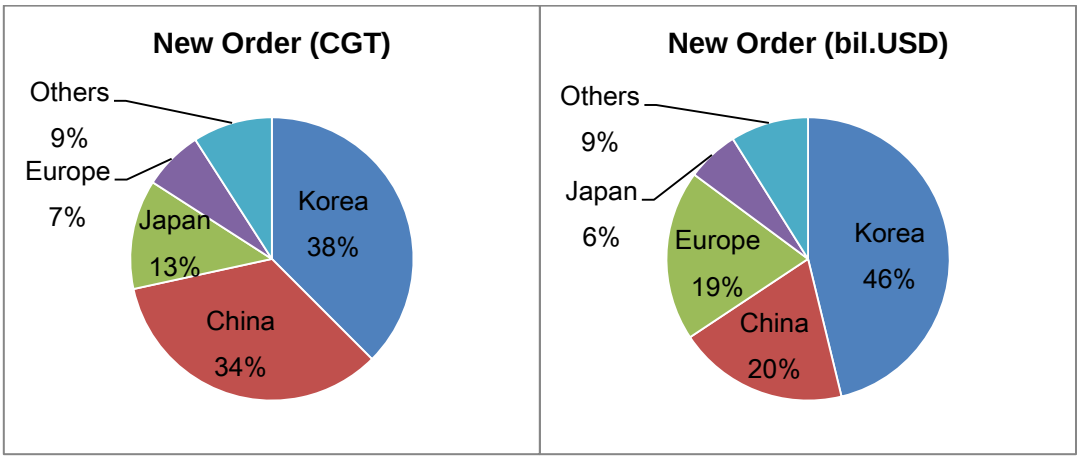


Figure 4 Market share by new order in the first half of the year 2012
Source: World Shipyard Monitor (July 2012), Clarkson Research

Table 1 Comparison of added value by new order in the half of the year 2012

	A=Million CGT[2]	B=Billion USD	B/A×100
Korea	3.3	14.0	4.24
China	3.0	5.9	1.97
Japan	1.1	1.8	1.64
Europe	0.6	5.3	8.83
World Total	8.8	30.3	3.44

Source: World Shipyard Monitor (July 2012), Clarkson Research and edited by Author

[2] Compensated Gross Tonnage: a measure of shipbuilding output which takes account of the work content of the ship

When it comes to the added value of new order ships, European shipbuilders are contracting the most expensive vessels. Table 1 compares the added value of new ordered ships among countries. The added value per compensated gross tonnage could be assessed by simple calculation. European yards contracted the highest value vessels. Korean yards contracted half of that of Europeans. Although Chinese yards contracted the largest amount of world's new orders, constructed ships in China are relatively low in added values. Actually, most orders taken by Chinese yards are bulk carriers or oil tankers, according to the Clarkson Research, while European yards took contracts for passenger ships, cruise ships or special purpose ships.

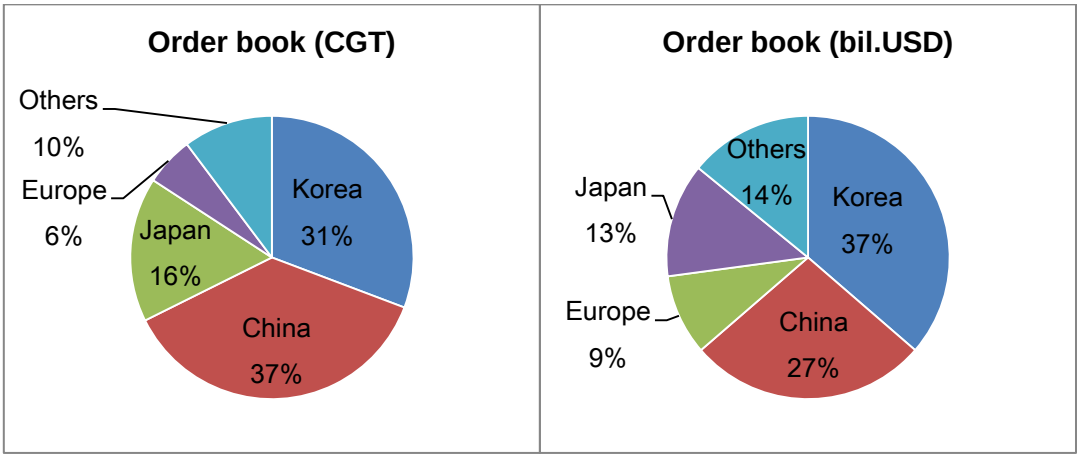


Figure 5 Market share by order book in the first half of the year 2012
Source: World Shipyard Monitor (July 2012), Clarkson Research

Table 2 Comparison of added value by order book in the half of the year 2012

	A=Million CGT	B=Billion USD	B/A×100
Korea	30.9	107.2	3.47
China	37.1	80.5	2.17
Japan	16.6	38.4	2.31
Europe	5.6	27.2	4.86
World Total	100.5	294.9	2.93

Source: World Shipyard Monitor (July 2012), Clarkson Research and edited by Author

Figure 5 illustrates the cumulative time series performance of global market share. China has the largest contracts with 37% of global shipbuilding contracts in terms of

CGT. However, Korea occupies the largest portion of global order book in terms of ship prices. Europe successfully maintains the expensive contracts comparing with other countries. In fact, the most common ship type coming out of Chinese shipyards is bulk carriers. Comparing with the added value of Table 1, the relatively low added value of Table 2 shows that there are fewer orders regarding low price ships such as bulk carriers and tankers.

On the other hand, a quarter of the world order book is occupied by the top 4 shipbuilding groups. Figure 6 illustrates the order book occupied by groups. Korea has the total top 4 major shipbuilding groups. Also, half of global order book is shared by 15 shipbuilder groups. Furthermore, only 10% of global ships will be constructed by smaller shipbuilders. This means that a polarization of the global shipbuilding industry exists and the deviation between large shipyard groups and small shipbuilding groups could get wider with the downturn of global shipbuilding market.

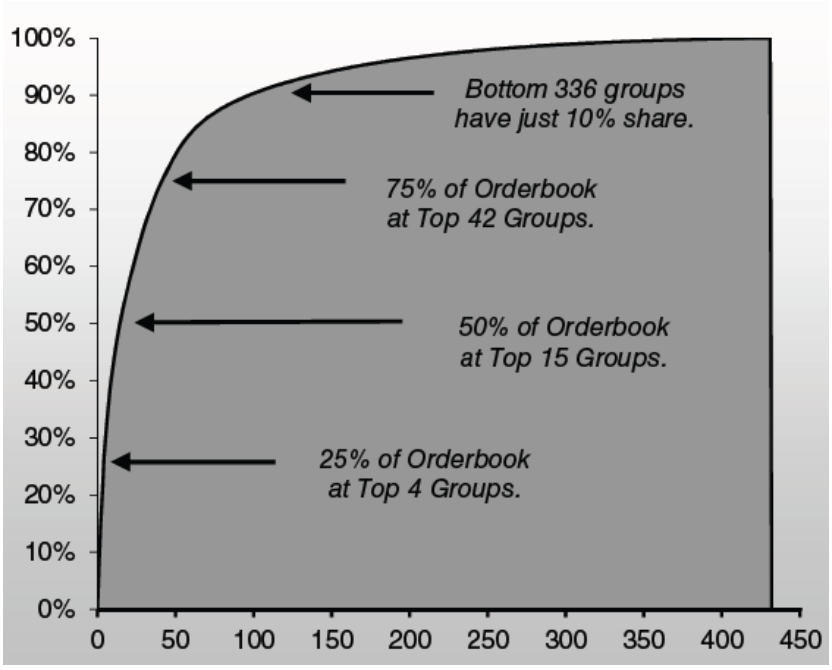


Figure 6 Shipyard groups share of order book (CGT)
Source: World Shipyard Monitor (July 2012), Clarkson Research

China's aggressive expansion of shipbuilding capacity made them outpace Korean shipbuilders in new building record. China's shipbuilding capacity has grown nearly 16 times from 2000 to 2010 (Hong, 2011). Also, Korea's capacity has increased nearly triple over the same period because of the expansion of existing shipyard facilities and an increase in the number of new shipyards. Therefore, currently global shipbuilders are facing overcapacity as can be seen on Table 3. The overcapacity rate recorded at a percentage of almost two digits. The amount of demand is much less than the supply due to the recession of shipping and the global economy. According to Clarkson's report (Shipbuilding Forecast Club), the overcapacity will force shipbuilders to be exposed to more severe competition.

Table 3 Estimation of global capacity

(Unit: Mil. CGT, %)

	2008	2009	2010	2011	2012	2013	2014	2015
New orders	41.4	16.6	38.6	34.3	31.8	35.9	36.4	43.2
Completions	41	43.7	51.7	45	41.7	41.6	38.9	33.7
Shipbuilding capacity	46	50	56	51.3	49.5	49.5	47.8	44.5
Overcapacity	5	6.3	4.3	6.3	7.8	7.9	8.9	10.8
Overcapacity rate	10.9	12.6	7.7	12.3	15.8	16	18.6	24.3

Source: Lloyd's World Shipbuilding Statistics

On the other hand, as illustrated in Figure 7, the new building price has dropped since 2007 and it could be assumed that shipbuilders' profits have worsened. Compared with the peak price index in 2007, the price index has dropped to 24.5% in 2011. In detail, the price of a very large crude oil carrier was 148 million USD in 2007, yet now the price is 95 million USD in August 2012. In case of Capesize bulk carriers, the price has dropped to almost half of the peak price. The price was 97 million USD a bulker in 2007, yet now the price is 46.5 million USD in August 2012 (Clarkson Research Services, 2012). Therefore, the global shipbuilding market could not be revocable for a while due to the overcapacity of shipbuilding facilities and global economic recession.

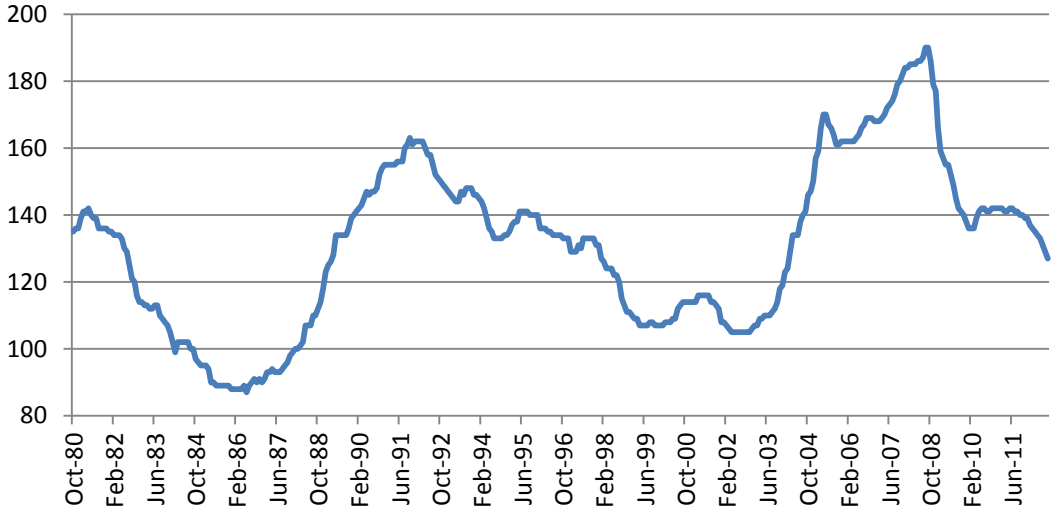


Figure 7 New building price index (1988=100)
Source: Shipping Intelligence Network, Clarkson Research Service Ltd.

To sum up, the major shipbuilding countries have changed and now the major shipbuilders are in the Far East region and the shipbuilding market is divided by major four countries: Korea, China, Japan and Europe. Although the European share in the global shipbuilding market is not so much, they construct sophisticated ships such as cruise ships. Currently, the global recession makes the shipbuilding market sluggish due to overcapacity.

2.3.1.2 Features of shipbuilding industry

The shipbuilding industry is one of the representative assembling industries, integrating capital, technology and labor such as the automotive industry. It still depends on workers' skill levels and the quality of ships is often decided by skillful workers like welders although a large portion of automated assembly work has been achieved. Also, huge capital is required to establish or expand production facilities such as yards or blocks to build ships. Moreover, gigantism, automation, and increased need for safe and green technologies are the trends of the current shipbuilding industry.

There is one worldwide market for building a large scale ship and global competition makes the market borderless. Ship-owners or brokers generally know all about the

shipbuilders and they can negotiate to buy ships due to their buying powers. In other words, at least the commercial ship market exemplifies a nearly perfect competition market due to symmetric information between buyers (ship owners) and suppliers (shipbuilders). Therefore, only a few countries and shipyards which have both technologies and cost competitiveness can survive the severe competition and dominate the market.

Unlike the automotive industry, which is a mass production industry, shipbuilding is a representative order made production industry. Generally a product purchased by a customer is provided by the seller's marketing strategy after being designed and produced by a manufacturer, while a ship is designed and constructed by the order of its owner. As a result, buyer's power is usually stronger than a supplier's power.[3] Therefore, it is hard to standardize and produce mass scale.[4]

The shipbuilding industry is sensitive to economic cycles especially shipping and international trade. In a boom period in shipping (but not often), shipbuilding industries enjoy their orders while shipbuilders suffer from difficulties during recessions in shipping. A global economic boom could cause a large amount of trade and it is a favorable condition for shipping companies. At the same time, a large number of new orders occur and new medium or small size shipyards are newly founded to meet the needs of buyers. Also existing shipyards invest and expand their production facilities such as dry-docks to prepare for new orders. However, recession causes ship owners to drop new orders sharply and most shipyards face depression. For example, world trade volume dropped and new orders plummeted after the financial crises in 2007. Figure 8 show that global new order has suffered a downturn since 2008. The global new order had been steadily increasing during the

[3] Sometimes, a supplier's power is stronger than buyer's power in case of shipping boom as a result of global trade inflation; however, such a case is not pervasive.

[4] Some shipbuilders such as Tsuneishi shipbuilding in Japan have their own standard ships to reduce production cost.

period from 1996 to 2007; however, the trend has changed since 2008 due to the world financial turmoil.

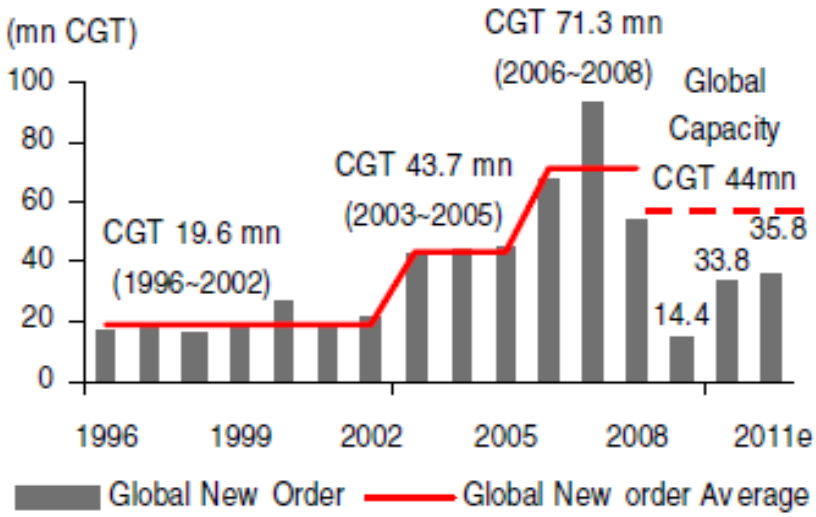


Figure 8 Global new building orders
Source: Choi & Ryu (2011), HSBC Global Research

Another characteristic of the shipbuilding industry is that a huge amount of sunk costs, which once incurred are irreversible, are required to newly enter the global market or operate a shipyard. Also, the long period of construction time, usually 1.5~2 years to build a ship, causes a shipyard to have a longer capital turnover period. As a result, long term financial planning is needed to operate a shipyard profitably. Therefore, it is not easy to acquire world class competitiveness with small scale capital. Sometimes, in case of recession, some countries provide their yards with direct or indirect financial support to maintain production facilities. Thus, project financing is a popular form of building a new ship.

From the perspective of labor cost shown in the Table 4, the shipbuilding industry is a highly labor intensive industry, which can contribute to a state's employment. Comparing with other industry sectors, the shipbuilding industry incurs a relatively higher ratio in overall labor cost. In detail, the percentage of the total cost of shipbuilding represented by labor is 10% while labor occupies 7.24% of total cost in

manufacturing industries. Also, it shows that shipbuilding still depends on manual processes despite automation in the construction process.

Table 4 Labor cost comparisons

	Manufacturing industries average	Shipbuilding Industry	Other heavy industries
Labor cost / Total cost	7.24	10.01	6.89
Labor cost / Turnover	9.83	12.78	9.22

Source: The Bank of Korea (2010)

2.3.2 Shipbuilding industry in the Korean economy

2.3.2.1 Economic indexes on Korean shipbuilding

The shipbuilding industry occupied 5.4% of total employment in manufacturing industries in Korea. Table 5 represents the economic contribution of the shipbuilding industry; however, it does not include the contribution of the marine equipment industry. Therefore, when it comes to including the marine equipment industry, the contribution to the national economy would be increased. Shipbuilders were recorded as representing 6.6% of total turnover and 6.2% of added value in the manufacturing industry of Korea as well.

Table 5 Importance in national economy

	Employment (No. of persons)	Turnover (bil. KRW)	Added value (bil. KRW)
Shipbuilding Industry	131,367	74,524	23,171
(% in manufacturing ind.)	(5.4%)	(6.6%)	(6.2%)
Manufacturing Industry	2,452,880	1,122,987	374,501

Source: National Statistics Office of Korea (2009)

On the other hand, the export figures of the shipbuilding industry have increased steadily despite world economic fluctuation. Considering the lead time of 2 years to construct a ship, the aftermath of a global recession in the shipbuilding market could

be seen in 2 years. As shown in Table 4, despite the sluggish world economic situation in the years 2008 and 2009, the export amount was steadily maintained in year 2010 and 2011. In detail, export growth rate of ship and offshore structures have maintained 2 digit percent increases since 2008.

As shown in Table 6 and Figure 9, Ships and offshore structures have been one of the best export items for the Korean economy. Furthermore, those products have shared over 10% of total Korean exports since 2008. Considering the high price of offshore platforms, around one billion USD, sometimes the timing of the export of a ship can dominate the monthly trade balance of total Korean trade. Conclusively, the shipbuilding industry has contributed a large portion of the national account of Korea.

Table 6 Export trend of shipbuilding industry in Korea

Year		2007	2008	2009	2010	2011
World Economic Growth (%)		4.0	1.7	-2.1	3.9	3.1
Export (mil. USD)	Total	371,489	422,007	363,534	466,384	555,214
	(Share of export)	(7.5)	(10.2)	(12.4)	(10.5)	(10.2)
	Ship and Offshore Structure	27,777	43,157	45,128	49,112	56,524

Source: The Korea International Trade Association (www.kita.net)

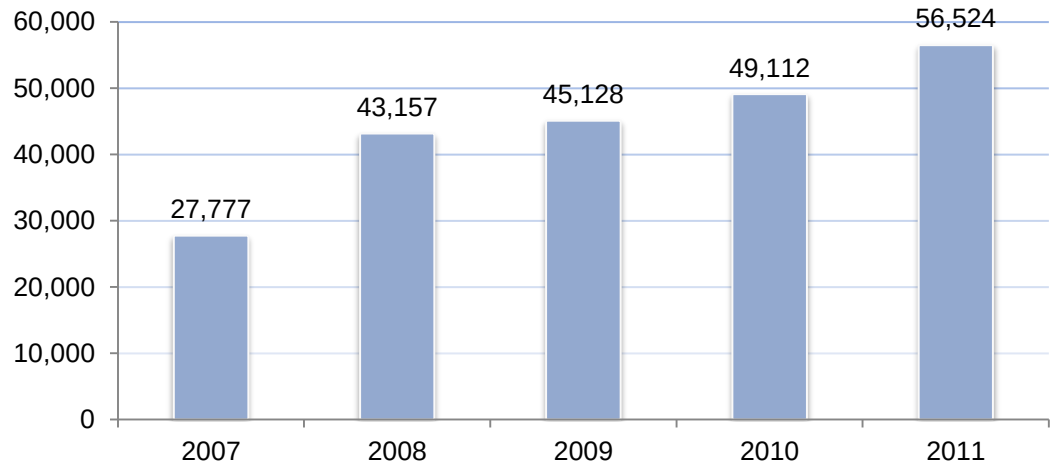


Figure 9 Export amount of ship and offshore structure (Mil.USD)
Source: The Korea International Trade Association (www.kita.net)

Conclusively, The Korean economy has largely depended on the shipbuilding industry with regard to various economic indexes. Losing competitiveness in the shipbuilding sector means deteriorating national accounts of the Korean economy because the Korean economy heavily depends on international trade rather than domestic demand due to deficiencies in natural resources and the relatively narrow scale of the domestic market.

2.3.2.2 Difficulties of Small and Medium Sized Shipyards

Contrasted with the splendid record of the total shipbuilding industry in Korea, SM sized shipyards have gone through difficulties accompanied by the global recession. Most of the economic index in the Korean shipbuilding industry comes from giant shipbuilders. Recently, the business performances of SM sized shipbuilders have gone down.

The new order for the first half of 2012 records 148 thousand compensated gross tonnage, a decrease of 88.2% compared with the same period in 2011 (Yang, 2012). As illustrated in Figure 10, new orders in the first half of year 2012 are estimated at 710 million US dollars, a drop of 72.3% compared with the same period in 2011. Therefore, the overall contribution by the SM sized shipbuilders in the Korean shipbuilding industry has dropped.

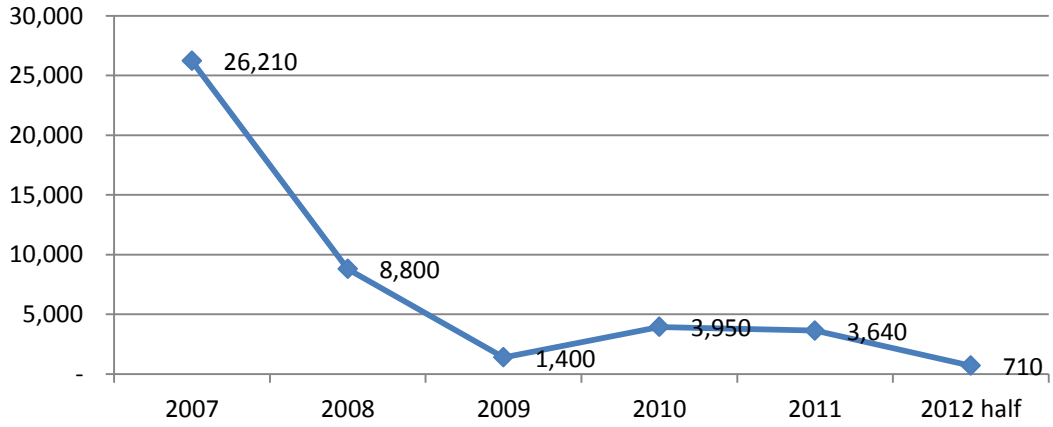


Figure 10 Amount of new orders by SM sized shipbuilders (Mil.USD)
Source: Yang, J.S. (2012) Report on the small and medium sized shipbuilding

The proliferation of SM sized shipbuilders in Korea was largely owing to the global shipping boom before the year 2007. Once they were the subcontractors of giant yards and their major products were hull blocks. However, speculation and shortage of bulk carriers before year 2007 stimulated them to convert to shipyards. As a result, the global credit crunch and recession made it hard for them to maintain their business. They did not have competitiveness to win over their competitors such as Chinese yards. Their product mix duplicated that of the Chinese competitors and their cost competitiveness was inferior to that of Chinese.

Korean yards polarized into two groups and the gap between them widened. Some politicians are insisting to stimulate cooperation between the giant and small/medium yards to overcome this matter. Another opinion group suggests that strong restructuring of weak yards is necessary. However, if they were exposed to belly up, it could lead to a threat to the overall Korean shipbuilding industry. If the Korean shipbuilding industry lost competitiveness in the field of SM sized shipbuilding, other competitors could occupy their position and expand their business scales to larger fields. According to the theory of Learning-by-doing, a company accumulates experience and reduces production cost in a new business activity by consecutive completion. Thus, the powerful competitor, China, could take the cost advantage and accumulate technologies if Korean SM yards went out of business. Finally, cost advantage could lead to technology advances and might threaten other giant shipbuilders as Korean shipbuilders did in the 1970s.

To sum up, the world shipbuilding cluster is in the Far East region. Korea, China and Japan occupy the largest portion of the global market. Among them Korea occupies the largest portion of the global shipbuilding market. However, recently China threatens the position of Korea and they have sufficient yard capabilities to cover global orders. The greater part of the performance of Korea was contributed to by large shipbuilders while other small sized shipbuilders played separately. There are wide gap between Korean shipbuilders. Therefore, it is necessary to consider

their destitute situation in the process of policy making for the sake of maintaining the lifelong competitiveness of the shipbuilding industry.

3. Global environmental regulation of GHG and competitiveness analysis

If an industry goes through a life-cycle, every state's position in an industrial life cycle must be different because of dissemblance of the development stage of each industry. As illustrated in Figure 11, currently the Korean shipbuilding industry occupies a mature stage within a lifelong industry cycle. Unlike Korea, some countries like China sit in the middle of their growth stage and Europe (or Japan) is in a declining stage.

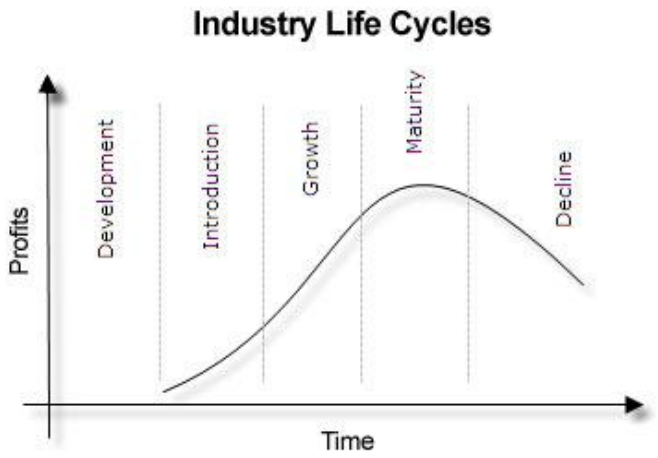


Figure 11 Industry life cycle
Source: http://www.anskypoker.com/2010/02/the-poker-life-cycle/

Therefore, it is necessary to review the adopted strategies of major shipbuilding countries and adopt a proper strategy for sustainable growth while strengthening the regulations for reducing GHG emissions. According to Harvard business school professor Porter's opinion, well designed environmental regulation could play a critical role for enhancing competition and innovation (Ambec, Cohen, Elgie, & Lanoie, 2011). Therefore, the response to the recent global CO_2 emission control regime could affect future competitive advantage. In this chapter, firstly, recent regulation on global and shipping industry will be reviewed. Then, a review of competition theory will be examined to seek a proper strategy. Finally the

relationship between GHG emission regulation and competitive strategy will be discussed.

3.1 Overview of the environmental regulation on emission control

Today, the environmental issue of mitigating GHG emissions is one of the hottest topics in global society. The shipbuilding industry is not free from the regimes of GHG emission control.

According to the GHG study, although there are a variety of greenhouse gases, the significant component for global warming from ships is carbon dioxide, which is similar to other industrial sectors (Second IMO GHG Study, 2009). Table 7 shows that CO_2 is the foremost GHG emitted by shipping and emissions from other sources are comparatively small. Therefore, most research on GHG emissions is focused on mitigating CO_2 gas rather than other gases.

Table 7 Relative importance of GHG emissions from ships

	Million tons	Global Warming Potential[5] %
CO_2	1,050	98%
CH_4	0.24	0.6%
N_2O	0.03	0.7%
HFC	0.0004	0.6%
SF_6	0	0
PFCs	Negligible	Negligible

Source: IMO, Second IMO GHG Study 2009

This section will examine the history of global and shipbuilding related GHG emission control. Then the relevant R&D activities between Korea and other countries (Europe/Japan) will be compared.

3.1.1 Background and review of GHG emission control regime

[5] Total warming impact relative to CO_2 over a set period, usually a hundred years

Climate change has been a global issue since the Villach Conference in Austria held by United Nations Environment Program (UNEP) in 1985, where scientists agreed on the high probability of global climate change due to the rising density of greenhouse gases. (Wendy, 1997). As a result of the conference, climate change has been an international agenda and proactive opinions on reducing greenhouse gases have been suggested.

In 1988 at Toronto Conference a statement that global CO_2 emissions should be decreased by 20% by 2005 was adopted. Also, it was recommended that a comprehensive framework convention on the law of the atmosphere should be developed by states. In the same year, UNEP and World Meteorological Organization (WMO) agreed on the foundation of the Intergovernmental Panel on Climate Change (IPCC).

The second World Climate Conference was organized by UNEP and WMO in Geneva, Switzerland in 1990. As a result of the conference, a decision was adopted to build a new convention to cooperate on global warming on the basis of the IPCC report. Thus, the general assembly of the UN decided to establish an Intergovernmental Negotiating Committee for a Framework Convention on Climate Change (INC) in 1990 (Bodansky, 1995). Then, through five successive conferences, 154 states signed to create the United Nations Framework Convention on Climate Change (UNFCCC) at the 1992 UN Conference on Environment and Development in Rio de Janeiro. The convention entered into force on March 21 1994.

The third Conference of the Parties (COP) held at Kyoto, Japan in 1997 is renowned for setting binding targets for reducing greenhouse gas emissions. The major feature of the Kyoto Protocol was its effectiveness for reduction of greenhouse gas emissions because it describes firstly the detailed targets for 37 industrialized countries and the European community. To secure the implementation of the protocol, the Marrakesh Accords was adopted in 2001. The Kyoto Protocol entered into force on February 16 2005.

3.1.2 Control of GHG emissions from ships

The first discussion on greenhouse gas (GHG) emissions at the IMO was originated from the proposal of including GHG emissions in the MARPOL Annex VI, which was not consented by member states until 1997. Then, the MARPOL Conference in 1997 adopted the Conference Resolution 8 on CO_2 emissions from ships. The resolution stated that the IMO shall perform the task of the study of emissions of GHG from ships in order to establish the amount and relative portion of GHG emissions from ships as part of the global inventory of GHG emissions. As a result of the resolution, the Marine Environmental Protection Committee (MEPC) undertakes the affairs on the GHG emissions from ships.

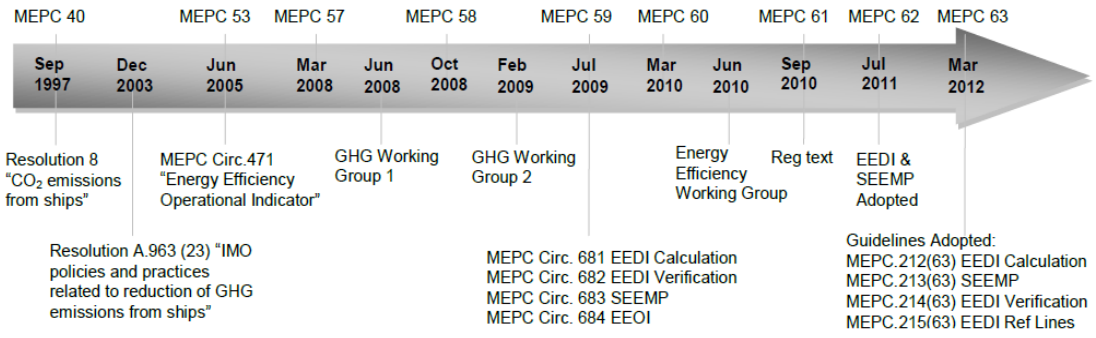


Figure 12 MEPC and Working Group Timeline
Source: Lloyd Register, Implementing the Energy Efficiency Design Index (June 2012)

The Assembly of IMO adopted Resolution A.963(23) requiring that the MEPC set up a mechanism for the limitation of emissions or reduce GHG emissions from international shipping. Also, the resolution calls for the establishment of a work plan with a time table for doing so. As a part of the result, MEPC 55 (October 2006) presented the "IMO Study of Greenhouse Gas Emissions from Ships" and MEPC 59 (July 2009) submitted "the Second IMO GHG Study 2009". The second report said that shipping is appraised at 3.3% of the global GHG emissions and the emissions of carbon dioxide from international shipping occupied 2.7% of total CO_2 emission in 2007. Then, the MEPC 59 approved to establish Interim Guidelines on the Method of Calculation of the Energy Efficiency Design Index for New Ships (EEDI), the Interim Guidelines for Voluntary Verification of Energy Efficiency Design Index,

the Guidance for the Development of a Ship Energy Efficiency Management Plan (SEEMP) and the Guidelines for Voluntary use of the Energy Efficiency Operational Indicator (EEOI). In accordance with those interim guidelines, MEPC 59 also requested Market Based Measures (MBM) for the reduction of GHG emissions (IMO, 2011). The following Table 8 shows regulation measures, target ships and instruments.

Table 8 Brief of MEPC 59 circulation

Regulation Measures	Target Ships	Instruments
[Technical] Energy Efficiency Design Index (EEDI)	New-building Ships	Mandatory MARPOL Annex VI
[Operational] Ship Energy Efficiency Management Plan (SEEMP)	All Ships	Voluntary MARPOL Annex VI
[Operational] Energy Efficiency Operational Indicator (EEOI)	All Ships	Voluntary MARPOL Annex VI
[Market Based] Market Based Measure (MBM)	All Ships	New instrument

Source: Main events in IMO's work on limitation and reduction of greenhouse gas emissions from international shipping (October 2011)

Recently, on 4 July 2011 the 62nd session of MEPC adopted mandatory measures to reduce emissions of greenhouse gases (GHG) from international shipping. The new chapter 4 of MARPOL Annex VI was added on the EEDI for new ships, and the SEEMP for all ships (MEPC, 2011). Some designated types of ships[6] gross tonnage 400 tons and above are applied and it is expected to enter into force from the first day of 2013 by tacit acceptance. Furthermore, the calculation and verification guidelines for EEDI and SEEMP were adopted in March 2012 at MEPC 63.

[6] Bulker, Tanker, Gas carrier, Container ship, General cargo ship, Refrigerated cargo ships, Ro-ro cargo and passenger ships (not initially subject to regulation)

As can be seen in Table 9, it is estimated that CO_2 emissions will be reduced by up to 200 million tons by 2020 and by up to 420 million tons by 2030 from the introduction of the EEDI and SEEMP. In other words, compared with the amount from business as usual[7], a reduction of 10~17% by 2020 and a reduction of 19~26% by 2030 will be achieved. Also, the EEDI and SEEMP will save fuel costs of 20~80 billion USD by 2020 and 90~310 billion USD by 2030.

Table 9 CO_2 reduction scale

	Quantity	Decreasing rate	Cost
By 2020	Up to 200 mil. Tons	10~17%	20~80 bil USD
By 2030	Up to 420 mil. Tons	19~26%	90~310 bil USD

Source: Second IMO GHG Study (2009)

By the adoption of technical and operational measures, IMO became the first[8] international organization which made a successful regulatory regime for the reduction of GHG emissions. Considering that this research is concerned with the shipbuilding industry, only EEDI will be examined in the next section.

3.1.3 Energy Efficiency Design Index

The adoption of EEDI will severely affect the ship design to save fuel or reduce GHG emissions. It is essential to review the detailed reasons why the EEDI can influence shipbuilders. The detailed EEDI calculation formula is complex and the simplified EEDI formula is as follows.

$$\text{EEDI} = \frac{CO_2\ emission}{transport\ work}\ \text{(g/ton·mile)}$$

[7] Projection of GHG into the future based on current technologies & regulations in the absence of other reductions

[8] UN Secretary General and UNFCCC Executive Director acknowledged on the adoption of amendment of MARPOL Annex VI.

EEDI indicates the efficiency that is expected for a ship to achieve, based on the ship specifications, calculated by engine power, specific fuel cost, deadweight and speed. The lower the value of EEDI means the better the efficiency of the ship. The transport work can be obtained by doing multiplication of the deadweight of a ship and ship's speed. According to the type of ship and its size, the amount of CO_2 emission will change. Also, technology potentials could contribute to the index of energy efficiency.

As illustrated in Figure 13, the EEDI requires that CO_2 emissions should be dropped by 30%. In the first phase (2015-2019), ships to which EEDI applies should reduce emissions by 10% of the reference line which is calculated by MARPOL Annex VI. In the second phase (2020-2024), those ships should reduce by 20% of the reference line. In the last phase (after 2025), emissions should be cut a further 10% of the second phase (Altenburg, 2011).

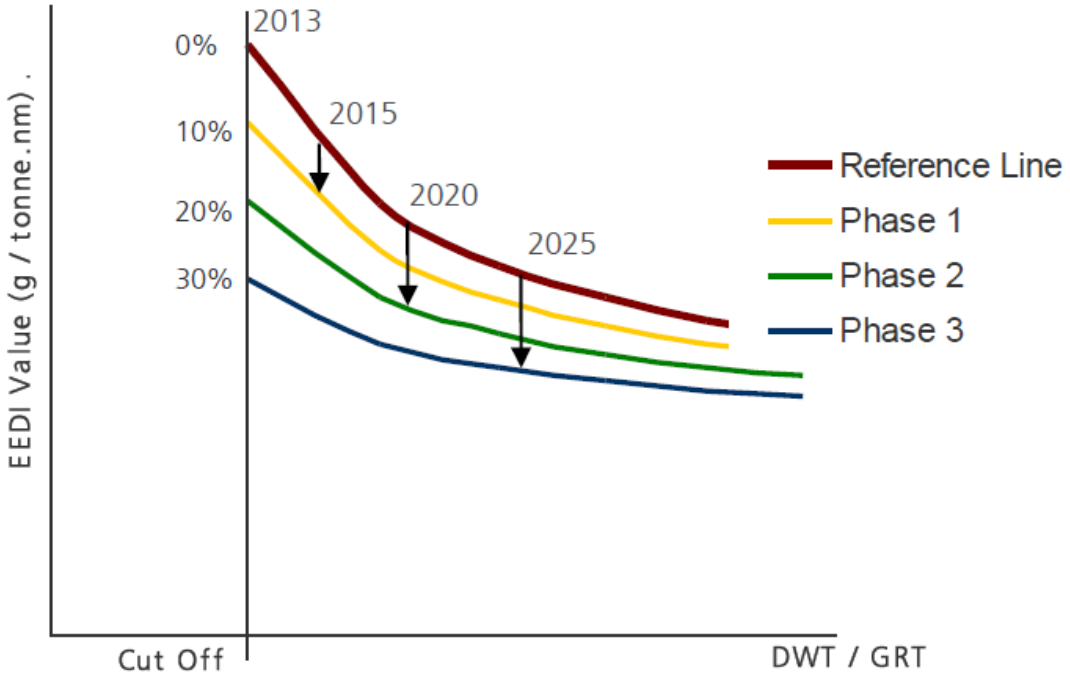


Figure 13 Regulatory concept of the EEDI
Source: Lloyd Register, Implementing the Energy Efficiency Design Index (June 2012)

Higher energy efficiency means that much work is done with less fuel (energy) consumption. There are three areas of options to improve energy efficiency (Second IMO GHG Study, 2009). The first category is concept, design speed and capability. For instance, principal dimensions and speed can affect the fuel economy of a ship. The second category is hull and superstructure. For example, optimized hull and superstructure form can reduce fuel consumption by lowering wave making and air resistance. The last category is power and propulsion systems. If a ship is propelled by only wind or fuel cells, CO_2 emissions could be minimized or zero.

Conclusively, there are various ways to improve energy efficiency and technology can play a critical role in reducing GHG emissions. Therefore, the future competitiveness of a shipbuilder can be deeply related to the EEDI and improving energy efficiency of new building ships could be a major strategy for shipyards to win competitions.

3.1.4 Major R&D programs of competitors for reducing GHG emissions

Major countries have attempted to meet the challenge of reducing GHG emissions by investing in various R&D programs. Most of them are aiming at improvement of energy efficiency and reduction in GHG emissions as well. Many of them are conducted by consortiums and supported by governments also.

The Danish maritime community organized the "Green Ship of the Future" program for the purpose of exploring, developing and demonstrating technical solutions for reducing SO_x, NO_x and CO_2. There are three research groups; novel ship design, onboard system/system integration, alternative fuels. The participants include more than 40 Danish affiliated companies or maritime research institutions. Most of them are not just shipbuilders but marine equipment manufacturers. The prototype research result was published for a bulk carrier and a container ship (Green Ship, 2012).

On the other hand, there are some R&D programs for eco-friendly shipbuilding from the perspective of a ship's lifelong period. Those kinds of projects stimulate recycling through adopting renewable materials at the design stage. TRESHIP (Technologies for Reduced Environmental Impact from Ships) and TEES (Tools for Environmental Efficient Ship design) projects are representative European programs for the promotion of an eco-friendly shipbuilding industry (Hayman, Dogliani, Kvale, & Fet, 2000) (Ellingsen, Fet, & Aanondsen, 2002).

From the perspective of alternative fuels, the "Zero Emission" (ZEM) ship project was performed from 2006 to 2010. Most participants were German organizations, supported by the Financial Instrument for the Environment (LIFE) of EU. They constructed a ship to carry 100 passengers propelled by a hydrogen fuel cell engine in 2010 (ZEMSHIPS, 2012). Another larger program for using fuel cells is "E4 Ship" project funded by German National Organization Hydrogen and Fuel Cell Technology. The project is aimed at larger ships and the total R&D budget is 50 million EUR from the period of year 2009 to 2016 (e4ships, 2012).

Japan also has invested in the field of development of low emission ships. The representative project is "Super Eco-Ship" Project supported by Ministry of Land, Infrastructure and Transport. As shown by the Figure 14, the concept of Super Eco Ship encompasses the optimum hull form design and adoption of Podded and contra rotating propeller (Minami & Kawanami, 2005).

Also, the renowned shipping company NYK Line is aiming at 69% reduction of CO_2 emissions by applying fuel cells (NYK Line, 2012). Recently, the University of Tokyo has been developing a next generation sailing ship named "Wind Challenger", which can mitigate CO_2 emission as much as 33% and save 30% of fuel consumption with the aid of optimum routing and retractable sails (University of Tokyo, 2012).

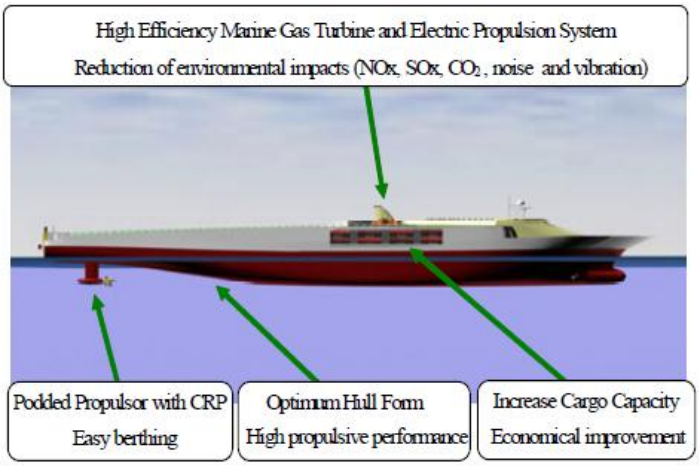


Figure 14 A concept of super eco-ship
Source: Minami & Kwanami (2005), On the Research and Development of Super Eco-Ship Project, Proceedings of 5th Int'l Offshore and Polar Engineering Conference, Seoul, Korea.

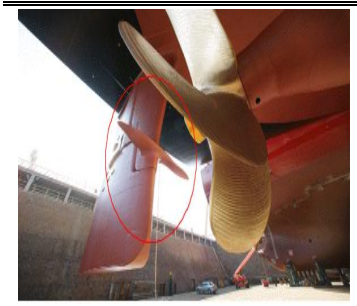
Conclusively, many European organizations support R&D activities for reducing GHG emissions from ships. One of the noticeable features of most R&D projects is that they are preparing for the technological advantages of the next generation. In other words, they have been considering the application of fuel cells as a substitution for the current internal combustion engine. Although the Grid Parity[9] of alternative power sources makes it hard to apply their early adoption, many R&D activities are already at the proof stage of pilot testing by construction of prototypes.

3.1.5 Korean technologies for reducing GHG emissions

Although Korea has the largest shipbuilders in the World, only a few competitive marine equipment manufacturers with source technologies exist. Most marine equipment companies are SM scale enterprises and do not have enough capital to invest in R&D activities. Therefore, most technologies for reducing GHG emissions have been developed by giant shipbuilders.

[9] Power generating cost from renewable energy, which is equal to or lower than the cost of fossil fuels.

Table 10 Fuel saving appendages

HHI	DSME	SHI
Thrust Fin	Pre-swirl Stator	Saver Fin
		

Source: Society of Naval Architects of Korea

As can be seen in Table 10, the big 3 builders of Korea mainly focused on the improvement of propeller and hull interactions. Hyundai Heavy Industries (HHI) developed and applied a "Thrust Fin" attached at the rudder, which can save 3~6% of fuel consumption, to improve propulsive power. Samsung Heavy Industries (SHI) developed the "Saver Fin" appended at the stern of a ship to save 3~5% of fuel consumption and reduce hull vibration. Daewoo Shipbuilding and Marine Engineering (DSME) also developed the "pre-swirl stator", which can reduce 5% of fuel consumption, appended at the front of propellers.

On the other hand, Wärtsilä and HHI established a joint company to manufacture duel fuel engines. Also, DSME and Man Diesel developed a high pressure LNG injection engine which can reduce 23% of emissions of CO_2 and other pollutants.

Conclusively, the Korean shipbuilding industry does not have enough core technologies relating to marine engines or is reluctant to invest in high risk R&D activities from the point of view of innovative propulsion systems. As a result they choose low risk ventures such as the establishment of a joint company. Therefore, it is necessary to stimulate more investment in the high risk field of technologies in order not to be a fast follower but to be a frontier innovator.

3.2 Competitive strategy analysis

There is a proverb that *"We can learn a lesson from another's failure or success"*. Like the proverb, competition in the global industry can come from the history of strategies adopted by competitors. Through reviewing the competitive strategies of major shipbuilders, each shareholder in the Korean shipbuilding governance can find their role to maintain competitiveness while reinforcing the global control regime for GHG emissions.

3.2.1 Review of competitive strategies on shipbuilding

The traditional method for analyzing competitive strategies for global industry is founded by Michael M.E. Porter. He analyzes the industrial structure by 5 competitive forces and recognizes the strength of competition. Then, the business activities of an industry can be analyzed as a value chain which contributes to core competitiveness. In other words, the competitive analysis of an industry is to find a proper option at a specific timing and situation. The options can be one of the strategies; cost leadership, differentiation, focus, national responsiveness and market protection strategies.

As shown in Figure 15, industrial structure can be represented as five components; industry competitors, potential new entrants, supplier, customer and substitutes.

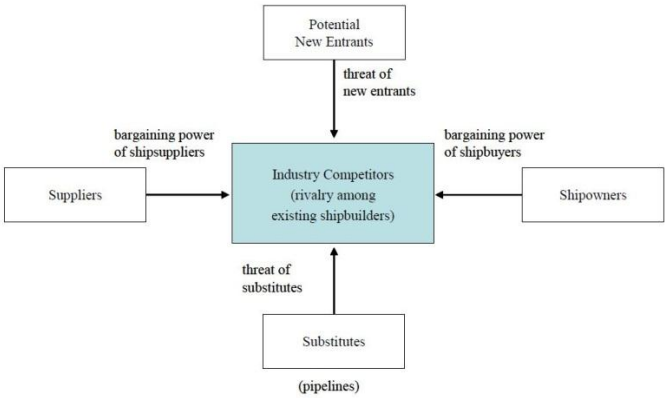


Figure 15 Competitive forces in the shipbuilding industry
Source: Cho, D.S. & Porter, M.E.(1987), Changing Global Industry Leadership: The Case of Shipbuilding, Boston, Harvard Business School Press.

In this thesis, the substitute's role within the shipbuilding industry is not very significant because there are not enough substitutes for the shipbuilding industry for supplying ships. Also, there are few economic modes of transportation comparable to shipping. Therefore, the government's role will be discussed instead of substitute since the policies of each government play a critical role in the shipbuilding sector.

< Industry Competitors >

From the global perspective, the most powerful countries affecting the shipbuilding market are the EU, China, Japan, and Korea. Japanese and European shipbuilders had dominated the shipbuilding market by 1960s. Since the 1980s, Korean and Chinese yards have occupied a larger portion of orders. Those four players have competitive advantages in different components. For example, Chinese shipbuilders have cost advantages while European yards have financing ability and advanced technology. Korean giant yards have short lead time to construct a ship and can guarantee higher quality. However, those countries are mainly competing in the field of cost advantage. In other words, the cost advantages can be substituted for profit margin. Furthermore severe cost competition is caused by the following components:

- High overhead cost and surplus facility
- Lots of competitors
- High withdrawal barrier

For the purpose of maintaining employment and their defense industry, many countries want to operate shipyards even if they have lost competitiveness and the yard facilities such as docks are not easily transformed to use for other products. Figure 16 shows that the naval shipbuilding market is still dominated by North America and Europe.

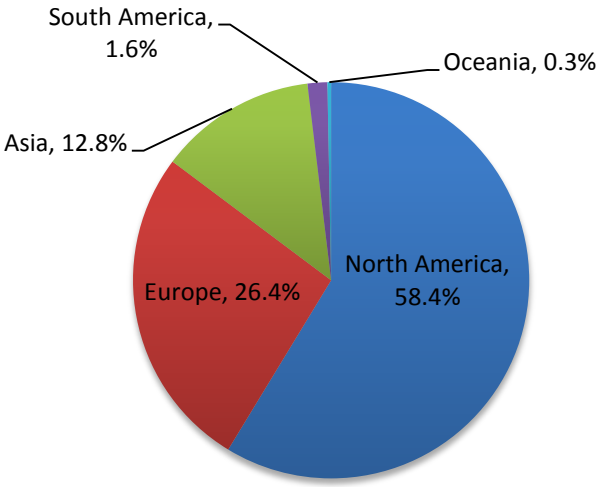


Figure 16 Market share in naval shipbuilding by region (in USD)
Source: ECORYS (2009), Study on the Competitiveness of the European Shipbuilding Industry

< Potential Competitors >

Potential competitors in the shipbuilding industry have existed always. Japan and Korea were also the newcomers from the point of view of European yards. Other developing countries such as Brazil and Vietnam tried to enter into the market but without much success so far. Recently, China has been the only successful case, moving from potential competitor to real rival. China Shipping and Shipbuilding Corporation (CSSC) was founded with a view to earn more foreign currency.

< Ship owners >

The shipbuilding market is easily swayed by the global shipping business. Business cycles between the two sectors are deeply interrelated. Generally, the price of a ship rather than its quality plays a critical role in making a decision to order new building for general cargo ships while the quality might contribute a more important role to order new building vessels such as LNG carriers or passenger vessels. In other words, when it comes to advanced technologies, the quality is more emphasized than

the price competitiveness. Moreover, delivery time could play a significant role in making a decision to order because the shipping industry has characteristics of market volatility.

< Suppliers >

Suppliers for the shipbuilding industry can be categorized as dual parts. One is human resources and the other is non-human materials. The production process in ship construction needs many skilled workers. Therefore, direct labor cost constitutes roughly 17% of the overall cost structure (Stopford, 2009). Sometimes shipyards go through strikes with strong labor unions. As a result a proper labor management could be one of the major jobs in the yards. On the other hand, materials or equipment for ship construction play a considerable role in competitiveness. A stable supply of steel and core parts like engines can contribute to the profit margin. For instance, with skyrocketing fuel prices, an innovative engine with low emissions can be a good attraction for ship owners.

< Governments >

Governments are outside of the major competitive forces but often affect five competitive forces. Governments often create a barrier to the import of ships from foreign shipbuilders. Major countries recognized the shipbuilding industry as strategic manufacturers to enlarge military and commercial capacities after World War II. As a result the Japanese and European governments supported their yards with subsidies. For example, the Japanese government carried forward KeiKaku Zosen (計画造船;けいかくぞうせん), a government aided (planned) shipbuilding program.

This policy promoted shipbuilders by supporting subsidies or low interest rates while harmonizing with shipping industry policy. The ships constructed under the planned shipbuilding program represented 70% of all new building ships between 1947 and 1953. As a result this program assisted Japanese shipyards in accumulating higher

technologies to get orders from overseas owners. Apart from the Japanese case, other major countries such as the U.S.A. and Great Britain also interfered with normal competition of shipbuilding in the global market. For instance, the U.S.A. has the Merchant Marine Act[10] whereby all goods transported by water between U.S. ports should be carried in U.S.-flagged ships, constructed in the United States.

Conclusively, industry competitors and ship owners are the most powerful forces in a competitive structure while governments exert their influences to maintain least competitiveness.

3.2.2 Generic global strategy in shipbuilding industry

According to Michael E. Porter, global industry can take one of the five generic strategies (Cho & Porter, 1987).

- Global Cost Leadership Strategy
- Global Differentiation Strategy
- Global Focus Strategy
- National Responsiveness Strategy
- Market Protection Strategy

Global strategy transition in the shipbuilding industry means that one of the five strategies transitions to another strategy. Generally, an entrepreneur who is in the entry level stage in the global market uses global cost leadership strategy to gain a reference from a customer (ship owner). After successful entry into the global market, a company (shipbuilder) accumulates technological capacity and can choose

[10] In other words Jones Act, U.S. has criticized for protectionism. When Korea negotiated with U.S. to make an agreement on free trade in 2006, U.S. denied demolishing the Act.

various strategic activities. Then a company can select a variety of strategic activities and blend those strategies. However, making a decision to form a sequence and choose proper timing is more important than composing and choosing strategies. This will be discussed in the next section.

< Global Cost Leadership Strategy >

The global cost leadership strategy is to build up a strategy in order to secure customers (ship owners) who are insensitive to the diversity of goods. The global shipbuilding industry has been led by giant shipbuilders who can use cost leadership. However, this can damage the profit margin when the recession lasts.

< Global Differentiation Strategy>

Differentiation strategy can be applicable to those customers who prefer differentiated products or services. Shipyards discriminate the prices of their products respective to each region or ship owners by differentiating their technologies and qualities. For example, competitive shipbuilders, having the technologies of energy efficiency, can construct low emission and high fuel efficient ships which cannot be built by their competitors.

< Global Focus Strategy >

This strategy is to focus on only a few types of products (ships) which can generate high profits. Construction of special cargo ships such as liquefied natural gas or cruise ships are representative examples for the application of this strategy. Usually, it takes a long time to accumulate the technologies to design and construct those kinds of high value added ships compared with bulk carriers or crude oil carriers.

< National Responsiveness Strategy >

This strategy entails focusing on a specific market and responding actively to the related interests of the owners and distribution structure. However, the global shipbuilding market is a single market and the preferences are homogeneous because

most ships can be operated in the high seas. Therefore, this strategy is unsuitable for the shipbuilding sector.

< Market Protection Strategy >

This strategy looks like national responsiveness strategy from the point of view of focusing on a single country. The difference between the two strategies comes from the protective action of a state and a protected shipbuilding market, which offers domestic shipbuilders a differentiated market position which is not acquired by the market mechanism. Today, many leading states in the shipbuilding industry adopt this strategy. For instance, the Jones Act of the U.S.A. and KeiKaku Zosen of Japan are examples of the protective policies of governments.

Those generic strategies can be selected at a specific timing and situation from the perspective of stationary aspects. However, most firms face variable business environments and modify their strategies with respect to their circumstances. Therefore, it is necessary to consider a dynamic approach from the point of view of mechanism. Porter's competitive analysis model is mainly focused on the present situation. On the other hand, the mechanism analysis of strategic management analyses the competitive environment through the tool of resources composition, combination sequence and application timing.

3.2.3 Competitive mechanism analysis in shipbuilding industry

Cho clarified that a mechanism formed by a firm could be decomposed by the composition of resources, combination sequence and application timing (Cho, M Management, 2006).

Composition refers to the combination of elements necessary to manage a company. For example, when it comes to running a business with only two elements, labor and capital, the ratio of each element could be various. Manipulating two elements could contribute to the performance of a business. A firm can create a competitiveness

and management culture through the process of combination and acquisition of various resources.

Sequence is how to preoccupy necessary resources in the process of resource acquisition. All firms need to acquire human and material resources to make a profit. However, the order of acquisition is different from the necessity of acquisition.

Timing has an influence on opportunities after deciding the acquisition process of resources. Composition and sequence is a kind of stationary element to execute, while timing has dynamic attribute, which means that the process of acquisition can affect the business performances.

In this thesis, only timing and sequence elements will be discussed because this topic mainly deals with the state level strategy and the composition is mainly applicable to a firm level strategy for profit maximization.

3.2.4 The sequence and timing of global competitive strategy

As examined in Chapter 2, no one state or region has dominated the global shipbuilding industry. Historically, global leaders in shipbuilding industry have changed as times go on. Recently, the global shipbuilding market is mainly dominated by three Far East countries and European shipbuilders also occupy their steady portions.

After World War II, high competitiveness in the European marine equipment manufacturing sector enabled European shipbuilders to construct ships at cheaper prices than Japan although labor wages in Europe were 20~30% higher than Japan. In the 1950s dual factors enabled Japanese yards to have low cost leadership. Firstly, the government planned shipbuilding program enabled them to cut down costs steadily. Also, early application of welding technology for new building vessels solidified Japan's cost competitiveness. As a result, those aspects contributed to the European shipyards' shift to a global segmentation in sophisticated vessels with advanced technologies (ECORYS, 2009).

The oil shock in 1973 and 1979 forced all businesses to manage on a lean cost structure and the maritime industry was not exceptional. Innovative construction methods such as block construction in dry dock, pre-outfitting, and tandem construction method made it possible to construct more economically homogeneous ships in emerging countries. At that time Korea appeared to be one of the global players in the emerging markets with the active promotion policy of the government. Then Japan chose a differentiation strategy and Europeans focused on more innovative vessels in the 1980s.

During the severe recession in the shipping market in the 1980s and 1990s, many yards in Europe and Japan faced restructuring. However, Korean giant shipbuilders had aggressively invested more capital to expand production facilities such as the largest dry dock in Hyundai Heavy Industries despite regulations on the additional dry docks according to government policy. From the 1990s, the Korean shipbuilding industry threatened Japanese yards in terms of all three indexes of shipbuilding, new order, delivery and order book while European yards tried to protect their market occupation by raising the issue of trade disputes on WTO and OECD Working Part 6 (Shipbuilding), which will be deeply discussed in section 4.2.

Recently, one of the most remarkable players in the global shipbuilding market is China. The Chinese government designated the shipbuilding industry as a strategic industry by adopting a long term plan for its promotion policy of the shipbuilding industry in 2006. China is the low cost leader and one of the strongest competitors to Korea. Unlike the Korean shipbuilding industry, which is mainly dependent on overseas ship owners, the Chinese yards can obtain orders by Chinese shipping companies. Moreover, they have enough finances to supply their yards with low interest rates.

Figure 17 shows that the strategies chosen by countries have changed in each period. The most interesting feature is that most countries began as cost leaders. Ship owners generally want their assets to be built at low cost and experienced yards. Therefore, new players have to appeal to them by cost advantage to win competitions.

Then cumulative experience could enable them to accumulate advanced technologies and they could build more sophisticated vessels. In other words, major shipbuilders have moved to differentiation strategy from low cost strategy (Won, 2010).

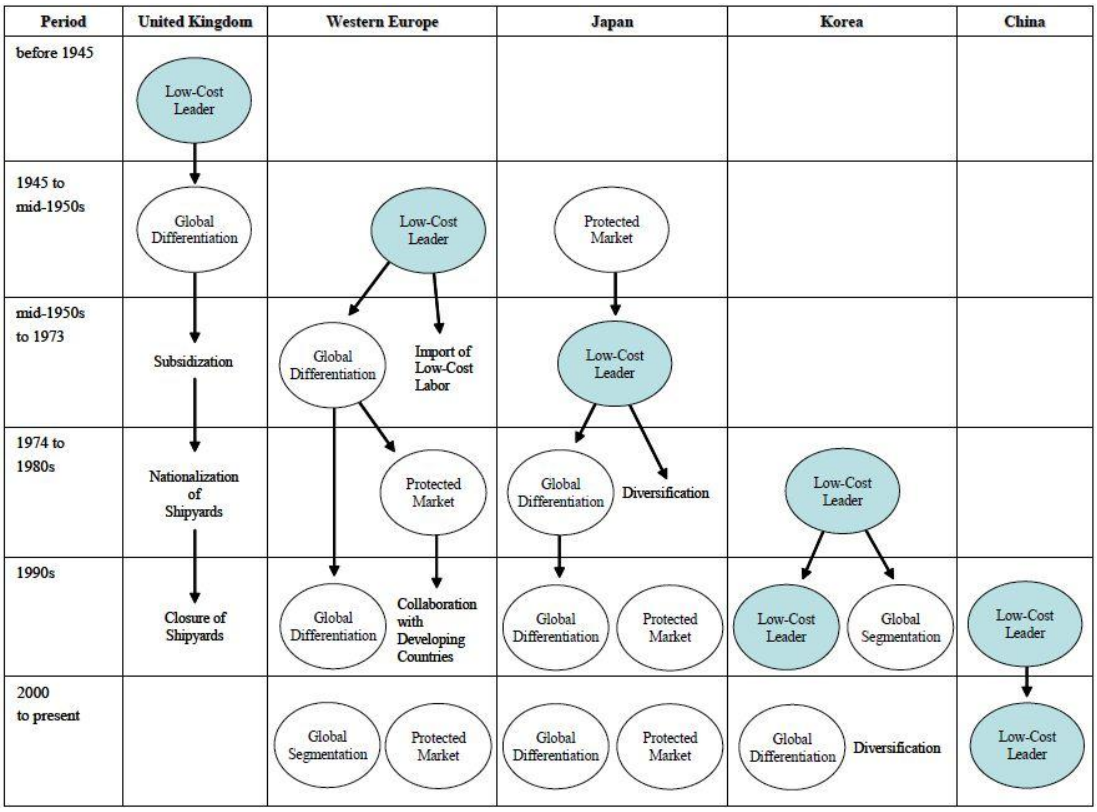


Figure 17 Sequence of strategy in major shipbuilding countries
Source: Won, D.H. (2010), A study of Korean shipbuilders' strategy for sustainable growth, MIT Sloan School of Management

Finally major countries like Europe and Japan have chosen a protected market. A protective market might mean building technical barriers for competitors as well. Substantially, IMO technical meetings on ship's regulation are being led by those states having advanced technologies. Therefore, the technology standard and regulations have been mainly suggested by those Europeans or Japanese. For example, the report "Second IMO GHG Study 2009" was undertaken by an international consortium led by MARINTEK (The Norwegian Marine Technology Research Institute). From the perspective of a global emission control regime, many developing countries do not want to establish new environmental regulations. For

instance, the dispute between the developed countries and developing countries has not produced a settlement, which is similar to the situation in IMO meetings.

Korea should prepare the proper strategy to maintain sustainable growth. Now is the time of ambidexterity strategy between differentiation and low cost strategy. Considering the sequence and timing of strategies chosen by major leaders in the shipbuilding industry, active participation in making technical regulations such as EEDI or SEEMP is necessary in IMO meetings or other international organizations. Also, more innovative R&D activities should be performed to win future global competition.

4. Policy reviews and R&D strategy

At the early stage of modern industrialization of Korea, coordination and planning for economic development by the central government had been established. Most firms followed the national policy and factors of production were supported directly. The shipbuilding industry was not exceptional like other industry revolutions.

However, international regulations for leveling the trade environment by the WTO affected national policy for specific industry promotion. As a result many of direct support systems were abolished and mainly R&D grants survived as a promotion policy tool. Therefore, it is necessary to review the policies affecting the shipbuilding industry and find a better way to maintain key competitive advantage.

In this chapter, firstly, Korean industrial policy will be introduced for the reflection of past measures and the trade regulation provisions for avoiding unnecessary conflict with other countries and seeking proper policy tools will be discussed. Then R&D strategy and system will be discussed.

4.1 Historical industry policy on Korean shipbuilding

Historically Industrial policies in Korea can be categorized as dual tracks. One is central economic planning and the other is decentralization. The shipbuilding industry policy has the same context as other industrial policies in Korea. Generally, it can be said that Korean industrial policy has been bifurcated since 1986. Instead of the abolishment of each industrial promotion law, a consolidated industrial policy started after the legislature of industrial development act for all industries. As a result there is no specific promotional law for the shipbuilding industry and the role of central government has diminishing. Thus, it is necessary to seek a new governance role instead of government for all stakeholders.

4.1.1 Before 1986

Central economic planning had been performed in the 1960s and 1970s. Throughout the successive economic development planning periods for five years, the Korean economy transferred from light industries to heavy industries. Prior to the 1960s most Korean yards had constructed only wooden ships. To be an industrialized country, the Korean government designated the shipbuilding industry as a strategic industry for export drive policy. The government provides private entrepreneurs with foreign loans. Both the strong leadership of the president of Korea and an entrepreneurial spirit made it possible to construct modernized shipyards.

In March 1973, a long term plan was made for the promotion of the shipbuilding industry. In the 1970s, most giant shipbuilders, Hyundai, Samsung and Daewoo, in Korea were founded and started new building. Also, the southeastern part of Korea was designated as a shipbuilding cluster and it has been maintained as the world's largest shipbuilding complex. At the same time, Korea's Export and Import Bank supported exports on a differed payment bases and the government founded a planned shipbuilding program linked with the domestic shipping industry.

4.1.2 Since 1986

On the first day of July 1986, the industrial development act came into effect. The law was a consolidated version and is still effective in all kinds of industries including shipbuilding sector. As a result the specific law for the promotion of the shipbuilding industry was abolished. The objective of the establishment of the integrated industrial development act was to support industrial restructuring from the perspective view of dynamic comparative advantage [11] on the basis of market mechanism. According to the law, interventions of government should be confined

[11] Shifts in a system's competitiveness that occur over time because of changes in three categories of economic parameters-long-run world prices of tradable outputs and inputs, social opportunity costs of domestic factors of production (labor, capital, and land), and production technologies used in farming or marketing. Together, these three parameters determine social profitability and comparative advantage (Dynamic Comparative Advantage, 2012).

to those industries in a state of recession or in a condition of comparative disadvantage. As a result many direct subsidies were revoked and the autonomy of shipbuilders has deepened.

Although the global shipbuilding industry had gradually escaped from the recession in the 1980s, financial pictures of some shipbuilders had not improved because of excessive loans. Therefore, the Korean government designated the shipbuilding industry as a rationalization industry in August 1989 for the purpose of minimizing the negative influence on the domestic economy. The contents of rationalization involved tax cuts for restructuring companies through selling of nonprofit assets or M&A and regulating expansion of facilitation such as dry docks by year 1993.

There have been no direct regulations by the government on the shipbuilding industry in Korea since 1994. The Korean government has mainly focused on the support of R&D activities through matching funds between the government and non-government entities.

4.2 Review of WTO regulation and R&D subsidy

4.2.1 Overview of WTO Agreement on Subsides and Countervailing Measurements

Over 90% of the number of ships constructed in Korea is being exported to overseas ship owners and Korea's shipbuilders are largely dependent on the overseas market. Korea has disputed with the EU on the issue of government subsidies for the shipbuilding industry before 2010. Therefore, it is necessary to review policy tools which can create conflict with other states or regions for the purpose of stable promotion of industrial policy.

The World Trade Organization (WTO) was established to promote international trade and stimulate fair trade circumstances for all by reducing or eliminating trade barriers, thus contributing to economic growth and development. The WTO was a

substitute for the GATT framework including service and intellectual property. The WTO Agreement on Subsides and Countervailing Measurements (SCM) sorts subsidies into three categories, according to the so called Traffic Light System. Generally SCM requires member states to prohibit specific subsidies but allow some exceptions. Subsides are defined in the Article 1 of SCM. Specifically, if there is any financial aid by a government or any public entity, it is regarded as a subsidy. For instance, direct transfers of funds or liabilities are deemed as subsidies.

Table 11 Traffic Light System of SCM

Prohibited	Actionable	Non-actionable
Red light subsidy	Yellow light subsidy	Green light subsidy

Source: World Trade Organization and revised by Author (2012)

The specificity is decided according to Article 2 of SCM. Therefore, the specific policy for the shipbuilding industry could cause trade conflict and export might be damaged severely by countervailing actions of other states. For instance, tax reduction only for Korean shipbuilders could be argued by competitors but tax reduction for all industries can be free from trade conflict. The R&D subsides are classified as actionable subsidies and can be or cannot be allowed by specific cases according to Article 8. Other actionable subsidies are endowed to disadvantaged regions and environmental facilities by regulations within the territory of member states. Those three kinds of yellow light subsidies are often used as policy asylums by member states for the purpose of economic development and industrial promotion.

Conclusively, every state must make an industrial policy under the complete comprehension of allowed subsidies and try to avoid unnecessary trade conflicts. Korea once struggled with being suspected of shipbuilding subsidies by European Communities but finally won its dispute on the WTO Disputes Settlement Panel in 2005 (WTO, List of disputes citing SCM agreement, 2012). As a matter of fact, policy tools should be carefully chosen because it is not easy to prove innocence from breaching WTO regulations.

4.2.2 R&D grant and other policy tools

Considering recent the recession in the shipping and shipbuilding industry, regional governments and politicians in Korea want to direct assistance to revive SM sized shipbuilders because most giant shipyards manage other business units such as plant engineering or wind mills and they can hedge their risks to other sectors. Their support request is mainly to stimulate issuing refund guarantee[12] or direct assistance of financing by banks. However, this kind of assistance underlies not only specificity on shipbuilding, prohibited subsidy, but also a kind of government intervention on liquidity, against market mechanism. Therefore, those kinds of measures are hard to use from the perspective of avoiding international trade disputes.

As a result, support for R&D activities could be the only alternative way to help destitute enterprises but it is not so popular because of its long gestation period compared with other policy measures such as tax cuts. However, effective assistance with R&D activities could be the lasting way to gain competitiveness. On the other hand, all R&D activities cannot be guaranteed to be free from breaching SCM. Therefore, it is necessary to review the detailed constraints of SCM about R&D support systems by a government. Article 8 of SCM describes member states to subside assistance for research activities conducted by firms or research institutes on a contract with firms, where the assistance is at most 75% of the cost of industrial

[12] The builder's bank undertakes that in the event the purchaser ends the contract for good reason (for example, due to the builder's insolvency), if the builder for any reason fails to refund the advance installments of the contract price the bank will refund those installments on the builder's behalf. Where the purchaser has taken a loan to finance the installments, the purchaser will usually be required to assign the benefit of the refund guarantee to the financier. In this situation it is important to check that such an assignment is not prohibited in the refund guarantee.

In the current economic climate, it is likely that shipbuilders will experience difficulties in financing new orders; making refund guarantees a very important tool in protecting the purchaser and its lender's interests. It is therefore vital for the purchaser to ensure that the refund guarantee provides as much protection as possible and, importantly, that the refund guarantee is actually enforceable (Lexology, 2009).

research or 50% of the cost of pre-competitive development activity. Therefore, roughly every R&D program for shipbuilding should not exceed the maximum limitation of government aid.

To sum up, direct support systems by governments could be regarded as an infringement of SCM and could raise trade conflict. Therefore, the R&D grant might be the safer way to assist shipbuilders.

4.3 Overview of Korean government R&D system

According to the International Institute for Management Development (IMD) in Switzerland, Korea ranked 14th in technological competitiveness and 5th in scientific competitiveness in the world in 2012 (IMD, 2012). It could be interpreted that the R&D results are not effectively interrelated to the business and most Korean technologies are mainly oriented to the production technologies.

It could not be denied that R&D investment in Korea has played a significant role in economic growth. The strategy model of Korea's miraculous economic development involved being a fast follower instead of innovation creator. However, a recent shift in the R&D paradigm indicates that Korea should not stick to its old strategy.

In this section, Korea's R&D strategy and system will be reviewed. Also, an analysis of whether the R&D budget is fair in comparison with the contribution to the domestic economy between the automotive and shipbuilding industries will be undertaken. Then, a new paradigm of R&D Open Innovation will be discussed for application to the Korean shipbuilding industry.

4.3.1 R&D strategy of Korea toward sustainable growth

Today, the global village faces environmental risk and scarcity of natural resources. For instance, oil prices have been skyrocketing every year. Korea does not have affluent natural resources and always must import them from other countries. Thus Korea has depended on export drive policy and usually exports items having comparative advantages. Comparative advantage and innovative technology are

deeply interrelated. Innovative technology can lead economic development for those with insufficient resources.

An economic model using only factors of production meets the limit of economic growth and it needs to measures global climate change. Moreover, it is necessary to evade the stereotyped concept that environmental protection contradicts economic growth and show that it can play a positive role as a synergy effect to an economic boom. Therefore, a low carbon, green growth vision [13] can improve national competitiveness through occupying advantages in global green related industry.

The vision has three main objectives: effectively dealing with climate change and attaining energy independence; creating new engines of economic growth; and raising the overall quality of life. Korea's energy intensity is about one-fifth above the OECD average and Korea places as the tenth-largest energy consumer in the world (Jones & Yoo, 2012).

To achieve a virtuous cycle of growth between economics and environmental protection, a neo-paradigm for industrial development is necessary through green technology innovation. Furthermore, the value chains of most industries should be transferred to eco-friendly low carbon procedures.

4.3.2 Overview of government R&D investment

There is no specific national R&D program solely for the shipbuilding industry in Korea. Almost all national investment for research activities on shipbuilding and offshore industry are designed for the purpose of achieving the national technology agenda. Therefore, most R&D programs funded by the government are composed of consolidated industrial sectors, which is aimed not only at evading trade conflicts from competitors but also at managing a flexible budget regardless of the respective industry. Moreover, an R&D budget funded by the government for the shipbuilding

[13] National agenda of incumbent Korean government regime for archiving economic growth by reducing greenhouse gas emission and environmental pollution.

industry is not proportional to its contribution to the domestic economy and there are often competitions to gain a greater allocation of the R&D budget among different industries.

To analyze the R&D allocation amount for the shipbuilding industry, it is necessary to examine each R&D program related to the shipbuilding sector with the assistance of Korea Evaluation Institute of Industrial Technology (KEIT) because there is no official resource regarding national R&D investment for the shipbuilding sector. However, those data obtained from KEIT show only the budget of the Ministry of Knowledge Economy because the scale of the R&D budget of the Ministry of Land, Transport and Maritime affairs is much smaller than that of the MKE.

Table 12 shows that the total amount of government grants for R&D was 13.7 trillion KRW (12 billion USD) in fiscal year 2010. The MKE expenditure scale on R&D represents 32.2% of total grants and the amount was 4.4 trillion KRW (3.9 billion USD). The major usage of the R&D budget is for technology innovation, raising infrastructure and supporting researchers.

Table 12 R&D grant scale by ministries

Ministry Name	Grant (tril. KRW)	Portion (%)
Ministry of Knowledge Economy	4.41	32.2
Ministry of Education, Science and Technology	4.39	32.0
Defense Acquisition Program Administration	1.80	13.1
Ministry of Land, Transport and Maritime Affairs	0.58	4.2
Etc.	2.52	18.4
Total	13.7	-

Source: Korea Evaluation Institute of Industrial Technology (2010)

Figure 18 illustrates the trend and amount of R&D grants for the shipbuilding industry supported by MKE. The amount of R&D expenditure for the shipbuilding industry has dramatically risen since 2000. In the year 2000 the R&D grant for the shipbuilding sector was only 1.8 billion KRW, however, the amount of the R&D budget became 37 billion KRW (32.7 million USD) and the annual average of

investment recorded 35%. Considering 10% of the annual averages of investment for overall R&D grants, the rate of increase has been dramatic. Specifically, a 200% increase was recorded in 2001 and an increase of more than 10 billion KRW (8.9 million USD) occurred in 2009.

Considering the overall investment scale of the national R&D budget for the same period, the increase of R&D grants for shipbuilding is not specific. The national R&D budget for the 10 years has enlarged more than 3 times compared to 2000 (NSTC, 2012).

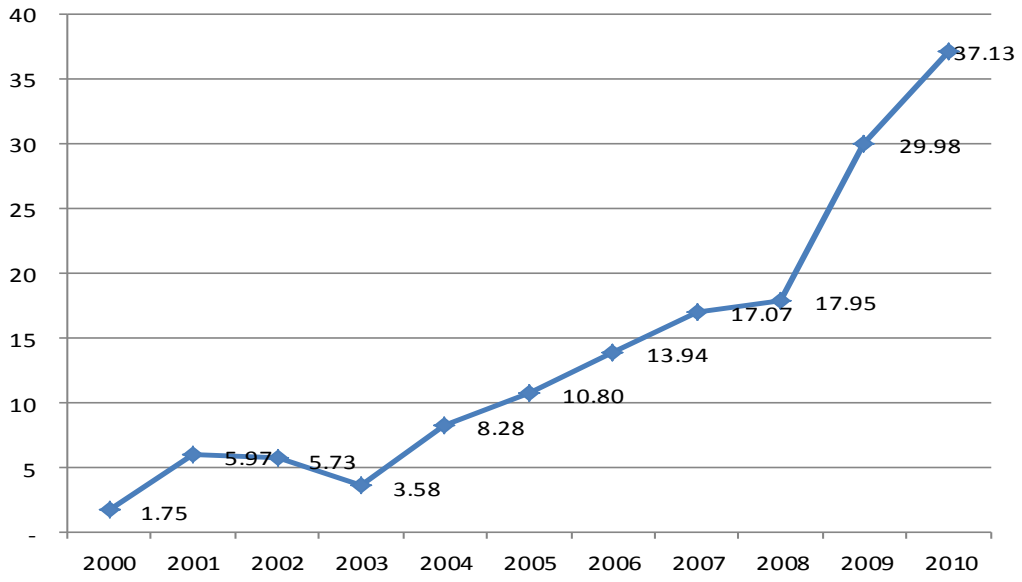


Figure 18 R&D grant trend for shipbuilding industry (unit: billion KRW)
Source: Korea Evaluation Institute of Industrial Technology (2010)

For the purpose of comparison of R&D budget allocation, the automotive industry's case will be examined. The automotive industry is one of the representative industries acting in a cash cow role for the Korean economy and its contribution to domestic industry is much more than that of the shipbuilding industry from the point of view of number of employees, turnover and added value. Table 13 shows that the portion of turnover and added value attributed to the automotive industry is more than one and a half times that of the shipbuilding industry. The Shipbuilding industry represents 5.4% of the manufacturing industry while the automotive

industry occupies 10.2%. Considering the export amount of the automotive industry, the shipbuilding industry is more highly profitable to the domestic economy because ships and offshore structures are the best export items.

Table 13 Comparison of contribution to domestic economy

	Employment	Turnover	Added value
Shipbuilding Industry	5.4%	6.6%	6.2%
Automotive Industry	10.2%	10.1%	9.4%
Manufacturing Industry	100%	100%	100%

Source: National Statistics Office of Korea (2009)

However, when it comes to comparing R&D investment in the shipbuilding sector, it is not necessarily proportionate to its contribution to the domestic economy. Specifically, for the purpose of showing imbalance in the allocation of the R&D budget, Table 14 shows the budget apportionment between the automotive and shipbuilding industries of one of the R&D programs, Industrial Strategic Technology Development (ISTD) funded by MKE.

Table 14 R&D budget of ISTD by MKE (unit: billion KRW)

Year	Shipbuilding	Automotive
2008	12.6	30.2
2009	17.5	73.7
2010	18.2	74.0

Source: Korea Evaluation Institute of Industrial Technology (2010)

Table 14 shows that the grants allotted to the automotive industry have been more than four times that to the shipbuilding industry since 2008. The overwhelming allocation of the R&D budget to the automotive industry is due to various reasons.

Firstly, there have been so many appeals to allot government grants from politicians to regional governments because infrastructure for research activities related with Green Cars is also accompanied by technological innovation. For instance, many visitors related to the automotive industry come to government complexes to appeal

for larger budgets, which could be a kind of social amplification mechanism; however, in the case of the shipbuilding sector, few petitioners are active..

Secondly, the number of subcontractors in the automotive industry having global competitiveness is much less than in the shipbuilding industry on account of the nature of order production.

Thirdly, there is not enough communication between government and shipbuilders. The government can control the automotive industry by taxes or environmental regulations and they need to keenly communicate with government officials not just to be policy takers. On the other hand, the government cannot play a critical role in the shipbuilding industry because their major customers are outside of the Korean peninsula.

Conclusively, it is necessary to build good governance for the shipbuilding industry. Like the automotive industry, the shipbuilding industry needs to have a kind of opinion group in order to have a louder voice.

4.3.3 The system of government R&D program

There are many R&D programs for all kinds of industries supported by the Korean government as shown in Table 15. Those R&D programs are designed for achieving specific goals. For example, the Components & Materials Technology Development (CMTD) program aims at promoting competitiveness of core parts or materials for any sorts of industries. Therefore, the applicant industry can be whatever manufacturing industries. On the other hand, the amount of assistance by the government does not exceed 75% of the total R&D program cost, which satisfies the limit criteria of the SCM Agreement of WTO. In case of major conglomerate companies, the grant scale diminishes to 50% in order to give SM firms advantages.

The qualification for applicants is opened to any type of company having manufacturing systems, research institutes and colleges or universities. Some programs often give more incentives to small businesses in accord with national

policy. Also, there are some disqualifications for application in case of failure in tax payment or poor management conditions such as a high debt ratio[14] over 500% or current ratio[15] less than 200%.

Table 15 Major R&D programs

Name	Summary
Industrial Strategic Technology Development	To support the development of key/source technologies in the fields of strategic industries pinpointed by national policies for economic growth, thereby strengthening the competitiveness edge of industries in current focus, and fostering up-and-coming industries.
Components & Materials Technology Development	To support technology development programs designed to foster innovate capacities of small and medium size companies, as well as to better respond to rapidly changing market need and policy need by retaining flexible structure.
Global Excellent Technology Innovation	To support technology development programs designed to foster innovative capacities of small and medium size companies, as well as to better respond to rapidly changing market need and policy need by retaining flexible structure.
Small and Medium Enterprises' Technology Development	To support the growth of innovative small and medium enterprises and the marketing of trailblazing high value added products by aiding the development of technologies sustainable solely by their participation as well as technologies needed for new enterprises.
Others	To support technological development and raise the nation's global competitiveness in targeted areas of technologies.

Source: Korea Evaluation Institute of Industrial Technology (2010)

The results of R&D activities are assessed in four categories: excellent, normal, pass, and dishonest grade. In case of receiving a dishonest grade, the applicant cannot

[14] A ratio that indicates what proportion of debt a company has relative to its assets.

[15] A liquidity ratio that measures a company's ability to pay short-term obligations.

apply for future R&D programs for two or three years and must make restitution for the grants. It was not been tolerated to have an unsuccessful outcome until 2009. However, many researchers had insisted that failure in R&D activities should be accepted because it is unrealistic that every research performance is assessed to be successful. In case of a successful research result, the grant beneficiary should make a payment of royalty to the Korean government and the amount of royalty is different from the R&D programs.

According to KEIT, the success rate of R&D projects is over 95%, which suggests that the difficulty levels of most national R&D projects are not so challenging and the pool of assessors is not so wide. Therefore, most applicants apply for low risk R&D projects and the shipbuilding sector is the same.

Another problem is that the newly developed technology is not directly linked with commercialization. For example, liquefied natural gas (LNG) carriers have been getting popular as oil prices increase. The LNG carriers can carry -162℃ liquefied natural gas in order to improve transport efficiency by reducing the volume of natural gas. All Korean giant yards have paid royalties for using Gaztransport &Technigaz's technologies in the construction of LNG carriers. Korean shipbuilders established a consortium for R&D projects with the purpose of substituting the French LNG cargo containment systems (CCS) for local CCS. The LNG CCS technology itself was successfully developed; however, the construction of a prototype LNG carrier was not realized because each builder was unwilling to share their common CCS technology for construction. Furthermore, they had secretly developed their own LNG CCS technologies respectively and held each other in check. As a result, the national R&D project itself succeeded was not connected to new order.

Briefly, there is a variety of R&D programs and each program encompasses all round industries in Korea. To gain more grant allocations for the shipbuilding industry, it is necessary to persuade officials and publicize their contributions to the domestic economy. Moreover, open innovation could be necessary not just for each shipbuilder but for national profit.

5. Industrial policy suggestion for Korean shipbuilding industry

For the economic prosperity of a country, innovation has been a significant factor and a precondition for sustainable growth. Innovation could be categorized as dual aspects: tangible and intangible. Today, OECD countries tend to increase investment in intangible assets such as human capital and patents (OECD, 2012). The product ship and offshore structures themselves are tangible; however, the innovation processes such as R&D are intangible.

Global markets are getting more competitive and players need to adopt alternative approaches to strategies and business processes. The Shipbuilding industry is not exceptional. In this chapter, an alternative innovative strategy will be introduced and examined. Also, a proper decision making scheme for the stakeholders in the Korean shipbuilding industry will be suggested.

5.1 Background and concept of Open Innovation

The Open Innovation paradigm is often used in the highly fashionable industries such as electronics or biotechnology. Also it might be understood as the opposite concept of the traditional model, where internal R&D activities are regarded as the primary activities. According to Chesbrough, the definition of Open Innovation is "the use of purpositive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (Chesbrough, 2012). As illustrated in Figure 19, Open Innovation is a paradigm that insists a firm could and should use both internal and external capacity in the process of R&D activities. In other words, it uses all possible resources regardless of firm boundaries.

Today, the rate of technological advancement is so fast and a single firm cannot develop all kinds of necessary technologies. The concept of Open Innovation

already exists and Henry Chesbrough named it the recent R&D trend. Outsourcing and collaboration with external organization has been done without the perception of Open Innovation.

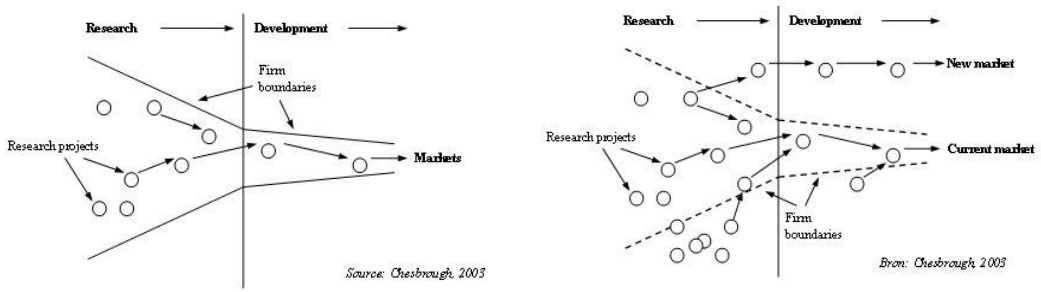


Figure 19 Closed vs. Open Innovation
Source: http://www.openinnovation.eu/open-innovation/

Also, merger and acquisition (M&A) and technology transfer are other forms of Open Innovation. According to Chesbrough, globalization of the world economy makes it possible to move a specialist from one state to another state, which stimulates the Open Innovation process of R&D activities. Chesbrough pointed out that several factors contributed to the decline of the traditional closed innovation. Firstly, the mobility and availability of high quality human resources has risen over past years due to globalization. As a result knowledge has also transferred easily to other organizations. Secondly, spin-offs of technologies have increased due to increased availability of venture capital. Finally other companies in the supply chain contribute significantly to the innovation process.

Unlike those fields of information technology industry, the background of Open Innovation might not be directly applicable to manufacturing industries such as the shipbuilding industry. Especially the role of venture capital in the shipbuilding industry might not hold much relevance to the promotion of the shipbuilding industry. However, the importance of the supplier's role in R&D processes cannot be disregarded. As it was pointed out in section 3.1.5, the Korean shipbuilding industry does not have competitive marine equipment firms and related technologies for

reducing GHG emissions, which represents those most innovative R&D activities that have been led by giant shipbuilders.

Currently, few industries are free from the issue of GHG emissions. Although the contribution of the shipping industry to entire GHG emissions is a small portion, 2.7%, it is not negligible. With respect to the reduction technology for GHG emissions from ships, the IMO allows all applicable methods to diminish CO_2 emissions (MEPC, 2011). Considering the wide variety of options for emission reduction, the Open Innovation paradigm can play a major role also in the shipbuilding industry.

As it was discussed in section 3.1.4, the majority of R&D programs performed in Europe involve not just shipbuilders but also other marine equipment manufactures or alternative fuel research organizations.

To sum up, Open Innovation is to use exterior knowledge in the process of innovation. The Open Innovation paradigm is necessary to develop innovative reduction technology for GHG emissions. A variety of shareholders in the value chain should be involved for a successful performance result.

5.2 Desirable Open Innovation model for Korean shipbuilding

As a matter of fact, many huge shipbuilders might have enough capabilities to innovate by themselves. Sometimes they merge with overseas shipbuilders or establish a new overseas company to reduce production costs.

For example, STX Shipbuilding Co., the fourth largest shipbuilder in Korea, took over the Aker Yards ASA (renamed to STX Europe), the largest shipyard in Europe, in 2008. It took one year to take over control of the Aker Yards because it was required to obtain the European Commission's decision concerning antitrust policy (Commission, 2009). The acquisition by STX was meaningful in terms of entering a

new paradigm for Korean shipbuilders because construction of the highest value added vessels such as cruise ships or ice breakers could be achieved.

Moreover, giant shipbuilding conglomerates have invested large amounts of funds into other relevant industries such as the green energy market to alleviate risks from specializing only in the shipbuilding business. For instance, all of the big 4 shipbuilders, HHI, SHI, DSME and STX, are promoting the wind turbine business. Especially, the world's largest shipbuilder HHI established a new business unit for green energy in its organization in 2011 and devoted their capacity to leading the renewable energy market. The leading shipbuilders in Korea hope to reduce their business portion in the shipbuilding sector and increase clean energy businesses.

Table 16 Business diversification of big 4 shipbuilders

Name	Contents
HHI	Established new business unit in 2011 (Green energy)
SHI	Entered into wind turbine business in 2008
DSME	Acquired wind turbine company in 2009 (DeWind)
STX	Established solar cell company and acquired wind turbine company

Source: Each company's annual report in 2011

The French engineering company GTT, having the key technology for LNG cargo containment system, could now be sold in the global M&A market due to the current depression of the shipbuilding market (Song, 2012). Today, LNG is to be in the limelight as one of alternative fuels to oil. Heavy fuel oil of ships could be substituted with LNG and LNG could be used in other fields of industries as cleaner fuel as well. Most Korean shipbuilders have paid huge royalties (roughly 5% of a ship's price) for using their patented technology to construct LNG carriers although almost all of LNG carriers have been constructed in Korea. Therefore, it is necessary to create a consortium for the acquisition of GTT for the sake of preventing the pursuit of competitors' like Chinese yards.

However, many other SM sized shipbuilders have insufficient innovative capabilities both internally and externally. Most of them do not have research centers as well as design divisions because of the shortage of capital. Therefore, they do not have room for investing in new business areas like the big 4 shipbuilders do. Considering their struggling condition, The Korean government has recommended that they shift their business from commercial vessels to pleasure crafts; however, there have been no subsidies except R&D grants. Although there is the Korea Shipbuilding Research Association, the members are confined to giant shipbuilders. Therefore, for the sake of SM sized shipbuilders, the Open Innovation paradigm should be applied.

For the sake of balanced growth for both giant shipbuilders and small shipbuilders, it is necessary to share their technology, which does not mean obtaining free copyright of technology but purchasing intellectual property. Maintaining competitiveness in commercial shipbuilding is necessary to hedge the risk of losing global leadership in the shipbuilding industry because the commercial ship is the largest segment of the shipbuilding market.

On the other hand, there are few key technologies pertaining to marine engines in Korea. Although Korea manufactures over 50% of all marine engines in the world, most of them are produced by being licensed from the original engine makers such as MAN or Wärtsilä. Considering the contribution of engine technologies to reducing CO_2 emissions, this lack of key technology in the field of marine engines makes it hard to improve energy efficiency from the perspective of whole ship system.

Compared to the automobile (engine) industry with competitive advantage in Korea, the shipbuilding industry (marine engine maker) has insufficient key technology in the field of engines. The Automobile industry has its own key technologies to counter emission regulations such as *EURO VI*. Hyundai-Kia motors group has invested huge capital to meet the requirements of the emission regulations and has successfully developed original engine models.

The Internal combustion engine has been applied to most power sources in commercial ships and it occupies around 16% of the total cost of a ship's construction (Stopford, 2009). Considering the importance of the engine, various types of Open Innovation systems could be applied between the automobile and shipbuilding industries. For instance, not only the internal combustion engine but also alternative fuels have been considered to reduce (zero) emissions from cars in the future. Similarly, fuel cell research and its application in shipbuilding could be reflected.

To sum up, giant shipbuilders have experience with Open Innovation through various channels from M&A to cooperative R&D projects. They are investing in renewable energy businesses in order to diversify their business field and hedge the risk from concentration on shipbuilding. However, in the case of innovative engine development, large scale shipbuilders need to collaborate with some domestic partners like the automotive industry to develop original models. On the other hand, SM sized shipbuilders need to obtain the advanced technologies from the giant yards. For the sake of activated transfer of technology, governance has to create many opportunities to actively communicate with each stakeholder.

5.3 Role of Good governance

As it was stated in Chapter 2, government leadership in the Korean shipbuilding industry has shrunk, which might be due to the global regulations by WTO and the maturation stage of the shipbuilding industry.

Instead of government, governance encompassing all stakeholders should play a significant role. However, there are not so many options to use except R&D support by public administration. Therefore, the role of governance would be confined in the procedure of planning R&D programs. Although governance is usually positively in the limelight, negative governance is possible. Negative governance could lead a situation of irresponsibility and produce an undesirable or unproductive outcome.

In this section, the heart of good governance will be reviewed and a desirable governance model of an R&D program to counteract GHG regulations on the shipbuilding industry will be discussed.

5.3.1 Review of good governance

According to the UN, there are 8 features of good governance. In this thesis the characteristics of good governance shall be interpreted from the point of view of industry instead of citizens because participants in decision making are shipbuilders and other related marine equipment manufacturers. Good governance is participatory, consensus oriented, accountable, transparent, responsive, effective and efficient, equitable and inclusive and follows the rule of law. It can guarantee that the views of minorities are taken into account and that the opinions of the weakest in an industry are heard in decision making. It is also responsive to the present and future needs of companies (UNESCAP, 2012). Figure 20 shows the core features for good governance and the features will be examined individually.

Figure 20 Features of Good Governance
Source: http://www.unescap.org/pdd/prs/ProjectActivities/Ongoing/gg/governance.asp

< Participation >

Participation from a small marine equipment manufacturer to a large shipbuilder is a key cornerstone of good governance. Participation could be either direct or indirect, by intermediate institutions or representatives (associations). Participation needs to be informed and organized, which means freedom of association and expression on the one hand and organized entities on the other hand.

Actually, in the process of policy making for the shipbuilding industry, many opinions come from the giant shipbuilders' association. Also, in the process of selection of R&D subjects, it is not easy for small firms to participate because of asymmetric information. Although there is an association of SM sized shipbuilders, their activities to express their interests are inferior to that of large shipbuilders' association.

< Rule of law >

Good governance requires fair legal frameworks that are enforced impartially. It also requires full protection of minorities. There is no discrimination between large companies and small companies while there are many incentives for small companies such as tax reduction. Therefore, explicit leveling of the playing field exists; however, there still remain unfair practices between large companies (shipbuilders) and subcontractors (marine equipment makers). For example, pressure for cost reduction from shipbuilders makes profits shrink for subcontractors. As a result subcontractors cannot accumulate enough capital to innovate their products. The partnered growth culture should be settled through strict application of fair trade law.

< Transparency >

All processes of decision-making and enforcement should consider the policy takers and those who will be affected. Also, sufficient information should be provided and be easily understandable. Therefore, transparency means that decisions or

enforcement should be carried out on a reasonable basis. Especially, government officials should pay heed to improving transparency.

< Responsiveness >

It is necessary for good governance to take care of hot issues within a reasonable timeframe. For instance, emission control for SM sized shipbuilders might be more pressing than giant shipbuilders because they lack sufficient technology.

< Consensus oriented >

Stakeholders' viewpoints might be various due to their standpoints. Good governance needs mediation of numerous interests to reach a broad consensus. Collection and coordination of interests is a significant matter.

Sometimes, Korean ministries skip the process of collection of a variety of public opinions regarding hot issues for the purpose of expediency, doing what is convenient rather than what is morally right. Consequently, minority (small firms) opinions often ignored and could not be reflected in policy making. For instance, when it comes to collecting opinions of SM enterprises, their opinions are not gathered effectively because public officials usually hope to proceed with their work as fast as they can. Therefore, there is not enough time to gain feedback from various opinions and they prefer well organized issues from giant shipbuilders. The government needs to open all channels to communicate with minority stakeholders.

< Equity and inclusiveness >

Equity and inclusiveness is deeply related with consensus. All stakeholders should feel that they have a stake in a matter and do not feel excluded from the mainstream of policy making. This necessitates that all groups, principally the weakest (small firms), have opportunities to express their interests.

< Accountability >

Accountability is the most important factor of good governance. Private sectors as well as government must be accountable. When it comes to building a policy, some stakeholders regard some issues as irrelevant matters. For example, the recent desperate situation of SM sized shipbuilders could be regarded as an irrelevant matter for large shipbuilders. From the perspective of national economic interest, losing competitiveness of small yards could affect the competitiveness of the whole shipbuilding industry according to the theory of learning by doing.

5.3.2 Good governance role for innovation system of Korean shipbuilding industry

Every stakeholder in Korean shipbuilding governance can agree that the leaders in the Korean shipbuilding industry are the giant shipbuilders. They have enough capability and capacity for closed innovation. They have competed in the global market to win contracts, which established the Korean shipbuilding industry as a global leader. In contrast to the impressive performance of the giant shipbuilders, SM shipbuilders and marine equipment manufacturers have not joined their prosperity.

As discussed in Chapter 2, there are limited instruments for the government to promote the shipbuilding industry; an R&D system could be the most potent measure for assistance of small sized firms as well as giant firms. However, as stated in the previous chapter, the scale of the R&D budget for the shipbuilding sector is relatively small compared with other major industry's contributions to the domestic economy.

First of all, all players in shipbuilding governance should strive to increase the pie for national R&D investment. For the purpose of expansion of the R&D budget in shipbuilding sector, every stakeholder should strive to promote public relations (PR). The total scale of R&D investment for the shipbuilding industry would come true through active PR aimed at other organizations such as the Ministry of Strategy and

Finance and National Assembly, where planning and approval of the national budget take place.

Secondly, it is necessary to build spin-off system of technology between large shipbuilders and small shipbuilders. The technological gaps are so wide and there are few opportunities to transfer advanced technologies to smaller yards. Therefore, shipbuilding governance should pay attention to transfers of ship technologies. Diffusion of technologies is linked with Open Innovation. It could be a chance for giant shipbuilders to earn new profit sources and for small firms to learn state-of-the art technologies as well.

Thirdly, more active participation by small yards and marine equipment manufacturers should be encouraged. They lack human resources, capital and networks. Compared with European manufacturers, Korean marine equipment manufacturers usually depend on domestic shipbuilders (ECORYS, 2009). When it comes to planning national R&D projects, more consideration of R&D grants to these industries is necessary to improve their global competitiveness.

Finally, more efficient collaborative works are necessary between MKE and MLTM. Those two ministries often make plans and invest in R&D activities independently for their own interests. At times they have competed to take the helm of the hegemony of the shipbuilding industry policy, which might not have contributed to the national interest. It is necessary to build up a regular dialogue channel for shipbuilding governance. Consequently, duplicated investment could be eradicated and positive synergy effect could be achieved.

6. Conclusion

The shipbuilding industry has an important role from the point of national security as well as from an economic view. Therefore, those countries that have lost competitiveness in commercial shipbuilding maintain naval shipbuilding facilities. Also, it can promote employment and contribute to gross domestic product. In Korea, ships and offshore structures comprise the top cash cow products and occupy 10% of national export receipts.

Currently, the global shipbuilding industry is facing a depression and Korean shipyards are not exceptional regardless of their business size. Credit crunch and financial crisis cause global trade to shrink and shipbuilders have to manage their businesses despite contracting shortage. Also, no one can assure how long the recession period will last. To make matters worse, ship prices have gone downward regardless of types of ships. Consequently, many countries have carried out large scale restructuring of shipyards.

As introduced in chapter 3, Porter insisted that sound planned environmental regulation could cause players to be more innovative and competitive. Today's green issues on reducing emissions could be applicable to the theory. Those issues encompass all sectors regardless of the nature of the business. Without exception, the shipbuilding industry is involved in the global GHG emission control regime by the adoption of EEDI. When looking at prior centuries, effective adoption of new technologies like welding or internal combustion engines could affect differentiation strategy. Accordingly, innovative technologies for improving fuel efficiency or reducing emissions could contribute to a shipbuilder's sustainable growth.

As discussed in previous chapters, the Korean government's role in the shipbuilding industry has become smaller because of the transition of socio-economic policy and constraint of global trade regimes like WTO. The Korean large shipbuilders are leading the world shipbuilding market while the SM sized shipbuilding related firms are exposed to a desperate condition. However, there are not so many options to

assist specific industries for the purpose of avoiding unnecessary trade conflicts. Therefore, a cooperative R&D scheme of shipbuilding governance is necessary from the point of view of national interest. Each stakeholder in Korean shipbuilding governance should support each other to sustain the competitiveness of shipbuilding industry of Korea within the limits of the market mechanism.

The Open Innovation paradigm could be applied to Korean shipbuilding governance. Some of the giant shipbuilders already apply the strategy taking the form of M&A or diversification such as wind turbines. However, there are not so many innovative technologies for energy efficiency from the perspective of measures for EEDI. Thus, giant shipbuilders in Korea should invest in more high risk R&D activities and government R&D programs should be planned to support those hard efforts. Fusion or benchmarking of other industries could be recommended for the purpose of innovative R&D activities.

On the other hand, SM sized shipbuilders or marine equipment manufacturers should be encouraged to gain the advanced technologies of giant shipbuilders. Losing competitiveness in the field of the SM sized shipbuilding market could lead giant shipbuilders to future risk because of the Learning- by-doing effect of other competitors like Chinese shipbuilders. The Technology transfer market between giant shipbuilders and SM shipbuilders should be more inspired. Also, it is necessary to take more consideration of R&D budget allocation for marine equipment manufacturers.

Finally, all stakeholders in Korean shipbuilding governance should keep an eye on national interests rather than a company's or organization's interest. Most industrial policies should be founded on the basis of transparency and accountability. Mutual agreed decision making in governance could make it possible to have long lasting competitiveness.

Through a partnered growth between giant and SM shipbuilders, the overall competitiveness of the Korean shipbuilding industry can be maintained. Furthermore,

employment and the regional economy could be managed effectively. As a result, contribution to national wealth can be sustained in the future.

This thesis does not cover all issues regarding environmental topics in the shipbuilding industry. For example, ship recycling, marine carbon capture and storage systems or marine renewable energy could be deeply related with both diversification and differentiation strategy for the Korean shipbuilding industry. Therefore, more comprehensive policy study should be performed to enhance green shipbuilding and the marine engineering sector in Korea.

References

Lexology. (2009, March 24). Retrieved August 20, 2012, from http://www.lexology.com/library/detail.aspx?g=af88c679-9613-46b1-9bb5-b57b86dc13e4

Second IMO GHG Study. (2009). Retrieved August 24, 2012, from IMO: http://www.imo.org/blast/blastDataHelper.asp?data_id=27795&filename=GHGStudyFINAL.pdf

Dynamic Comparative Advantage. (2012, September 3). Retrieved from http://www.stanford.edu/group/FRI/indonesia/documents/pambook/Output/chap28.html

Committee of Experts on Public Administration. (2006, March 27-31). *UN Economic and Social Council.* Retrieved August 13, 2012, from UN Public Administration Network: http://unpan1.un.org/intradoc/groups/public/documents/un/unpan022332.pdf

Altenburg, T. (2011). Turning the time 20 years back can solve EEDI problem within shipbuilding. *Danish Maritime Magazine,* 24.

Ambec, S., Cohen, M. A., Elgie, S., & Lanoie, P. (2011, January). *The Porter Hypothesis at 20.* Retrieved from Resources for the future: http://www.rff.org/Events/Pages/The-Porter-Hypothesis-After-20-Years-How-Can-Environmental-Regulation-Enhance-Innovation-and-Competitiveness.aspx

Bodansky, D. (1995). *The History of the Global Climate Change*. Retrieved July 2, 2012, from The Graduate Institute: http://graduateinstitute.ch/webdav/site/iheid/shared/iheid/800/luterbacher/luterbacher%20chapter%202%20102.pdf

Chesbrough, H. (2012, August 30). Retrieved from Open Innovation: http://www.emotools.es/static/upload/files/Openinnovationparadigm.pdf

Cho, D. (2006). *M Management.* Seoul: Han's Media.

Cho, D., & Porter, M. (1987). *Changing Global Industry Leadership: The case of shipbuilding.* Boston: Harvard Business School Press.

Choi, P., & Ryu, J. (2011, March 29). Retrieved June 18, 2012, from HSBC Global Research: http://www.research.hsbc.com/midas/Res/RDV?p=pdf&key=tpJr8381l0&n=294618.PDF

Clarkson Research Services. (2012, September). *World Shipyard Monitor*. Retrieved from Shipping Intelligence Network 2010: http://www.clarksons.net/sin2010/pdf/Default.aspx/world-shipyard-monitor

Commission, E. (2009, June 27). Retrieved from Official Journal of the European Union: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2009:147:0014:0018:EN:PDF

e4ships. (2012, August 24). Retrieved from e4ships: http://www.e4ships.de/e4ships-home.html

ECORYS. (2009, October 8). *Study on Competitiveness of the European Shipbuilding Industry.* Retrieved from http://ec.europa.eu/enterprise/sectors/maritime/files/fn97616_ecorys_final_report_on_shipbuilding_competitiveness_en.pdf

Ellingsen, H., Fet, A. M., & Aanondsen, S. (2002). *Tool for Environmental Efficient Ship Design.* Retrieved from NTNU: http://www.iot.ntnu.no/users/fet/Publi-Forfatterskap/publikasjoner/Ensus-ellingsen-fet-2002.pdf

Green Ship. (2012, August 29). Retrieved from Green Ship: http://www.greenship.org/

Hayman, B., Dogliani, M., Kvale, I., & Fet, A. M. (2000). *Technologies for reduced environmental impact from ships.* Retrieved from NTNU: http://www.iot.ntnu.no/users/fet/konferanser/2000-treship-newcastle.pdf

Hong, S.-I. (2011). *POSRI CHINDIA Quaterly.* Retrieved June 17, 2012, from POSCO Research Institute: http://www.posri.re.kr/eng/html/ChindiaQuarterly/chindiaQuarterlyList.asp?page=&mngCode=0005008&idx=&pubCode=&strIdR=&mngId=196

Hughes, O. E. (1998). *Public management and administration.* London: Macmillan press.

IMD. (2012, September 6). Retrieved from World Competitiveness Online: https://www.worldcompetitiveness.com/OnLine/App/Index.htm

IMO. (2011, October). *Main events in IMO's work on limitation and reduction of greenhouse gas emissions.* Retrieved August 24, 2012, from IMO: http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Documents/Main%20events%20IMO%20GHG%20work%20-%20October%202011%20final.pdf

Jones, R. S., & Yoo, B. (2012). *Achieving the "Low Carbon, Green Growth" Vision in Korea.* Retrieved from OECD: http://dx.doi.org/10.1787/5k97gkdc52jl-en

MEPC. (2011, July 15). *RESOLUTION MEPC.203(62).* Retrieved August 24, 2012, from IMO: http://www.imo.org/MediaCentre/HotTopics/GHG/Documents/eedi%20amendments%20RESOLUTION%20MEPC203%2062.pdf

Minami, Y., & Kawanami, Y. (2005). On the Research and Development of Super Eco-Ship Project. *Proceedings of the 5th International Offshore and Polar Engineering Conference*, 583.

NSTC. (2012, September 6). Retrieved from National Science and Technology Commision: http://sts.ntis.go.kr/lo/retrieve/retrieve.jsp?icode=DT_AAC0013

NYK Line. (2012, August 29). Retrieved from NYK Super Eco Ship 2030: http://www.nyk.com/english/csr/envi/ecoship/

OECD. (2012, May). *New Sources of Growth Knowledge-Based Capital Driving Investment and Productivity in the 21st Century.* Retrieved from OECD: http://www.oecd.org/sti/50498841.pdf

Pierre, J. (2000). *Debating Governance: Authority, Steering, and Democracy.* Oxford University Press.

Song , J.-a. (2012, January 9). *S Korean shipbuilders eye bid for GTT*. Retrieved from Finiancial Times: http://www.ft.com/intl/cms/s/0/0a0ab4da-3a9e-11e1-a756-00144feabdc0.html#axzz26eAnuimQ

Stopford, M. (2009). *Maritime Economics.* London: Routledge.

Sung, A. (2009, November). *Competition in the shipbuilding industry.* Retrieved from System Dynamics Society: http://www.systemdynamics.org/conferences/2010/proceed/papers/P1104.pdf

UNESCAP. (2012, September 7). *What is good governance?* Retrieved from UNESCAP:

http://www.unescap.org/pdd/prs/ProjectActivities/Ongoing/gg/governance.pdf

University of Tokyo. (2012, April 26). *Transportation Update: A Return to the Days of Sailing Ships the High-Tech Way.* Retrieved from 21st Century Tech Blog: http://www.21stcentech.com/transportation-update-return-days-sailing-ships-high-tech/

Wendy, F. E. (1997). *The Development of an International Agenda for Climate Change: Connecting Science to Policy.* Boston: Kennedy School of Government, Harvard University.

Won, D. H. (2010, June). *A study of Korean shipbuilder's strategy for sustainable growth.* Retrieved from MIT Libraries: http://dspace.mit.edu/handle/1721.1/59147

WTO. (n.d.). Retrieved August 21, 2012, from Agreement on subsides and countervailing measures: http://www.wto.org/english/docs_e/legal_e/24-scm.pdf

WTO. (2012). *List of disputes citing SCM agreement.* Retrieved August 20, 2012, from World Trade Organization: http://www.wto.org/english/tratop_e/dispu_e/cases_e/1pagesum_e/ds273sum_e.pdf

Yang, J. (2012). *Report on the small and medium size shipbuilding industry.* Seoul: The Export and Import Bank of Korea.

ZEMSHIPS. (2012, August 29). Retrieved from ZEMSHIPS: http://www.zemships.eu/en/index.php