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CONTENT

Figures and Tables

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ABSTRACT

Today, industry clusters play an important role in the global economic structure. A cluster is a geographic concentration of related companies, organizations, and institutions in a particular region. From a company's view, cluster helps to improve its productivity and competitiveness; from a nation's view, cluster can raise the economic performance and improve the progress of whole industry.

This thesis studies five industry cases in the world, it describes the development and performance of industry clusters in these countries, and by comparing different aspects of the clusters, the paper shows the similarities and differences of the clusters, especially it analyzes the challenges and risks in the clusters.

Industrial clusters have unique competitive advantage but also have potential challenge and risk. Because of the organizational structure of industrial cluster and geographic boundary, they limit the further development of the cluster. Creating boundaryless organization makes the main body of industrial clusters full of activity, and improves the flexibility of clusters and the adaptability to the change of the outer environment.

1. INTRODUCTION

1.1 Background

The word “global economy” is talked more and more in every business, companies can outsource almost everything, from every corner of the world. The distance seems no more a consideration in modern business. But we also can see the tendency that interconnected companies and institutions in a particular field are often have a geographic concentration, this organization of companies and institutions is called cluster.

At beginning, the researchers defined the cluster as “a group of industries connected by important flows of goods and services” (Czamanski and Ablas, 1979). They did not see the importance of geographical factor in the cluster. Later in the 1990s, Redman (1994) gave a new definition to cluster, he said that a cluster is a pronounced geographic concentration of production chains for one product or a range of similar products, as well as linked institutions that influence the competitiveness of these concentrations (e.g. education, infrastructure and research programs).

From the definitions, geographical factor plays an important role in the formation process of clusters, especially in some resource-based industry, for example the maritime industry is required to build near coast area. Geographical concentration plays a key role in the early stages of the life cycle of a product or technology, facilitating the use and transfer of tacit knowledge that is a key to successful development (Chiesa, 2005). But for other type of industry clusters, geographical factor may be not the significant one, Silicon Valley is a well-known electronics industry cluster, but why it is located in northern California rather than in northern New Jersey? By cases analysis we may find answers to these questions.

1.2 Scope

The scope of the thesis is to study five industrial cluster cases to find the issues, challenges and opportunities related to cluster. And analyze how the cluster enhance the industry performance.

Review related literature to identify drivers and trends in relation to Industrial clustering, and connect the knowledge to real industry cases. Furthermore, try to give recommendations regarding the better use of opportunities, and overcoming challenges.

The thesis will study five different industry cluster cases around world, three of them are in Norway, one is in China, and the other is a German cluster. The cases are related to marine, offshore, and aviation industry, study and compare those cases will help to explain why the clusters form and what the benefits, risks, and gaps related to performance enhancement.

1.3 Methodology

The study of cases is based on public materials, research reports, and gathered information. Five different industry cluster from three countries will be studied and analyzed, the study tries to find the common and different area of these cases. By study these areas, find the issues and challenges of industry cluster and provide possible recommendations.

1.4 Limitation

The limitation of the thesis focus on only five cases, of which covers over a limited area, thus the analysis result can not reflect a general situation. The cluster are in three countries, their industry environment are not identical, while the direct compare may not reflect the true difference between the clusters. Due to lack of data, the analysis of each case uses more description than data, thus the analysis is a qualitative analysis rather than a quantitative one.

1.5 Thesis Structure

The thesis consists five chapters. The first chapter in an introduction about the thesis to describe the background, the scope, and the detail of how to achieve the results. The second part is about the review of existing literature was performed to support the study undertaken in this thesis. The next two chapters are case introduction and case analysis, while the final chapter is summarize and conclusion of the study.

2. LITERATURE REVIEW

2.1 About Cluster

Cluster is a group of companies and institutions located in a specific geographic region and linked by providing a related group of products and services (Porter, 1990, Porter, 1998b, Porter, 1998a). From the definition, there are three key factors in the building of a cluster (Ketels and Memedovic, 2008). The first one is geography, the companies and institutions in the cluster are concentrated in a region, which create a physical connective environment for the industry. The second pillar is the same value chain, the companies and institutions may work in different areas, but they should be in the same value chain and contribute in the production of same products and services. The last one is the business environment. Here the environment means the actions from the cooperation of companies, government agencies, and research and education institutions in the cluster, the business environment affect the cluster's performance (Lundvall, 2009, Freeman, 1995).

Clusters can enable companies to leverage business environment quality to reach higher economic performance. Companies in strong clusters often have better chance to turn business environment advantages into competitive advantages. Clusters are to some degree also the result of the general business environment: they are more likely to emerge and develop fully in a strong overall business environment.

The form of a new cluster takes time, and there is no single model for the formation process. Some clusters develop from networks of small and medium size companies, while some may develop from a core company. The core company provides the launch pad for smaller supply companies, and attracts them to form a cluster. From the later cluster cases, the different formation process of industry cluster can be seen.

2.2 The Advantage of Cluster

In a survey report (Arif, 2012), it points out the importance of industrial clusters in developing countries. They not only create substantial survival-type employment opportunities in the manufacturing sector but also seed-beds for further industrial development by creating economies of agglomeration.

In general, three kinds of advantages were identified by Porter (1998a) in his paper, the first advantage is that clustering brings productivity advantages to industry. The cluster create a geographical concentration environment of related inputs (components or services). It minimized the cost in inventory and transaction, and also the joint purchasing services or shared infrastructures may reduce fixed costs for existing companies and initial investments for new ventures.

The second advantage is about knowledge and information transfer. Because the customers and suppliers are in the same or proximity industry, they share and transfer their knowledge and information more frequently and efficiently. Moreover, because of the proximity and transfer, it offers a strong potential for innovation, allowing critical mass to be gained, particularly for the basic research. Besides, the concentration of qualified labor can strongly improve the innovate capacity.

The third advantage brought by cluster is new market opportunities and potential can be generated due to the efficiency circulation of information, and the barriers and risks also will be lower for new companies.

Clusters have great potential. They generate enormous synergies through the exchange of knowledge across the boundaries of institutions, disciplines and technologies. Personal contacts as well as content-related and regional proximity in clusters accelerate technological development as well as the path to market maturity - turning ideas into internationally competitive products, technologies and services. Clusters are particularly suitable for long-term research strategies and the development of international partnerships. They offer ideal conditions for promoting young talent and starting up new companies.

Clusters are formed for many factors, even same industry clusters in different countries is formed in different factors, the following chapters will study two maritime industry clusters in Norway and China separately to discuss their formation process.

2.3 Stakeholder in Cluster Analysis

It has been proved by real numbers that the cluster is benefit to local economic development, so the cluster analysis is becoming important as well. However, cluster analysis has tended to be an expert-driven, "top-down" process that leaves stakeholders out of shaping the economic development priorities for their regions (Cortright, 2006). While someone argue that stakeholders can participate in even the most technical analyses to help shape the economic

According to Brun (2011), the analysis of industry cluster consists three distinctive phases: definition, identification, and activation. Cluster analysis has become an important part of state and local economic development planning because of its usefulness in guiding local area economic development policy.

Numerous cluster studies conducted at the national, state, and local levels now guide company recruitment, retention, and entrepreneurship promotion efforts by governments. Cluster analysis, however, has tended to be an expert-driven, " top-down" process that leaves stakeholders out of shaping the economic development priorities for their regions (Cortright, 2006).

2.4 From Company to Industry Cluster

In the resource-based view (RBV), it believes that the basis for competitive advantage lies primarily in the application of the firm's bundle of resources (Wernerfelt, 1984). Later in 1991, the RBV of the firm was prominent enough to warrant a special research forum in the Journal of Management edited by Jay B. Barney. The articles in this forum helped establish that resources and capabilities are important for understanding the sources of sustained competitive advantage for firms (Barney et al., 2011).

The resource and capacity consists tangible or intangible assets. The tangible assets could be natural resources, ideal location, capital assets, etc. While the intangible assets include a company's management skills, its organizational processes and routines, and the information and knowledge advantage.

Barney identified four attributes that firm's resources must possess in order to become a source of sustained competitive advantage. The system was called VRIN framework, which represent Valuable, Rare, Inimitable, and Non-substitutable (Barney, 1991). In 1995, he improved this system to VRIO framework (Barney, 1995), the difference is the "Organized" take place of "Non-substitutable".

- Valuable -- meaning that they must be a source of greater value, in terms of relative costs and benefits, than similar resources in competing firms.
- Rare -- rareness implies that the resource must be rare in the sense that it is scarce relative to demand for its use or what it produces.
- Inimitable -- it is difficult to imitate.
- Non-substitutable -- other different types of resources cannot be functional substitutes.
- Organized -- company must be organized to capture the value from resources.

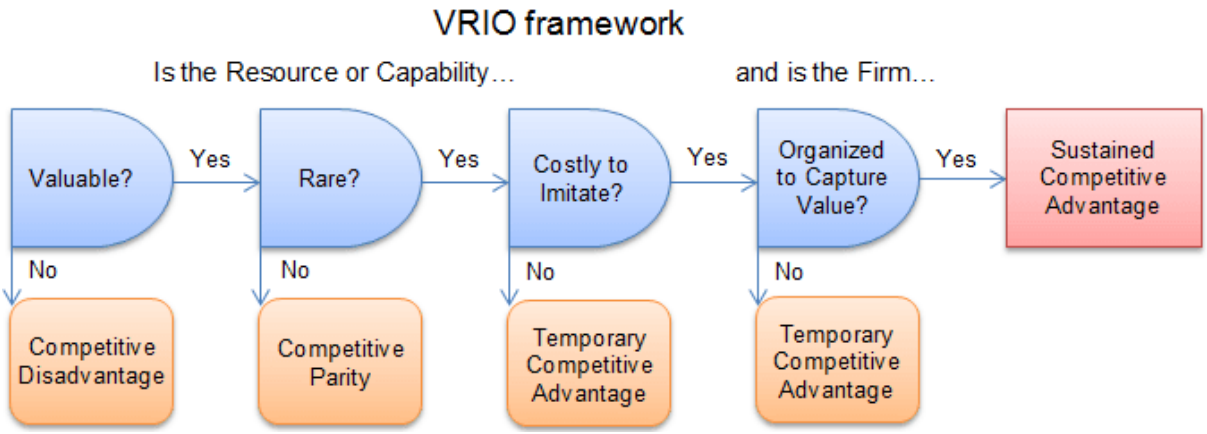

Figure 1. The VRIO Framework (Rothaermel, 2013)

The resources is the source of company's sustained competitive advantage, thus when the VRIO attributes have been identified, the first thing is to make the top management aware of such resource and suggest how it can be used to lower the costs or to differentiate the products and services. Then the next step is to find a way to make it more costly to imitate. If other companies won't be able to imitate a resource at reasonable prices, it will stay rare for much longer.

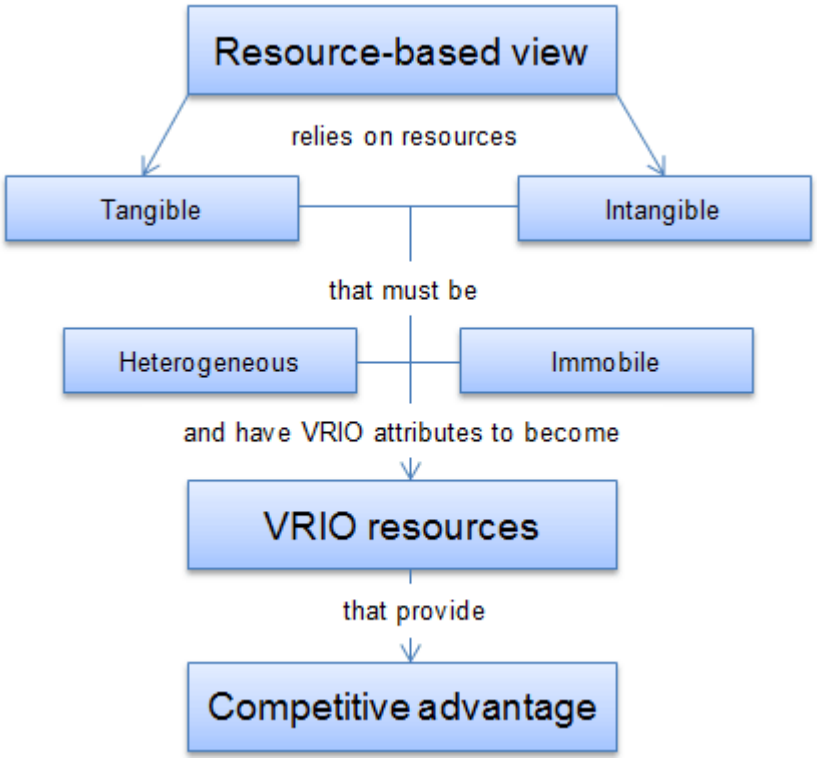

Figure 2. RBV and Key Points (Jurevicius, 2013a)

The competitive advantage brought by the resources help to build a strong company, as the cases will show, the natural geographic advantage in some cities help them to build world-class shipyards, but this is the first step to build a modern industry cluster. Ship building is a complex industry, it is impossible to cover the entire process by a single company. Figure 3 shows the value chain of modern industry.

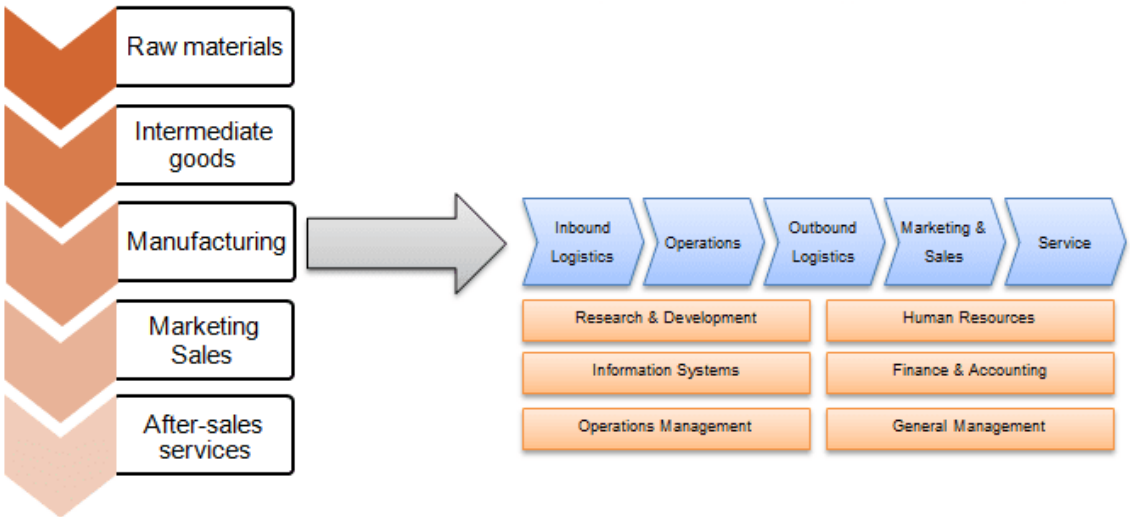

Figure 3. Industry Value Chain (Jurevicius, 2013b)

A value chain is a chain of activities that a firm operating in a specific industry performs in order to deliver a valuable product or service for the market (Porter, 1985). In the Figure 3, the left side is industry value chain, while the right side is the company level value chain.

Value chains can be organized in different ways, one of the most common way is "buyer- driven". The buyer-driven value chain refers to those industries in which larger retailers, marketers and branded manufacturers play the pivotal roles in setting up decentralized production networks in a variety of exporting countries (Gereffi, 1993).

The value chain is different with supply chain, which is also mentioned a lot in business. The value chain approach considers a broad market system and the development of products/services from input suppliers to end-market buyers. Essentially, the value chain focuses on the flow of a developmental process. It differs from a supply chain in its emphasis on creating value in each segment of the chain (USAID, 2008). Figure 4 can be a pictorial example to show the difference.

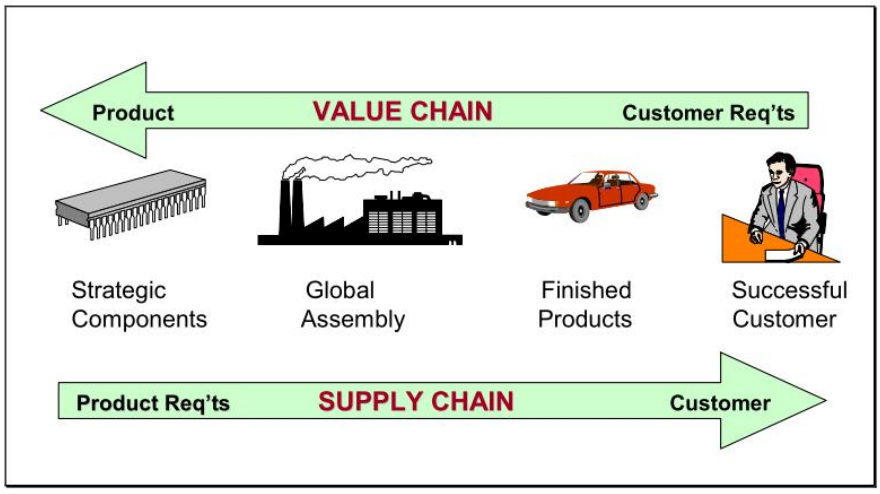

Figure 4. Value Chain and Supply Chain (Feller et al., 2006)

The two are difficult to separate in that most of their functions overlap. Both of them need transportation and storage. But both of them are important to the business. Without one or the other, we would simply be mired in a logistically impossible nightmare. The two key areas that value chain can play a crucial role are: (1) transforming relationships among stakeholders in value chains, especially between large and small producers, and (2) promoting a focus on end markets (USAID, 2008).

The cluster also considers as an industry value chain, only it focuses on geographic concentrations of interconnected companies and their interactions. They are both important ways to enhance the competitiveness of regions or industries. A cluster can be highly supportive to value chain, especially in transforming stakeholder relationships and value chain governance and in building trust among stakeholders.

Connolly (2002) summarized four elements that cluster has:

1. Core Businesses
2. Specialist Supporting Firms
3. Supporting Soft Infrastructure: research institution, education facility, etc.
4. Physical Infrastructure: transportation system, communication and power, etc.

A competitive company can be seen as the core business in the cluster, while specialist supporting firms and the supporting soft infrastructures together with the core business forms the entire value chain. At last, the physical infrastructure such as the transportation system reflect the advantage of geographic concentration. From this point of view, the cluster is an improved form of a value chain.

3. INDUSTRY CLUSTER CASES

3.1 Norwegian Maritime Cluster

3.1.1 Introduction

Norway is well known as its abundant resources of oil and gas under the North Sea, and it is believed that to meet the future food and energy needs, we need to both harvest new resources from the oceans, as well as to better utilize our marine resources.

On the west coast of Norway, there is maritime cluster which is a world leader in designing, building, equipping and operating the world´s most advanced vessels for the global industry. According to NCE (Norwegian Centre of Expertise), this cluster is formed by 14 design companies, 14 ship yards, 18 ship owner companies and nearly 200 ship-related equipment suppliers. About 22,500 employees work in this cluster, and it runs 40 percent of the world's modern fleet. Maybe some of the above number were not so expressed, but considering the fact of the population in Norway is only 500 million, we have to say this is an outstanding achievement.

3.1.2 Cluster Status

The maritime industry cluster on the west coast of Norway is a world's leader in designing, building, supplying and operating the largest and most advanced vessels for the oil industry. It composed of three main groups; shipping, maritime services and ship industry.

The structure of the cluster is as shown on the Figure 5. The three main groups are surrounded by facilitating associations, educational & research institutions and political bodies.

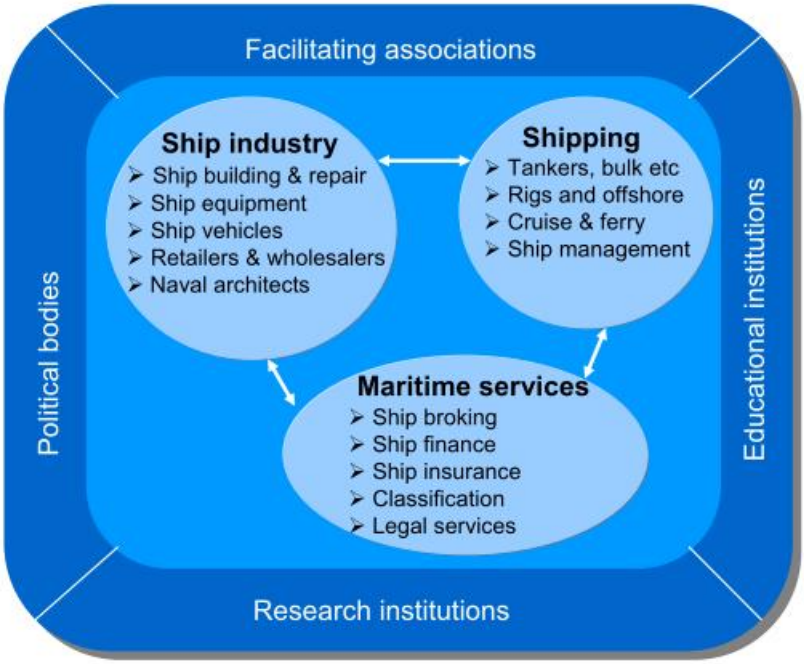

Figure 5. Structure Norwegian Maritime Cluster (Wijnolst, 2006)

Among these three groups, shipping is the largest one. The shipping group is the ship owners and operators. The fleets consists almost all kinds of vessels, such as oil tankers, bulk carriers, container ships, gas carriers, cruise ships and ferries. And because of the well-known oil and gas industry in North Sea, there are a number of offshore drilling rigs and support vessels in this group. There are some leading companies based on Norway, Wallenius Wilhelmsen is the world's largest transporter of cars, Teekay Navion Shuttle Tankers is the leading operator of shuttle tankers, SeaDrill is one of the largest rig drilling company, and Farstad is the leading offshore supply company (Wijnolst, 2006).

The shipping group is also the core of the maritime industry cluster. Not only because it is the largest one, but also it is the most international one. The shipping requires goods and services from others in the cluster, hence stimulating continuous innovation in the entire cluster.

Maritime services can be seen as the most complex part in the cluster. The maritime industry cluster in Norway can provide all kinds of services in the value chains of maritime industry. Major services include technic support, ship financing, ship insurance, broker, legal services and ship classification.

Ship financing is a vital and knowledge intensive activity, while Norway is one of the largest ship financers of the world. The three biggest bank, DnB, NOR and Nordea, are among the leading ship financers of the world, and both have increased their market shares in recent years. Take Nordea as an example, Nordea's shipping division is the largest arranger of syndicated loans to the shipping, offshore and oil services industries globally. They have branch offices all over the world, according to their latest Fact Book, the total lending in the shipping, offshore and oil services is 10.7 billion Euro (Nordea, 2014).

Another major service is ship insurance. Skuld, one of the leading insurance companies of the world in Norway, has a branch specialized in this area called Skuld 1897. It is an innovative and service-driven provider of marine and energy insurance with clients all over the world. The maritime cluster in Norway is a fundamental and stable basis for maintaining and developing insurance products and services that are demanded by both domestic and international clients.

Ship brokers provide services in four markets: freight, sale and purchase, new building and demolition. They are the linkage between ship sellers and buyers, ship owners and ship yards. Nearly 200 broker companies in Oslo, while the two largest ship broker companies in Norway are Fearnleys and R.S Platou. Fearnleys is also the second largest ship broker company in the world after Clarksons. It specializes in providing its clientele with sound business advice, innovative solutions to a broad spectra of commercial problems, professional execution of all manner of transactions, and full access to shipping markets. Besides brokerage services, Fearnleys also provides other professional services such as strategic advice, logistical support and market research and consultancy services.

Ship Classification is a system for safeguarding life, property and the environment at sea. It entails verification against a set of requirements during design, construction and operation of ships and offshore units. DNV (Det Norske Veritas) is one of the oldest and most important actors in Norway maritime industry cluster, over 80% of the Norwegian fleet is registered with DNV.

DNV was one of the five largest ship classification companies of the world. In 12 September 2013, DNV and GL (Germanischer Lloyd) have merged to form DNV GL, now it is the world's largest ship and offshore classification society, the leading technical advisor to the global oil and gas industry, and a leading expert for the energy value chain including renewables and energy efficiency.

Legal services related to maritime include charter parties, shipbuilding, finance, commodities, energy, insurance, cargo, collision, salvage, general average and pollution. Norway has a world best academic milieus of maritime legal, the Department of Maritime Law at The University of Oslo, and two strong players in this area, Wikborg-Rein and Nordisk Skibsrederforening (Nordic Defence Club).

Ship building industry is the third major group in the cluster. For the historical reason, Norway has a long tradition in ship building along the long coastline. Because of lack of labor force and other reasons, there are not as many shipyards as in other countries today, but the yards in Norway are more specialized.

Most of the yards are running by a local company Aker Solutions, which is a giant company with over 28,000 employees. As this paper is written, Aker Solutions announces that Aker Solutions will split into two companies to speed up a streamlining process that will reduce costs and better position all parts of the group to meet the needs of customers in an increasingly competitive global energy industry. The Subsea, Umbilical, Engineering and Maintenance, Modifications and Operations (MMO) areas will form a new company under the Aker Solutions name, while the other units, including Drilling Technologies, Aker Oilfield Services and Process Systems, will be developed independently as part of a new oil-services investment company, named Akastor.

As for ship equipment, there are suppliers in variety areas in Norway, such as engines, propulsion, pump, navigation system, paining, and positioning system, which is quite useful in the offshore vessels. The famous names among them include Rolls Royce, Frank Mohn, and Kongsberg.

3.1.3 Formation of Cluster

For centuries, Norway has always been a nation that has lived off the resources of the sea, from fishing to the modern oil and gas industry. Norway has a coastline as long as 85,000 km with a lot of nature harbor. The maritime industry cluster is just located at west coast city Møre, which is an ideal place to develop maritime industry.

Figure 6. Location of Norwegian Maritime Cluster

Throughout history, because of the geographical characteristics, the long coastline together with climatic factors has made the country extremely well suited for fishery industry, it has been a major industry in Norway. The role of fishery industry in Norway's national economy can be shown on the Table 1. The numbers come from the Organization for Economic Co-operation and Development (OCED), due to the rise of oil and gas industry from 1960s and the fall of whaling industry, the figure shows a dropping tendency after that time.

Year	Per cent
1930	5.7
1939	2.3
1950	3.7
1960	2.2
1970	1.6
1980	0.8
1989	0.5
2002	0.7

Table 1. Fisheries Contribution to GNP of Norway

Long coastline and rocky inland, makes the ancient Norwegian people choosing boat for travelling, and also transport the nature resources, such as fish and wood, oil and gas in nowadays, also create a demand for ships. This demand led to the building of a large fleets which pushes the development of maritime industry.

Norway is a relatively small nation with 5 million population, which means there is a limited domestic market and work force. According to the Confederation of Norwegian Enterprise (NHO) 99.5 % of all enterprises in Norway are small and medium-sized enterprises. One reason of this phenomenon and also a disadvantage of being a small nation is the problem of employment shortage.

According to a report (Reuters, 2012), an analysis report commissioned by the oil ministry says that the main constraint of the industry is the lack of qualified personnel, particularly experienced engineers. From the report, the record high investment in oil and gas industry create high demand of skilled engineers, which could rise 40 percent in 2011-2016, and lack of supply could create a shortage of up to 8,000 engineers. And 84 percent of surveyed firms suffer from skill shortage.

Another way showing the importance is the ratio of foreign workers in the sector rose to 10 percent by 2010 from just 6 percent in 2003. Therefore, the globalization provides a measure to the industry to deal with this situation. They establish engineering bases overseas and introduce talent engineers to their main offices in Norway. This measure greatly relieve the work force pressure and lay the foundation of a modern maritime industry.

Smaller and medium-sized enterprises usually means they are more flexible and agile than those big ones, and they also contribute great innovation and creativity to the industry. But, on the other hand, the globalization also brings challenges, compare to those big and giant enterprises, the small businesses find it difficult to keeping up in the modern competition environment. There is an old Chinese saying goes, it is easy to break one chopstick, but hard to bread ten. To compete with the giant ones in the industry, they have to work together as a cluster. From this point of view, the situation pushes these smaller and medium-sized enterprises forming a cluster, so that they can survive and compete with the giant enterprises.

Another factor of formation of the maritime cluster is the industrial environment of the country. This country has some of the world's leading ship owners, shipping firms, yards and ship equipment firms and a whole range of specialized maritime services. Oslo and Bergen have their strengths on the commercial side of shipping, while Oslo also is home for the global leaders in ship finance, insurance, brokers and law, as well as being headquarter for such global maritime actors as DNV GL and Aker Solutions.

Norwegian West Coast is the production base with the leading yards, ship equipment industry and offshore firms. Another maritime technology node can be found at Kongsberg and Horten, including lead positions in maritime IT. DNV GL provides ship classification and technical services at the highest international level, and Marintek and NTNU offer maritime research and development that helps the maritime industry to keep its technological edge.

3.2 Norwegian Systems Engineering Cluster

3.2.1 Introduction

A complex system consists of a number of subsystems and components that interact and collectively achieve the desired performance. Systems Engineering is the bridge between various traditional engineering disciplines. It provides methods and techniques to integrate design and functionality work across disciplinary and organizational boundaries.

Systems Engineering focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem.

Like the Maritime Cluster in previous chapter, they are all the cluster under Norwegian Centers of Expertise Program (NCE). The NCE is established to enhance sustainable innovation and internationalization processes in the most dynamic and growth-oriented Norwegian clusters.

The NCE Program is jointly owned and implemented by the three main Norwegian innovation agencies: Innovation Norway, the Research Council of Norway and SIVA, with Innovation Norway having the main responsibility. The program was launched in 2006, and funded by two ministries: the Ministry of Trade and Industry and the Ministry of Local Government and Regional Development.

The Norwegian Systems Engineering Cluster is located in Kongsberg, the home to a world class expertise cluster. The cluster is formed by the group of global technology companies in Kongsberg. These companies cover a range of different industries, from maritime, subsea, energy and oil technology to defense, automotive, air and aerospace.

Figure 7. Major Members in Norwegian Systems Engineering Cluster

The main task of NCE Systems Engineering is to strengthen the industrial expertise cluster through enhanced technical collaboration, common commitment to innovation, joint research projects, shared skills development and inter-company collaboration within and outside the cluster. Sound cluster values enhance synergistic effects between enterprises and between industries.

The work is intended to lead to increased synergy between the companies and to contribute to making the cluster into one of the most attractive in the world for development and industrialization of high technology products and systems. NCE SE is also the driving force for increasing the attractiveness of the local area and the region and for ensuring good, competitive Norwegian framework conditions. The aim is to make it attractive for global investors to invest here in the future.

3.2.2 Cluster Structure

The structure of Norwegian Systems Engineering Cluster consists three parts: members, business partners, and development partners. They list is not fixed, it changes every year.

Currently, there are fourteen members in this cluster: Data Respons Norge, ibruk, Industriell Dokumentasjon, K-Tech, Kongsberg Esco, Kongsberg Target Systems, Servi Hydranor, Sparebank 1 Kongsberg, Visual Garden, Berget, NoPro, Notodden Technology Group, Oswo, and Techni.

There are eight business partners and another eight development partners in 2014, the cluster has decided not to require annual fees or upfront payment from the companies, but tied their resource contributions to defined activities to ensure that activities are in accordance with corporate needs and requirements.

From the member of the cluster and the way it works, we can see that unlike other industry cluster, this cluster's business is solely based on brain power and leadership positions in many industries, this helps to make the cluster robust.

NCE Systems Engineering has chosen to organize the work into four sub-projects:

- Knowledge development
- New businesses
- Supplier development
- Collaborative projects within and outside the cluster

Knowledge development

The cluster and Buskerud and Vestfold University College (HBV) have built up the Norwegian Institute for Systems Engineering (NISE). They recruit talented professional form university and enterprises to offer the enterprises cutting-edge expertise and contribute to their R&D projects. At the same time, they help ensure that instruction is even more relevant for industry.

The NISE reference group was set up to work with the development of a master's degree program in Systems Engineering with subsea as an in-depth specialization option. The industrial participants work with the professional staff at NISE to develop the program for the course.

NISE recruited several new industrial partners for the master's program in Systems Engineering in 2013, and now has partners all over south-eastern Norway. All the enterprises take part in an Industry Advisory Board to ensure the educational programs are of relevance to them.

There is a research project entitled Knowledge-based Development (KBD) involves four enterprises, Kongsberg Automotive, FMC Technologies, KONGSBERG and Kongsberg Devotek, along with HBV and NTNU. These enterprises operate in completely different markets and industries, so their cooperation can be open.

The project has attracted leading international experts and researchers, each of whom has furnished a piece of this formidable puzzle. Long-term business activities have been actively adapted to the new insight generated.

So far, this project shows positive results, their exchange of lessons learned enhances the efficiency and competitiveness of the enterprises. According to the Project Manager Frode I. Bergan, the enterprises in the KBD project have gained insight into Lean Product Development and Knowledge Management principles that are on the cutting edge of product development research today. Knowledge transfer between the enterprises also improves the efficiency of development processes.

The research shows that the new knowledge can be systematized, and made less person-specific and easier to share with others. And another result of the project is that two new master's degree courses have been developed at HBV: Lean Product Development and Knowledge Management.

New businesses

The cluster continues to focus on innovation to encourage enterprises in the field of energy and energy efficient systems. As one of the partners in the cluster, Kongsberg Innovasjon (KI) is responsible for the new businesses project.

The company is experiencing a favorable development trend in the volume of projects, and it has been contacted by entrepreneurs and innovation projects from all over the world. KI acts as a clutch between start-up enterprises and projects and industrial expertise from leading international technology enterprises. This enhances the value creation potential of the new business, accelerating their market penetration and making them more international.

In the past a few year, this project has successfully established some promising projects. For example, KI has established ownership in a new venture named Kongsberg Cable Systems. The company is based on technology developed in Germany and Switzerland, and represents a new intervention cable to monitor, control, maintain and optimize production in oil wells. By drawing on the expertise of oil companies and sub- sea systems suppliers, KI could quickly verify that there is a market potential for this kind of solution. Efforts are now being made to further develop the concept and to secure funding.

Angle Wind is another KI's project which works on developing new drive line solutions for windmills. They have developed a unique gearbox concept that has fewer parts, gives high gear ratios and is more robust and cost-effective than present day gearbox systems. The technology will lead to windmills becoming more reliable. KI act as development partner in this project, provides expertise from the industries in Kongsberg.

Supplier development

The Supplier Development Project (SDP) is designed to improve the enterprises' long-term competitiveness. As we all know that modern companies are competing with each other on global market. With the knowledge explosion and globalization, whole value chains face keener competition from all over the world and suppliers are required to maintain strict new standards.

SDP is a neutral facilitator that helps initiate improvement processes and brings together relevant networks. It focus on knowledge-based initiatives that will strengthen value chains and competitiveness. Specifically, the cluster focus on the development of regional subcontractors through specialist seminars, development projects and human resource development projects. The work raises the level of knowledge in enterprises, and improves communications and the ability to cooperate between suppliers and customers.

The cluster addressed two topics these years, Visual Management (VSM) and Corporate Social Responsibility (CSR). Enterprises that operate in the defense and oil and gas industry devote special attention to Corporate Social Responsibility (CSR) and have their own programs.

Along with the enterprises and Innovation Norway, NCE SE has organized CSR training initiatives among selected SMEs. SDP has also taken the initiative to develop courses, and collaborates with K-Tech and the National Institute of Technology in Norway. More and more enterprises in the cluster would like to be coached because the participants recognize the value of being observed by an independent party. The coaching project involves senior resource persons with long experience of industry in Kongsberg sharing their expertise and networks.

The project is being implemented in collaboration with VRI Buskerud (policy instruments for regional R&D and innovation), Innovation Norway, the Kongsberg region, the Kongsberg Chamber of Commerce, Buskerud and Vestfold University College and Notodden Development.

Collaborative projects within and outside the cluster

NCE SE helps facilitate new collaborative projects through networking between different players inside and outside the cluster. NCE SE and the technology clusters along the south coast of Norway and in Møre and Raufoss have joined forces with Buskerud and Vestfold University College, the University of Agder, Aalesund University College and Gjøvik University College to establish the Norwegian Industrial Cluster (NIC). Cooperation will strengthen global competitiveness and the development of the regions' expertise.

NCE SE together with the about mentioned organizations host a series conferences, forums and meetings, such as Technology Days, Korea and Kongsberg (K2K), Knowledge-based Development Forum Norway, etc.

Industrial enterprises in Kongsberg have played a central part in Norwegian industrial history. Originating with the munitions industry, the cluster developed into a knowledge industry based on advanced technology. Today, several of the companies are global market leaders in the automotive, aircraft, energy, maritime, defense, subsea and aerospace industries.

3.3 Norwegian Offshore & Drilling Engineering Cluster

3.3.1 Introduction

Norwegian Offshore & Drilling Engineering (NODE) is a business cluster of over 50 companies within the oil and gas industry in southern Norway. Like the Kongsberg Systems Engineering Cluster, NODE is also a member under NCE. The purpose of NODE is to assist in assuring that the oil and gas industry in southern Norway will maintain its globally leading position regardless of outside competition.

The oil and gas industry in southern Norway was one of the pioneers in the development of the Norwegian continental shelf. In 1972, the then Minister for Industry, Sverre Walther Rostoft, took the initiative to found Oil Industry Services A/S, which became Norway's first umbrella company for commissions in this new industry. This means that we have many years of experience of working in networks.

The offshore industry in southern Norway represents a strongly industrial environment. A high level of intercompany competition, interaction with demanding oil and gas clients as well as strict governmental requirements have resulted in the fact that several of the companies have gained a unique market position in each of their segments.

The companies within the NODE cluster took a generation to create workplaces for the first 1,800 and revenues of the first NOK 5 billion. Today, the 58 companies can count around 10,000 employees and have annual revenues of between NOK 40 and 45 billion.

3.3.2 Cluster Structure

The 58 companies in NODE cluster are world-leading with significant global market shares, they have enjoyed great commercial success due to their technical expertise and high-quality products. These companies are suppliers in four areas: offshore drilling, offshore loading and offloading, as well as anchorage systems, active heave compensated cranes and complete platform solutions.

Offshore Drilling

Among the member in the cluster, Aker Solution, National Oilwell Varco Norway are drilling equipment suppliers, they are able to supply the complete drilling system to customers. TTS-Sense has grown significantly these years and is the third company in this area now. While AS NYMO designs, builds and transports complete drill rigs.

The companies in NODE can handle the entire drilling process, including mud handling and material controls. Advanced skills in ICT process information from the well to optimize the drilling process. Drilling equipment has developed from simple machines to automated systems. Pictures from the drill bit are analyzed and the results determine how the drilling will be done.

Offshore Loading and Offloading and Anchoring Equipment

National Oilwell Varco and Aker Solutions in Arendal aslo supply complete systems for loading and unloading hydrocarbons. The systems transfer oil and gas from the seabed to a buoy, ship or platform. The advanced equipment fulfils the requirements for zero emissions. Additionally, the companies supply advanced anchoring systems for platforms and ships, ensuring stable positioning during harsh weather conditions, which is very important to offshore activities.

Active heave cranes

In the cluster, National Oilwell Varco and Cargotec are the two main suppliers of advanced cranes that hold heavy loads steady in relation to the seabed, whilst the crane/vessel is moving on the surface. They both provide industrial solutions to perform lifting operations at depths greater than 3,000 meters.

Complete platform solutions

Sevan Marine builds, owns and operates floating production solutions for oil and gas (FPSO). The company has developed a cylinder-shaped floating rig for tough seas and weather conditions, conforming to strict environmental requirements.

From the above shore introduction, we can see that National Oilwell Varco and Aker Solutions both have an important roles. The two companies have long history in the cluster, the Figure 8 shows their development history.

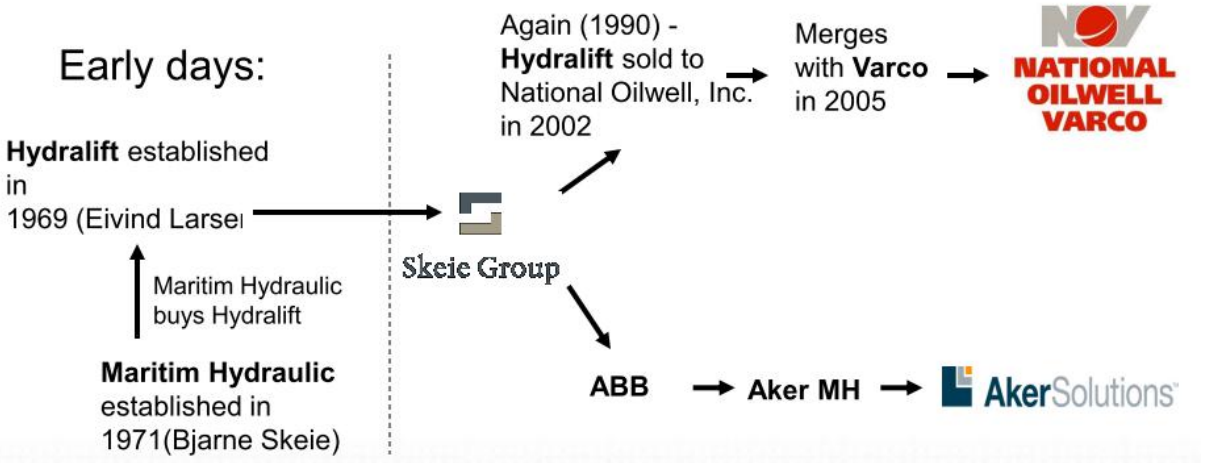

Figure 8. History of National Oilwell Varco and Aker Solutions

3.3.3 Cluster Formation

Southern Norwegian businesses have been involved as suppliers to the oil and gas industry since early in the 1970s, the time when oil was found under North Sea. Back that time, Norway was not so well-known, not even mention the southern Norwegian city Kristiansand. Many companies found that the region was not heard, and that the only way to carry on business was to move to Stavanger.

At that time, the CEO of Aker MH (Aker Solutions) once said " We are more well known in Houston as being world leading than in Norway." From the words, we can see the embarrass position of the companies in southern Norway, they delivered their products and services to the oil and gas industry without any form of cooperation. They had no influence on the surrounding community, no effect on the university colleges in the region and no communication with the authorities.

In 2004 a group of industry leaders from southern Norway began to discuss the need for collaboration. Because they understand if they want to complete with other companies in the world market, they have to unite to improve their competence.

These discussions also focused attention on the challenges connected with collaboration, since many of the companies wished to collaborate in spite of the fact that they were competitors in the same market, they also had to compete with each other first.

More and more companies were interesting in these discussions, when the pilot project was established in 2005, 29 companies were involved. And at that moment, the cluster had 1800 employees with sales of NOK 5 billion. The industry center in southern Norway had shaped. In addition, the government ministries were willing to listen to them.

However, the companies in southern Norway have competed with each other for many years, and they are not immediately prepared to cooperate or see the purpose of cooperating. It took more than a year to find a functioning form, and a good deal of time was spent initially in bringing together the biggest companies for discussions.

The NODE has defined certain guidelines to make collaboration possible. The collaboration is not only involve the big companies, but also have the small company with less than ten employees. For those small companies, the chance to meet with other managers in the cluster is an advantage to build an industry-wide network. Although the collaboration is not regarding finance and earnings, the relationship building has been important and beneficial to every member in the cluster.

The industry has been brought together and that they are able to benefit from the region's potential, i.e. the benefit brought by the mode of industry cluster. Although, the purpose of the collaboration is not to affect the companies' earning, it still gives the industry a boost. When the cluster was shaped in 2005, the industry had 1800 employees and sales of NOK 5 billion, while after four years, in 2009 there were 6500 employees and the sales went up to NOK 41.7 billion.

The growth of the industry means that the region becomes more attractive both for companies and for job applicants. The collaboration was not only carried out between the companies, but also involving the education institutions. The engineers from NODE companies sat down together and created a needs-related curriculum for the bachelor's degree at the University of Agder.

At beginning, there were 20 study place for application, but only half of them were taken. Then they revised the curriculum and the new curriculum was adapted to the companies. The study program was expanded to accommodate 90 study places. A master's study program was gradually established in the same way, and finally a doctorate degree as well.

The cooperation between the university and the companies is very close. Company managers take part in teaching, students can write their papers based on challenges in the industry, and Aker Solutions and National Oilwell Varco made part-time positions available to accommodate qualified professors from Australia and Germany.

The close cooperation helps to allow the companies to access qualified manpower, which is a guarantee that the studies are always up-to-date in terms of the absolute latest in technology. NODE also expand the cooperation to worldwide, the cooperation with universities in locations such as Australia, Sweden and Finland is also a part of the further development of already unique expertise.

3.4 Shanghai Ship Building Cluster

3.4.1 Introduction

Back at the end of last century, the ship building industry was not as prosperous as now. According to government figure, the number of accomplished shipbuilding output in 2000 to 2002 of China was 2.24 million, 3.92 million, and 4.61 million tons respectively. Compare with the neighbor countries, South Korea and Japan, the same number was 12.23 million and 12.02 million (Yonghong and Junwen, 2006). The gaps between them was so huge.

While in the later years, the ship building industry of China had a rapid expansion. Figure 9 shows the trends of the development. Note that the export take the major part in the ship building industry of China.

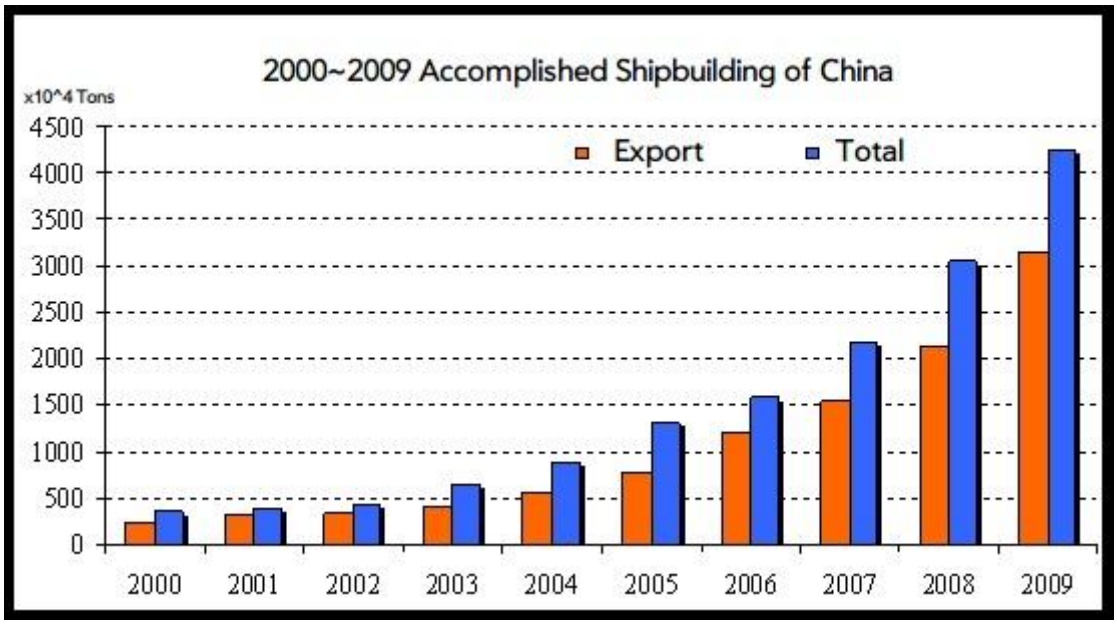

Figure 9. Shipbuilding Data of China

According to Clarkson Research Studies, the share of ship building market of China, South Korea and Japan in 2009 is as shown in Table 2. By 2009, the China shipbuilding industry overtake Japan's place and almost catch up with South Korea.

Accomplished Shipbuilding Deadweight 2009				
Country	World	Korea	Japan	China
Tons(x10^4)	12203	4387	2899	4243
Per cent (%)	100	35.9	23.8	34.8

Table 2. Accomplished Shipbuilding Deadweight of China in 2009

There are reasons why China shipbuilding industry develop so rapidly, one of them must be the efficiency brought by the industry cluster. China is the third largest country in the world, and the land area is way larger than Korea and Japan, hence there are some cities and areas in China have separated and completed shipbuilding industry cluster of their own. Among them, the cluster in the Yangtze River Delta is the largest one, the Table 3 shows the main factors' share of Yangtze River Delta to nation (Wenwei, 2011).

Year	Accomplished Shipbuilding Output	Newly Undertook Orders	Orders in Hand
2002	52.40%	78.40%	62.70%
2003	61.00%	68.40%	67.20%
2004	59.30%	51.20%	61.10%
2005	62.90%	67.60%	63.70%
2006	68.70%	74.70%	65.50%
2007	66.20%	68.50%	70.70%
2008	70.20%	64.10%	68.30%
2009	73.80%	77.40%	69.50%

Table 3. Share of Shipbuilding of Yangtze River Delta

Yangtze River Delta is a plain area at the connection of Yangtze River and the East China Sea, the Yangtze River Delta metropolitan region refers to 16 cities in Shanghai, southern Jiangsu, eastern and northern Zhejiang, including Shanghai, Nanjing, Suzhou, Wuxi, Changzhou, Yangzhou, Zhenjiang, Nantong, Taizhou, Hangzhou, Ningbo, Huzhou, Jiaxing, Shaoxing, Zhoushan and Taizhou, of which Taizhou was being included as part of the Yangtze River Delta metropolitan region starting from August 2003.

The Yangtze River Delta only covers an area of 110,915 sq.km, about 1.1% of China's total land area. However, its total population at the end of 2011 stood at 108.6 million, accounting for about 8.1% of China's total. Yangtze River Delta's Gross domestic product (GDP) reached RMB 8,214 billion in 2011, representing 17.4% of the whole China economy. The Yangtze River Delta is an important economic powerhouse of the Chinese mainland, with Shanghai being China's financial and logistics center, and Zhejiang and Jiangsu important manufacturing bases.

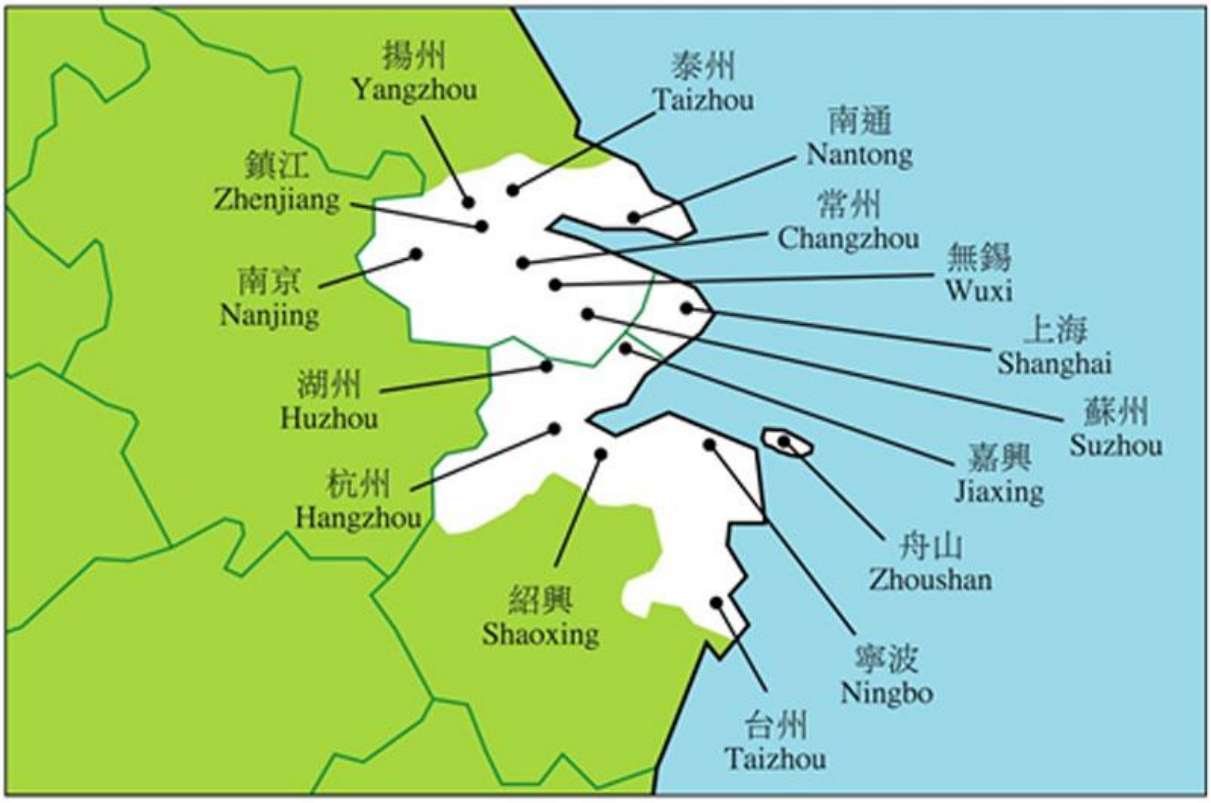

Figure 10. Location of Yangtze River Delta

3.4.2 Cluster Structure

Because of the geographic advantage, there were hundreds of ship building companies gathered in the Yangtze River Delta, especially in Shanghai City, Nantong City, and Zhoushan City. Among these companies, a part of these ship building companies are relatively small in the industry, but still there are some famous companies, such as Jiangnan Shipyard Group Co., Ltd, Shanghai Waigaoqiao Shipbuilding Co., Ltd, and which has built the first LNG carrier in China, Hudong-Zhonghua Shipbuilding (Group) Co., Ltd.

The three mentioned companies are state-owned, and there also are some similar size of enterprises, which are not fully state-owned, but government do have more or less a part of share in it. This phenomenon indicates that the government play a special role in this business, and it has significant influence on the developing of the industry.

Besides the shipbuilding industry, ship machinery industry is also important in the cluster. Two biggest ship main engine manufactures in China are located in Shanghai, Hudong Heavy Machinery Co., Ltd and CSSC-MES Diesel Co., Ltd, the two giant produce almost half of ship main engines every year in China. Yuecheng Town in Jiangsu Province is the world largest glass fiber manufactory base, it produce marine life boats, rescue boat, and other lifesaving appliance, and the products can be easily delivery to the shipyard by the road or water transportation network.

Some of the oldest marine research institutions are located in the Yangtze River Delta, the 704, 708, 711, and 719 research institution. These named by number institution were founded by government shortly after the found of China. At first they were used for military purpose only, but in the 1980s they began to expand their business into civil ships. Shanghai Jiao Tong University, one of the top-ten university in China, plays a vital role in China ship research area, and provides technic support to the ship industry.

3.4.3 Formation of Cluster

To discuss the formation process of the shipbuilding cluster in the Yangtze River Delta, the first thing to study the shipbuilding industry itself. To build a ship, a shipyard nearby river or ocean is necessary. From the above map, we can see that the Yangtze River Delta has a nature geographic advantage compare to other areas. The three provinces locate at the end of the longest river of China, face to the East China Sea, it is easier to find idea locations there to build shipyard. Besides, the paint landform create an environment of convenient transportation. This also create a basis for another two necessary requirements for forming a shipbuilding cluster: labor and capital.

Maritime industry is a labor intensive industry even in today, no matter how high the level of mechanical automation is, there still a lot work need experienced worked to do on site. Because of some policy benefits, the Yangtze River Delta develop much faster than other areas in China, people form inland provinces come to here to find a job. The figures in the previous chapter shows in the 1.1% area of China gathered 8.1% of Chinese population, and the number is still increasing.–The huge population gives a constantly sufficient labor force to the shipbuilding industry.

Regarding to the capital issue, it is obvious that the infrastructure of a shipyard cost billions of money, but maintain the cash flow during a project activation is not an easy task. Based on the China Shipping Database, the price of a common new building Panamax size dry cargo bulk carrier is list on Figure 11.

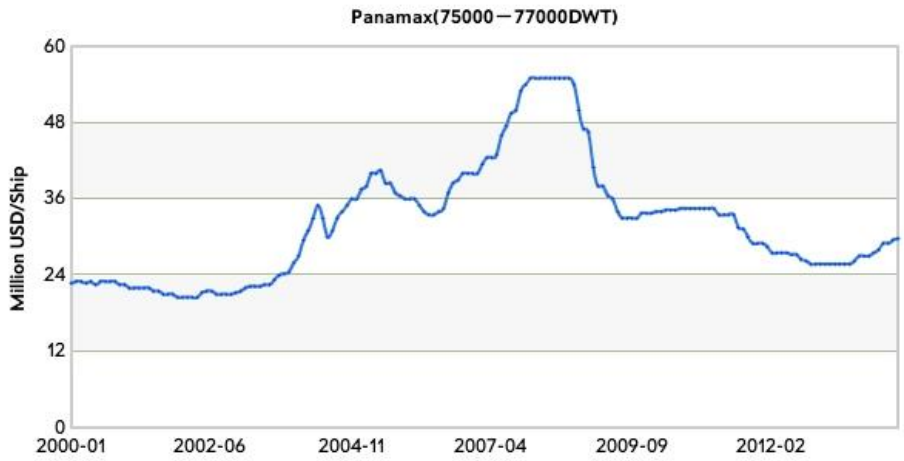

Figure 11. Price of Panamax Bulk Carrier

From the chart, we can see the lowest price is about 20 million dollars, and the price reaches the highest point at 2008, while it has a dramatically drop after that. And similar tendency also can be seen on the price of tanker and container ship.

About how rich the people there is, I have an example to show. In 2008, when the shipping building market was on the highest point, I was working on a project of 6450 DWT (Deadweight tonnage) oil tanker. What makes this project different was there was no "owner" of this ship. Normally when a project is activated, there should be an owner who has been approved to have enough capital to build this ship, and the first payment should already be paid to the shipyard. As for this project, it was financed by three brothers in Zhejiang Provinces, they threw tens of millions cash to build a small shipyard and this tanker, bet they would find a buyer after the ship finished. And at last, they managed to find an owner to take over this tanker, although the market went low at that time.

Geographic, labor force, and capital, they are three "visible" requirement for the shipbuilding industry cluster. The formation of the cluster still require an "invisible" factor to work as a catalyst -- policy support. China has a different political system with the western countries, it is difficult to judge which is better, but there is one thing can be sure is, the system in China is more efficiency.

China government issues a development strategy every five years to guide the economic and social development. In 2001, the government issued The Tenth Five Year Plan for 2001 to 2006, in this plan, it used one sentence to mention that the ship industry should be developed. In the following The Eleventh Five Year Plan, a whole section was used to emphasize the importance of developing the ship industry, and pointed out where to develop, one of the place is the Yangtze River Delta. It said, "Strengthen the independent design ability, marine equipment supporting capacity and large shipbuilding facility construction, optimization of bulk carriers, oil tankers, container ships three main ship, focus on the development of new high technology, high value-added ships and marine engineering equipment. In the Bohai rim, Yangtze River Delta and Pearl River Estuary and other regional construction shipbuilding base, guide the shipbuilding enterprises in other parts of the reasonable layout and development."

Combine with the accomplished shipping data, it raised from 2003, considering it takes time to construct new shipyards, and takes even more time to build a ship from little or even zero experience. After that, the ship industry of China develop at a unusual high speed, take year 2008 as an example, in 2008, Chinese accomplished shipbuilding output was 28.81 million deadweight tonnages, rising by 52.2% of last year.

From my point of view, the policy influence is the most important factor of formation of ship building cluster in China, but this is a two-edge sword. On one hand, it makes the cluster taking shape in the shortest time, but on the other hand, it is 100 percent follow the market economy. The market does not expand at the same pace, and it will cause serious problem in the future.

3.5 Hamburg Aviation Cluster

3.5.1 Introduction

Germany is the fourth largest economy in the world representing 6.3% of World's GDP and with a population of 82 million. It consists sixteen states, and each state has an elected legislature and state governments and parliaments have significant responsibilities including education and policing.

The Aviation Cluster is located at Hamburg Metropolitan Region, where is one of the world's most important locations in the civil aviation industry, it cross three states Hamburg, Lower Saxony and Schleswig-Holstein. More than 40,000 highly qualified specialist personnel are working in this cluster, the turnover is over 7 billion Euros, and it is the third-biggest site in the civil aviation industry worldwide.

Figure 12. Location of Hamburg

The Hamburg aviation cluster perform strongly in these years. The market share grew about 5% in 1997-2007, this was faster than other country; the employment grew 6.4% per annum 2000-2006 in the cluster, while at the same time the number in Hamburg region is only 0.7% (Porter, 2010).

3.5.2 Cluster Status

The Hamburg Aviation Cluster has a complete industry system covers the whole life cycle of an aircraft, from the design, manufacture and fitting out, to the global system of air transportation, maintenance, repair and overhaul, and finally to recycling.

In the cluster, there are variety types of key members: Airbus, Lufthansa Technik, Flughafen Hamburg, the associations Hanse-Aerospace, HECAS and BDLI, the institutes and research facilities DLR, HCAT and ZAL and Hamburg's four universities – Hamburg University of Applied Sciences (HAW Hamburg), Hamburg University of Technology (TUHH), Helmut Schmidt University (HSU) and the University of Hamburg. The Hamburg Business Development Corporation (HWF) and the Ministry of Economy, Transport and Innovation (BWVI) have also been members from the very beginning.

There are also more than 300 small and medium-sized enterprises, suppliers and service providers, that have gathered around the big industries. Many of them are represented by the two trade associations, Hanse-Aerospace and HECAS.

Among the business in the cluster, manufacturing of aircraft parts and equipment take small share, while providing services takes almost seventy percent of the part (Conrad, 2011). The Table 4 shows the detail of each business's share in the cluster in 2011.

Manufacturing (Aircraft Parts)	14%
Manufacturing (Factory Equipment)	17%
Service Industry	69%
- Engineering	21%
- Trade, Service	21%
- IT	14%
- Staff Contractors	8%
- Miscellaneous (Inspection, documentation, etc.)	36%

Table 4. Business's Share in Hamburg Aviation Cluster

The Figure 13 from Conrad (2011) gives a direct view of the structure of Hamburg Aviation Cluster.

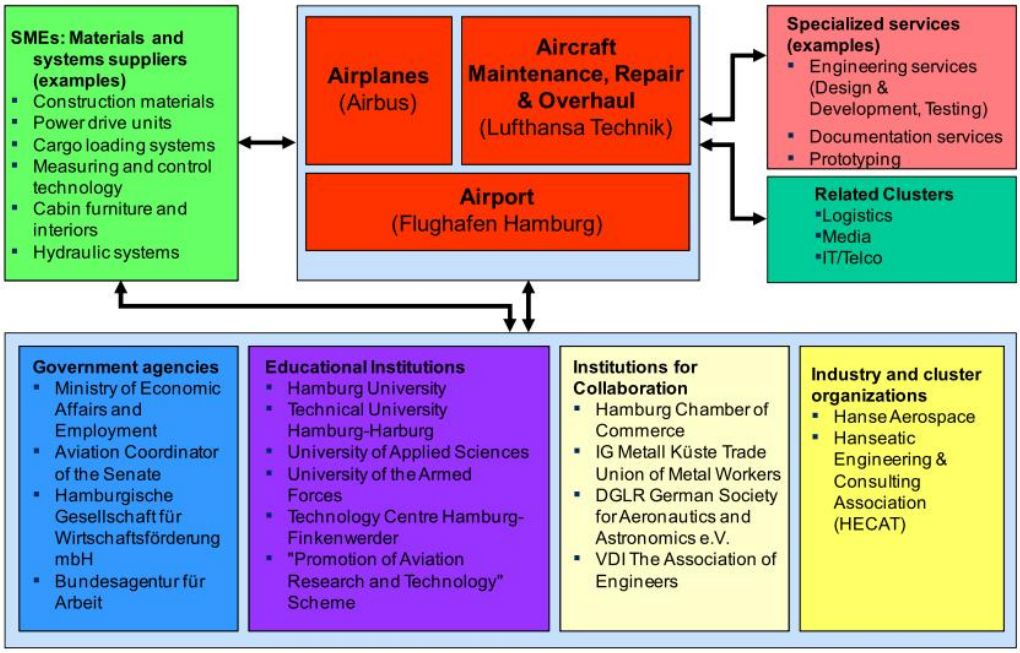

Figure 13. Structure of Hamburg Aviation Cluster (Conrad, 2011)

3.5.3 Formation of Cluster

As the structure map shows, there are three enterprises in the middle of the structure, Airbus, Lufthansa Technik and Hamburg Airport, they play a key role in the cluster, and they are the core of the cluster.

Airbus is one of biggest airplane manufacturer in the world, it is a European based group with production and manufacturing facilities mainly in France, Germany, Spain and the United Kingdom. Hamburg is the headquarters of Airbus in Germany and over 15,500 people working in it. It is home to the Airbus factory workshops where the entire A320 family of aircraft is constructed and where the section assembly, interior fitting and painting of the A380 take place. It also play a significant role in the research and construction of the new generation A350XWB.

Hamburg is also a spare parts center to Airbus. It holds about 120,000 proprietary parts for customers from around the world. The A320 Family maintenance training facilities is also located in Hamburg, the facilities have capacity to accommodate hundreds of airline trainees every year.

The next core in the cluster is Lufthansa Technik. Lufthansa is the largest airline in Europe, both in terms of overall passenger carried and fleet size. Lufthansa Group comprises a total of almost 500 subsidiaries and associated companies, while Lufthansa Technik is a 100% subsidiary of Lufthansa Group.

Lufthansa Technik is a leading manufacturer-independent provider of maintenance, repair and overhaul (MRO) services for aircraft, engines and components. With tailored maintenance programs and state-of-the-art repair methods, Lufthansa Technik ensures the unbroken reliability and availability of its customers' fleets. More than 750 companies around the world rely on Lufthansa’s technicians.

The third one is Hamburg Airport, which links the two giant groups and other more than 300 small and medium-sized enterprises. Hamburg Airport is not only one of the oldest airports in the world to still be based at its original location, but also one of the world’s most modern airports. According to the annual report, about 13.7 million passengers take-off and land here at 2012 and the number of aircraft movements that year is 152,890.

As mentioned above, there are over 40,000 employees in the cluster, while the three giants takes most of it. According to Conrad (2011), Airbus Hamburg has 15,500 employees, Lufthansa Technik has over 8,000 employees, and Hamburg Airport has 5,700 employees including airport businesses.

These three giants act like a core attracting other 300 small and medium-sized enterprises, this provides a strong basis for forming a modern industry cluster. Another important factor of the formation process is a historical reason: aviation has a long tradition in Hamburg.

As we all know that the Wright brothers invented and built the world's first successful airplane and made the first controlled, powered and sustained heavier-than-air human flight on December 17, 1903. Six years later, aircraft were being built and tested in Hamburg in 1909 in the Centrale für Aviatic, which later became Hansa-Flugzeugwerke, a German aircraft manufacturing company that operated during World War I. The foundation stone of the airport was laid in 1911. At the time, it was principally reserved for airships.

In the 1920s and 1930s, the aircraft manufacture industry was extremely stimulated by the World War II. According to different researches, over 110,000 planes were built by Germany in the World War II. The manufacturing peak was at 1944, more than 40000 planes was built on the single year. Although at the end of the war, most of the plane factories were disassembled, the development of aircraft manufacture industry was highly related to the World War II.

World War II stimulate the aviation industry not only on creating a vast demand on the airplane, but also catalyze the technology development in the aviation area, the first jet airplane was the HE-178 which was developed and built in 1939 for Germany Air Force.

At the mid of 1950s, aircraft were produced in Hamburg again. At first, Hamburger Flugzeugbau began building military aircraft, followed by the government personnel transport. The next boost of the industry was in 1969, this developed into the Franco-German Airbus program, and it was a beginning of a new era of aviation.

On 29 May 1969, at Le Bourget airshow, French transport minister Jean Chamant and German economics minister Karl Schiller signed an agreement officially launching the A300, the world’s first twin-engine wide-body passenger jet. It was to be built by a French-German consortium which would also involve the British and the Dutch. The decision to give the go-ahead to the A300 was the formal starting point of the Airbus program. The Airbus A300 was introduced to service by Air France at 1974, and total 561 A300 series have been built by 2007, the production ceased after that time.

The Figure 14 shows the evolution history of Hamburg aviation industry, it marks the important events in the history.

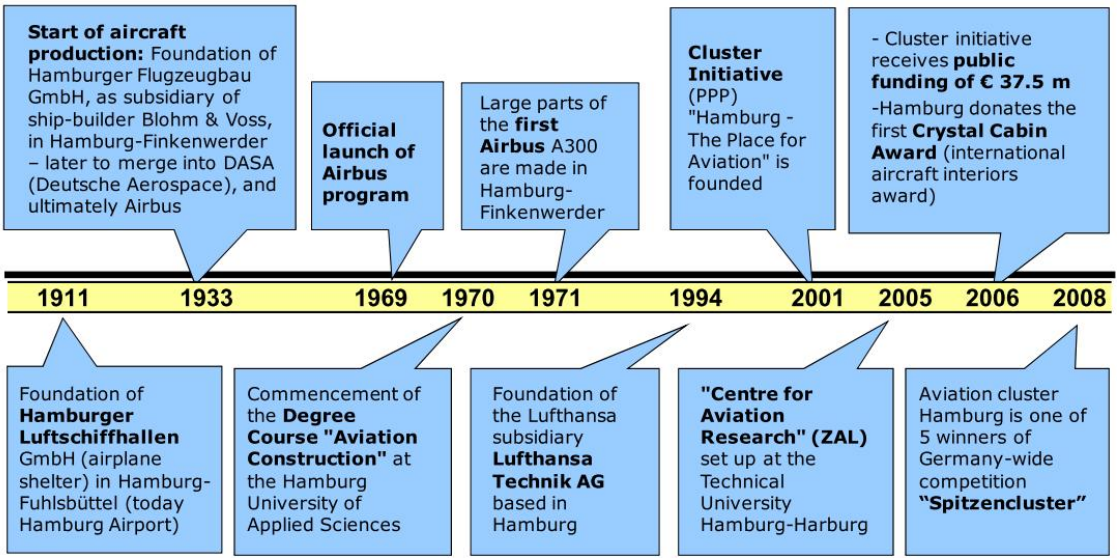

Figure 14. Evolution History of Hamburg Aviation Industry

The manufacturing of A300 series provide an opportunity to Hamburg aviation industry to develop the modern aviation industry, but more importantly, the industry can gain experience of building modern aircraft from it before the other competitors.

To take and maintain this advantage, more resources should be put into the education and research. Science, technology and innovation statistics have been acknowledged in 2010 by the Commission as to be closely linked to the policy activities carried out by the European Union. According to Eurostat (2010), Figure 15 shows the Gross domestic expenditure on R&D of Europe countries.

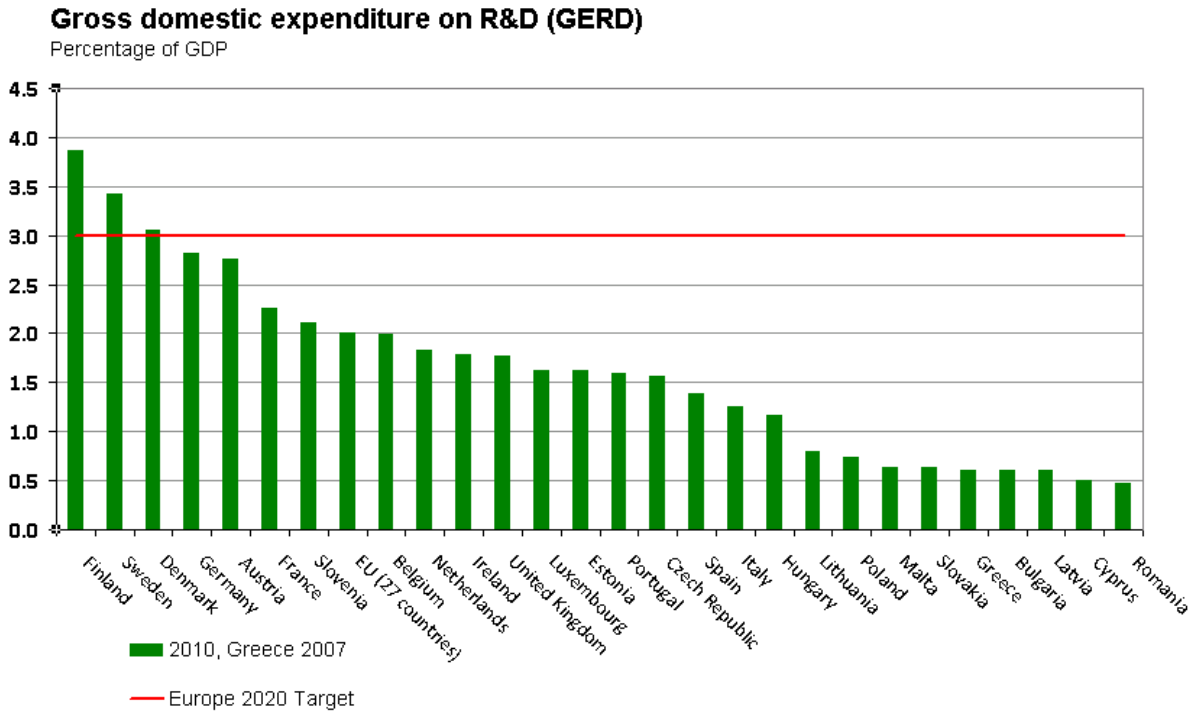

Figure 15. Gross Domestic Expenditure on R&D of Europe Countries

The red line marked on 3% on the graphic is a set target that should be achieved by the EU countries by 2020. From the graphic, Germany is on the fourth place after Finland, Sweden and Denmark, the exact number of Germany is 2.84% according to Eurostat, which is above the EU-27average 2.03%.

Regarding to Hamburg, in September 2008 the Aviation Cluster Hamburg Metropolitan Region has been selected as a Leading-Edge Cluster by the German Ministry for Education and Research and R&D Projects volume is about 80 million Euro until 2014. The Leading-Edge Cluster competition is intended to take Germany to the top of the league of technologically advanced nations.

To ensure an efficient integration of distributed business process within the cluster, the German Ministry for Education and Research sponsored a program to develop a Knowledge Management System for the Hamburg Aviation Cluster. Based on that the Hamburg Model of knowledge management (HMKM) is developed for the design and implementation of knowledge management systems (KMS) which focuses on the inter-organizational co-operation. The current implementation of this system has shown positive results (Krenz et al., 2014).

4. CASE ANALYSIS

Above chapters introduces some industrial cluster cases in three different countries. To have a better understanding of the role of cluster in modern industry, a way is to compare these clusters.

4.1 The Main Factors of Cluster Formation

Each of the cluster are formed for many factors, to compare these different main factors helps us to understand cluster formation process.

In the Norwegian Maritime Cluster case, according to the above analysis, the main factor is the demand for the ships created by other industries. From travelling need in old times, to cargo transportation needs in modern oil and gas industry. Also the suitable geographic characteristic and rich fisheries resources act like a catalyzer accelerating the formation of the cluster.

Policy is considered as the third factor. Norwegian politicians have also taken initiatives to improve the competitiveness of the maritime industry in Norway. There is an organization called MARUT (Maritim Utvikling) established by the cluster organizations in 2004 to enhance the value creation in the maritime sector. It cooperates with several governmental bodies to ensure a more coordinated and targeted efforts in cooperation between industries, research institutions, funding agencies and authorities.

However, the policy usually works in the initiation phase, the long-term competitiveness of the maritime industry in Norway is dependent on the attractiveness of Norway as a host for maritime business.

In the case of Shanghai Maritime Cluster in China, similarly the ideal geographic location gives the premise to cultivate a maritime industry, but the most important one is policy, or more specific, the guidance from government.

There are a lot discussion about the different political system of China, despite the other issues, being in a different social system makes some activities more efficiency. In 2006, the government issued China's Economic Development Plan for the Eleventh Five - Year period, in this plan, it addressed the strategy of maritime industry development. Accordingly, the local government issued detailed policy to support the maritime industry.

Besides, Shanghai is one of the wealthiest city in China, and it has complete and mutual modern industry systems, this kind of environment gives another premise of developing a maritime industry.

As for the Hamburg case, long aircraft manufactory history is the main reason of the formation of Hamburg Aviation Cluster, the three giant enterprises shaped in the history, and act like the core to attract, organize other small and medium-sized enterprises. Table 5 summarized the main factors:

Cluster	Main Factors
Norwegian Maritime Cluster	Demanding from other industries; Geographic advantage; Government support.
Shanghai Shipbuilding Cluster	Five-year development plan; Geographic advantage; Good industry and capital environment.
Hamburg Aviation Cluster	Long tradition of aviation; three core enterprises; Government fund support.

Table 5. Main Factors in Cluster Formation

The role of government appears in all cases, although it is difficult to quantization the importance of each factor in every case, but from the above analysis, the political factor plays a more important role in Shanghai shipbuilding cluster than in other two cases. Also, the geographic is not listed as a main factor in the Hamburg, the geographic factor do play a role in the cluster, but not as a key one in this case.

4.2 Policy Factor in Clusters

In the past decades, researchers have studied the formation of different clusters all over the world. According to Porter (1998b), usually there are four main factors in the formation process of an industry cluster: historical reason; unusual/urgent demands of certain product; existed supply chains for an industry; and leading of one or more creative companies. It can be seen that most of the factors summarized for the three clusters are the four categories, the only exception is the policy factor.

It is a sensitive issue to discuss policy, but the policy factor is indeed an important one in the formation of industry cluster, especially in Asia. The Institute of Developing Economies of Japan External Trade Organization (IDE-JETRO), ran a study about the clusters in different Asian countries. In the study report, it points out that industry cluster in China is the interaction ground of governments' industry policy and transnational corporations' foreign direct investment. And it is well known that industrial policy and the foreign investment are two main contributor of Chinese economic development and growth in the past decades.

The foreign investors usually can get beneficiary policies when they invest in China, such as cheap land, labor forces, and favorable tax rate. Although after access of WTO, these beneficiary polices has been treated as a super national treatment and been withdrawn since 2008, a lot foreign investment have been already set down in China.

At the early age of attracting the foreign investment, the quantity was one of the figure to evaluate local governments' performance, as this, they attracted foreign investment without pay much attention on the quality. The low quality investments not only mean less efficiency, but also have chance do harm to the development of cluster. For example, large investment on the low technic shipyard increase the manufactory capacity fast and dramatically, but the market capacity do not increase at same scale, it even went down because of the global economic crisis in the past years.

As mentioned above, the National Government issued the tenth and eleventh five years plans to guide the development in the next five years. These plans only point out the direction, tell to public that developing shipbuilding industry is next to be done. Accordingly, the local government issued plans with more details, take Shanghai for example, short after the central government's issue, they issued the Shanghai marine economic development eleventh five years plan, this plan summarized both positive and negative side in the previous five year, and detailed what to do in the following in this city. The policy is so efficiency that the Chinese shipbuilding industry experienced considerable expansion virtually in parallel with China's accelerated economic growth.

The shipbuilding industry is a labor and capital intensive industry, while in China, it is also a strategic industry. The shipbuilding industry contribute to national defense capability, drive economic development, and stimulate the raw material industry and manufacturing industry, such as iron and steel. The China government has to push the development of shipbuilding industry to maintain the growth of GDP at 8% yearly, or they have to face a huge pressure of unemployment.

One of the support from China government is by exempting from tariffs applicable to imports for key components for high-tech ships from other countries. On the other hand, the government also support the R&D and innovation in order to catch up in the technic area. The Commission of Science, Technology and Industry for National Defense (COSTIND) has selected basic, general-purpose and frontier technologies as major targets to provide financial support since 2001, the support amount is about 10 million Yuan.

Today, the global economic brings a huge impact to the shipbuilding industry, China government issued a three-year plan to urge financial institutions to support its troubled shipbuilding industry. More about this will be discussed in the following chapter.

Compare with the other two European countries' case, the political factor is not as important as in China. In the Norwegian Maritime Cluster, the policy works in the initiation phase, while the long-term development is still depending on the industry itself. Also in Hamburg Aviation Cluster, the government plays a supportive role, let the industry develop itself.

The formation process of a cluster should take a long time, like the in the case of Norwegian Maritime Cluster and Hamburg Aviation Cluster, they all take decades to become mature clusters, while under the policies' help, Shanghai take less than ten year to achieve this. From this point of view, it seems the policy-orientated is a good choice to develop a cluster; but this conclusion should be test in a longer term, once there is no longer any policy to guide or the effect of policy is not so obvious, then what would happen?

4.3 Geographic Factor to Clusters

There are different versions of definitions about cluster, and the word "geographic" appears in most of them. While when we talk about a cluster, a question is always asked, why the cluster is formed here? For the companies inside the cluster, it may easy to understand, for example, the shipyard in the shipbuilding cluster and maritime cluster, has to be built by the water. But why the supportive industries are all built nearby?

In the history of studying the geographic agglomeration of economic activity, most researchers point out the importance of geographic. Marshall (1920) said the advantages brought by geographic agglomeration are specialized labor pools, intermediate goods and the presence of knowledge spillovers. Porter (1990) added the effect of local rivalry may critically provide competitive advantage. And some other researchers believe this can improve the industry's performance.

The labor pools advantage is talked the most. This theory argues that the companies in a cluster may have better access to workers and at lower recruiting and training costs. Usually, the workers come from two sources, one is the graduates from the education institutions in the cluster, and the second is from similar or related companies in the cluster.

The intermediate goods advantage means the company in a cluster may benefit from privileged access to local suppliers that offer a variety of highly specialized intermediate goods and services. With these supply companies, the company in upper stream can buy or outsource activities locally so that they can get quick response for what they want. And considering that there may many suppliers provide the same goods or services, the competition between them may lower the cost.

Knowledge drives innovation, companies in a cluster may also be able to absorb specific knowledge that has been accumulated by other firms via market and non-market channels (Bonte, 2003). The sources of knowledge could be labors, suppliers or even customers (Von Hippel, 2007).

From Porter's (1990) view, the industry cluster create a competitive environment for companies within it, and he believes this brings some advantages as well. On one hand, the competition between companies is considered as the best driven force for them to improve and to innovate, hence may positively influence productivity and innovation performance. On the other hand, the suppliers compete with each other to achieve a higher performance give them some advantages to win the market outside the cluster.

The competition between suppliers may drive them to try to find new area to develop, which means they desire to fulfil sophisticated local buyers' requirements. In the further, this may help suppliers them to attract customers outside the cluster too.

The above mentioned and other common sense advantages brought by geographic agglomeration can be summarized as in the Table 6.

1. Labor market pooling:	Labor cost savings due to a privileged access to specialized skills especially in an environment where firms have non-positive correlations in the temporal variations of their demands.
2. Accessibility to specialized goods and services:	Privileged access to a local supplier base that has great product variety and a high degree of specialization.
3. knowledge spillovers:	privileged access to tacit knowledge in geographic proximity by means of both formal fashioned transmittal-processes as well as through such informal channels as knowledge leakages made possible by casual inter-firm interactions, workers changing jobs, etc.
4. Demanding customers:	Privileged motivational effects due to high demands of highly competitive local customers that may lead to higher competitiveness on distant markets.
5. Rivalry:	Privileged motivational effects due to better benchmarking opportunities and a more intense interpersonal competition for immaterial gratification between specialized workers in geographic proximity.
6. Complementarities:	Privileged sales opportunities of firms due to search cost savings of buyers' of complementary products offered in proximity and privileged opportunities for cooperation (sales, marketing, etc.) between nearby suppliers of complementary products.
7. Transportation cost advantages:	Transportation cost savings due to geographic proximity especially in the case of just-in-time delivery contracts.

Table 6. Advantages of Geographic Agglomeration

From the above analysis, the geographic agglomeration is a necessary condition to a cluster, but most of these theories are proposed decades ago, which the oldest one was on 1920. While the world is changing every day, today in a globalized world , distance seems to be no longer an obstacle, as capital, knowledge, and other resources travel almost freely and at high speed, we would expect economic activity to spread over space (Lublinski, 2003).

In modern world, the labor pools are not limited in the local cluster, on the contrary, the big company seems to seek employee from the global market. The best example is from my family, when I had decided to take the master program in University of Stavanger, my wife began to seek a job position in Norway. After a while, she found a position in DNV headquarter in Oslo on their website seems suit for her, so she sent the resume online to apply for it. Then DNV Oslo invited her to join an online video interview in their branch office in Shanghai, finally, my wife successful to get the job.

There are similar examples around us today, especially to the global corporations, they like to use the global recruitment to form a diversified enterprise culture, one of the reason is this kind of corporations have business in many countries, and by using local people may lead a good communication. In the modern clusters, there are many such global corporations, from this point of view, the advantage of local labor pool is not as obvious as before.

Technology is developing every day, today people can video chat with each other anytime easily, and this is almost the same with chatting face to face. The video chat also save a lot time on travelling on face to face chat, which is more appreciated by modern corporations. The technology development changes the travelling as well, with well-developed land and air transportation, the geographic barrier not the first consideration in business.

Another tendency is that customer today cares quality more that cost, and this drives the product or service providers care about quality too when they seeking their supplier. They are willing to pay more if the expensive one is able to improve the quality of product or service. Thus, the suppliers in the cluster may only have little transportation cost advantage on providing to customer in the cluster. All the suppliers should expand their customer group to survive in modern competition environment.

Given all that, in my opinion, the geographic factor is not as important as before, or in other words, the formation of modern industry cluster should not limited on the geographic agglomeration. As a matter of fact, in the listed three case, we can see the indication of this tendency.

Among the three countries where the cluster located, Norway is the smallest one. Even in the Norwegian Maritime Cluster, the actual business activity has been expanded to the whole country, instead of the west coast of Norway. As for the Shanghai Shipbuilding Cluster, it involves two provinces and one of the biggest city in China, the land area is about 50,000 square kilometers, it even larger than some countries, such as Denmark and Switzerland, which is about 40,000 square kilometers. In this scale, there seems no exist of so called transportation cost advantage.

We talk about Global Economic today, maybe we can build a Global Cluster in the future. With the development of technology, the long distance communication could be more real, as if be personally on the scene; the long distance transportation could be faster and cheaper. Without the geographic limitation, the world is connected together, it is full of possibilities, and more opportunities will be created. I believe there will be a new model of industry cluster

4.4 Risks and Challenges

Industry Cluster has been proved that it increase the productivity with which companies can compete. The development and upgrading of clusters is an important agenda for governments, companies, and other institutions. But nothing is perfect, we can still find risks and challenge in the developed clusters.

In the Norwegian Maritime Cluster case, the challenges come from different aspects. The first one is the raise of costs. According to Statistics Norway, the full-time employees in manufacturing had average basic monthly salary of NOK 39,100 as per 1 October 2013, excluding overtime pay. Figure 16 shows the growth tendency in these years.

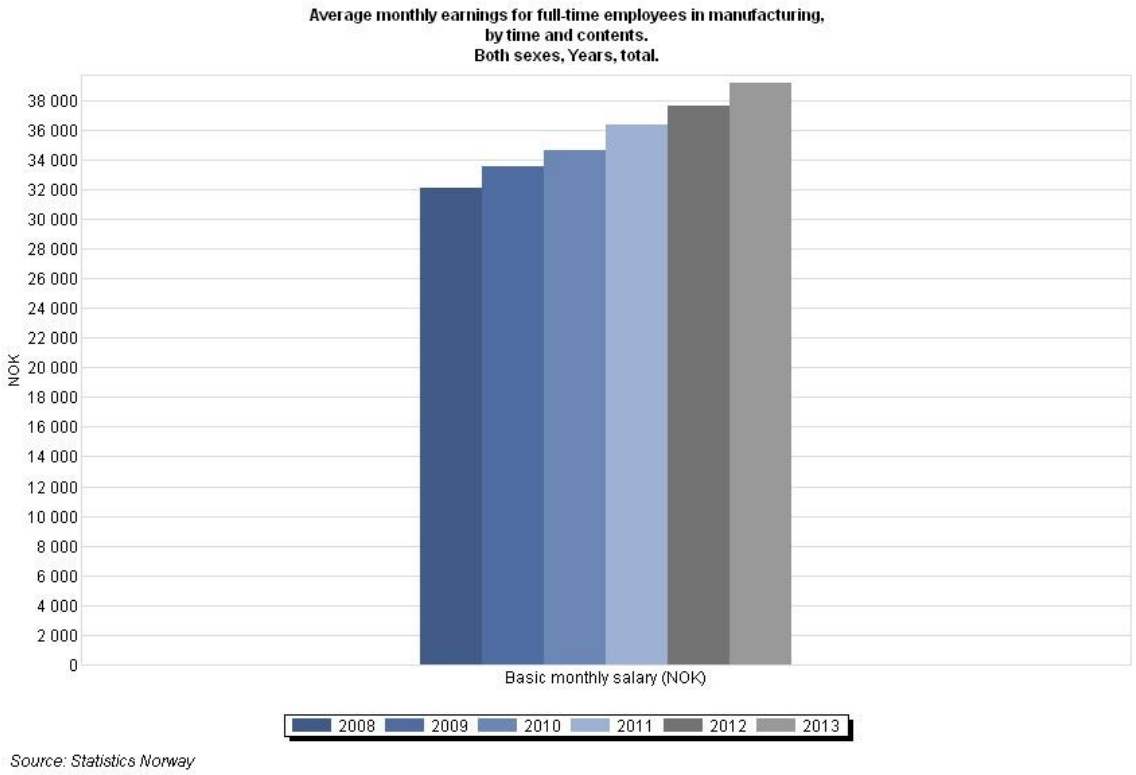

Figure 16. Average Monthly Earning of Norway

Compare to Shanghai, the richest city in China, which has a similar industry, according to Shanghai Statistical Yearbook 2013, average the monthly wages in 2012 is 4700 Yuan, the exchange rate between the two currencies is about 1:1.1. From the numbers, the labor cost in Norway is over 8 times of it is in Shanghai, actually the salary level in Norway is higher than most countries in the world. The higher labor cost lead to high building cost in a certain extent, which lower the competitive of the industry in the market from the price perspective. Report says that even Norwegian ship owners order their new fleet from Asian countries, especially China.

As mentioned above, one of the formation factor of Norwegian Maritime Cluster is the demanding from related industries. In other word, the maritime cluster is depending on other industries partly, like oil and gas industry, and sea transportation.

Today, there are other ways of travelling than by sea to Norwegian people, the boat travelling is more like a leisure activity, the demanding from local transportation market is no long like before, this situation affect the maritime industry performance and forces the center of the industry changes to around the oil and gas industry. But recent years, the oil and gas industry is not as thrive as before, it impacts the maritime industry too.

As for the Norwegian SE cluster and NODE cluster, these two cluster more like sub clusters to oil and gas industry and maritime cluster. There risks are similar with the above mentioned, they are highly depend on the host clusters. Besides, there size compare to the other three are relatively small, and it makes them more vulnerable to the impact, like economic crisis.

The biggest challenge that Shanghai Shipbuilding Cluster facing is the overcapacity situation. In the past a few year, the shipping industry has a boom development, which closely related to the rapid development of China’s foreign trade over the past decade. That pushed Chinese ship building capacity up to 100 million DWT, which is about 40 percent of the world’s capacity.

Zhang Yansheng, secretary general of the Academic Committee of the National Development and Reform Commission, said, “China's over-reliance on investment and foreign trade has fueled rapid growth in some sectors, and when global demand slides and domestic production cost rises, overcapacity inevitably surfaces and cannot be easily addressed.”

The shipbuilding industry’s overcapacity problem is also a global issue, global shipbuilding capability is 200 million DWT, while the new contracts in 2012 was 46.86 million DWT and 83.96 million DWT orders were inked in September, 2013. According to forecasts suggested by industry professionals, global new order demand will be around 70m-90m DWT yearly over the next three years with global overcapacity surpassing 50%.

The problem is that the market capacity is not booming as the pace, it even goes down during the global economic crisis. According to the Baltic and International Maritime Council (BIMCO), the supply trend of most common merchant vessel is as Figure 17 and Figure 18.

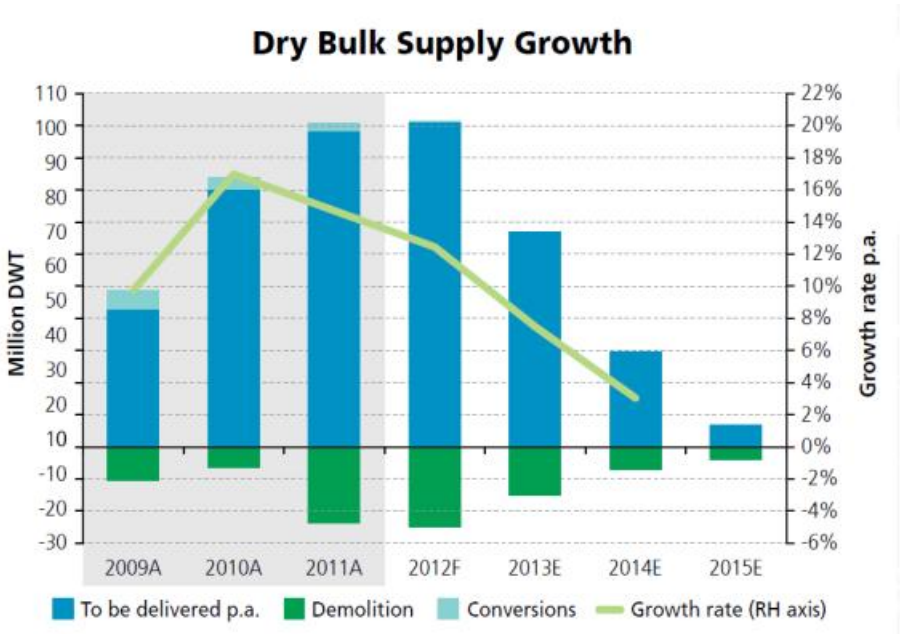

Figure 17. Dry Bulk Supply Growth

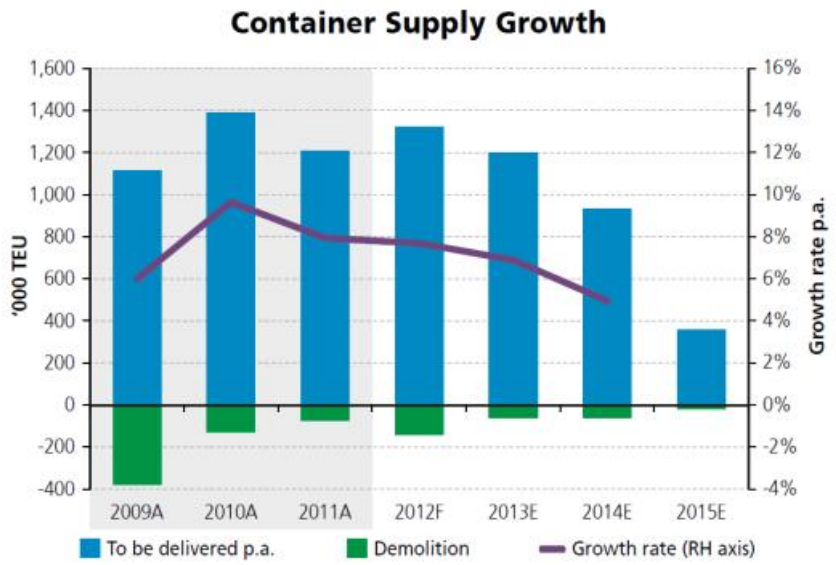

Figure 18. Container Supply Growth

The similar trends also apply to crude tanker and product tanker. The trends show the supply of these types of vessel are decreasing, which means that the market is shrinking. Combining this with the fact of overcapacity, the situation is severe. According to a report (Reuters, 2013c), by the first three quarters of 2013, the utilization of the shipbuilding capacity is only 50%, it roughly means there was about half of the ship workers had no job to do.

The overcapacity situation lead a chain reaction. Another report says that banks have tightened lending to Chinese shipyards (Reuters, 2013a). Some banks have started asking for more prudent ship construction contracts before they grant loans and have withdrawn loan approval rights given previously to branches.

These moves put more pressure on the shipbuilding industry that is already suffering from sluggish demand and a supply glut, as government tries to cut excess capacity across a range of sectors. China government has laid out a detailed three-year plan to restructure its massive shipbuilding industry, urging local governments to halt approvals of new projects and companies to move up the value chain by building high-tech vessels (Reuters, 2013b).

In general, vessels can be simply divided into two categories, low additional value vessel and high additional value vessel. The bulker carries, small tanker are low additional value vessels, while container vessels, LNG (Liquefied Natural Gas) carrier and offshore support vessel are high additional value vessel. In the rapid development period, most of the investors of new shipyards want to make profit as soon as possible, thus they intend to have the yards only capable of building the low additional value vessels, such as bulk carrier. The increasing building capacity of these vessels fill the market full in a short time. Without new orders, what they have to face is broke.

On the contrary, building high additional value vessels request more invest, more experience, and more time to gain these experience. That is the reason why investors do not like to put money on them.

Another challenge is one that both Shanghai Shipbuilding Cluster and Norwegian Maritime Cluster have to face, the new rule will take effect, such as Emission Control and Clean Design. It will require improvement on ship design, ship manufacturing, ship machinery, and so on. This is a challenge but also an opportunity to all, because now they are standing on same scratch line.

For the Hamburg Aviation Cluster, the challenge to them is the challenge to the air traffic industry. A significant increase in civil air traffic is expected over the next 20 years. Consequently, the aviation industry is faced with the challenge of making flying not only more economical, but also more ecological, more reliable, more flexible and more comfortable. Traditional concepts for modern air transport do not comply with these demands. It calls for innovative ideas to save important resources and to cut down fuel consumption, while at the same time improving comfort, flexibility and reliability.

To achieve this, something has already be done. The cluster partners have agreed to focus their research activities on areas including cabin technologies and the use of fuel cells, the extension of expertise to cover new aircraft types in maintenance, repair and overhaul, as well as increasing the efficiency of air transport systems at airports.

Aviation Industry is one of the most complex industry in the world, an A320 aircraft may be assembled in Hamburg, but the parts come from all over the world, Airbus and Boeing each have about 1,500 suppliers ranging from so-called tier 1 companies providing aero structures or equipment for jets to smaller tier 2 and tier 3 groups making components. Thus the requirement for the new aircraft is the requirement for those suppliers. The suppliers need to be smart & flexible enough in order to adapt to new & quickly changing developments/opportunities worldwide. They have to invest more in R&D in greener aviation, such as light weight, new materials, and full cells. And they also have to cooperate with international players as labs, universities, OEMs or research centers and other suppliers for a common & integrated approach.

Another challenge is from the market competition. Now there are two major aircraft manufacturers in the market, Airbus and Boeing, they almost take the whole share of the market now. But in the future, they are facing the competitors from other countries. For example, Embraer, a manufacturer form Brazil, their products have strong competitive in feeder liner market; COMAC from China, they are developing both trunk liner and feeder liner under government support. Fortunately, it will take long time to develop a new model of aircraft, Hamburg still have time to improve their products to maintain the current advantage.

5. RECOMMENDATION

5.1 Cluster and Competitiveness of Cluster

From the cases introduction and analysis, industry clusters have unique competitive advantages in the market. Compare with single industry, the cluster encompass the related industries and other entities important to competition. For example, suppliers of specialized inputs such as components, machinery, and services as well as providers of specialized infrastructure. On the other end, clusters also extend to downstream to customers and manufacturers of complementary products. Most of the clusters involve government and other institutions that provide specialized training, education, information, research, and technical support. Foreign companies can also be part of clusters, only if they make permanent investments in a significant local presence (Porter, 2000).

There are different types of industry clusters, they are present in large and small economies, in rural and urban areas, and they can be in small cities or across a few provinces. Clusters occur in both advanced and developing economies, although clusters in advanced economies tend to be far more developed (Porter, 1998b).

The cluster competition rests on innovation and the search for strategic differences. Close linkages with buyers, suppliers, and other institutions are important, not only to efficiency but also to the rate of improvement and innovation. The cluster affect competitive advantage through its influence on productivity and especially on productivity growth.

In general, the cluster can improve the competitiveness in the following three ways:

1. increasing the productivity of constituent firms or industries;
2. increasing the capacity of cluster participants for innovation and productivity growth;
3. stimulating new business formation that supports innovation and expands the cluster

5.2 Challenges

A cluster is a system of interconnected firms and institutions whose whole is more than the sum of its parts (Porter, 2000). But we also can see that cluster has potential risks and challenges.

- Resource depletion: particularly in the resource-based cluster, the core business of the cluster would shrink or even broke when resource depletion.
- Heavy capital investment: to keep the competitive advantage, investment is required all the time on infrastructure, R&D, and so on.
- Demand for raw material: for some industry clusters, as the maritime industry, it requires marine steel for production, while the supply and price of the steel is depending on another industry and not stable.
- Gaps in logistics and transportation: as mentioned above, the "size" of cluster is bigger and bigger, thus the pressure on the logistics and transportation is heavier and heavier.
- Environment protection issues: this challenge comes from two ways. First, new laws and regulations address the importance of environment protection, it requires the cluster keeps innovation and improving; second, when there is important environment protection issues, the companies in the cluster may be required to move to other place! This happened to Shanghai Shipbuilding Cluster a few years ago, Jiangnan Shipyard Group, a core company in the cluster, was forced to move to an island to improve the city's environment for Expo 2010.
- Aboriginal land claims issues: as the cluster and city are both expanding, the conflict on the land issues will eventually happen.
- Cutthroat competition: the competition between similar companies in the cluster may develop into a cutthroat competition, which would cause damage to the entire cluster.
- Foreign ownership: the complex ownership of a company is very common in modern industry, it brings management and decision making challenge to the industry.

All the industry clusters are or will be facing some of the above challenges, they have to be prepared for those challenges to survive in the competition.

5.3 Recommendation

As mentioned above, the challenges and risks come with benefits in the industry cluster. The way to alleviate the problem is improve the cluster organization.

Just like many other types of organizations, "cluster" is an organization with boundaries. Because of the organizational structure of industrial clusters depend upon the nature of enterprises in industrial clusters and their relationship and interaction. The emergency of boundaryless organization is the driving force and the constant is that the organization evoke different kinds of behaviors (Gallos, 2008).

The boundaries in the organization can be summarized of four types:

- Vertical boundary between levels and ranks of people
- Horizontal boundary between functions and disciplines
- Extensional boundary between the organization and its suppliers, customers, and regulators
- Geographic boundary between the locations and markets

Industry clusters have all of the boundaries in the organization especially the geographic boundary, the geographic factor brings both advantage and limitation to the clusters. While the boundaryless organizations make the main body of industrial clusters full of activity, and improves the flexibility of clusters and the adaptability to the change of the outer environment.

Compare with the traditional forms of organizations, the boundaryless organization has the following advantage:

	Identify Sources	**Select Provider**	**Deliver Material**
Traditional	Static default source;	Next unit up chain;	Only from local units;
Boundaryless	Search all providers; All unit can supply and consume;	Select the best based on readiness;	Dynamic positioning within supply chain; different and larger transport mix required;

Table 7. Compare Between Traditional and Boundaryless Organization

Boundaryless is a trend in many areas, in the internet area, the word “Cloud” represents a boundaryless model, every digital material can be stored to and accessed from the cloud, it is much more efficiency and safer than ever before, just like now I am writing the thesis using a cloud storage provider called Dropbox, I do not have to worry about computer break down or other incidents, because I can easily continue my work from my iPad or any other computer.

The education is becoming boundaryless too. MOOC (Massive Online Open Course) is an online course aimed at unlimited participation and open access via the web. Many famous universities, such as MIT, Harvard University, and Stanford University, have joined this program to provide the education services to people all over the world. In addition to traditional course materials such as videos, readings, and problem sets, MOOCs provide interactive user forums that help build a community for students, professors, and teaching assistants.

The industry can also be boundaryless, geographic advantage may help the development in the initial phase, but it is also a limitation if one focus on the local only. Break the boundaries will provide the industry a new area and a new opportunity.

6. DISCUSSION

6.1 The Future Development of Clusters

The thesis has studied and analyzed different industry clusters in different countries, the analysis shows the advantage of clusters in business performance and market competition, it also shows there still existing challenges and risks in current cluster.

Clusters are based on geographic concentration, which ensures some advantages for the companies, but the geographic factor also creates a boundary for the cluster. The geographic boundary and other types of organizational boundaries limit the future development for the cluster.

From this point of view, the way for further development is to create boundaryless organizations by breaking these boundaries. The problem is the cluster is based on the geographic concentration, a part of companies, especially those small and medium size companies, they are living on the geographic advantages, and they may not be able to survive in competing with the companies outside the clusters.

Assuming that the cluster loses some of its small and medium size companies in the global competition, the core companies in the cluster must seek for new suppliers for their production from other location. This demand create a new value chain for the business, the cooperation between them can be seen as a new model of industry cluster. For those survived small and medium size companies, they also need to develop new customers outside.

The point is that the cluster's geographic advantages only help them in the initial phase of development, after that they need and have to put their sight outside the cluster seeking for new opportunities for further development. This trend changes the concept of traditional cluster, the new one is a cluster on the global scale.

6.2 Recommendation for Further Study

The further study about the industry cluster can focus on two aspects. The first is try to study the current cases deeper and find some more cases in different areas. The analysis is to find different performance of these clusters in their different development phases, and compare the results to find if there is any tendency in the development progress.

The other aspect is find examples that companies in a cluster seeking for global suppliers. The possible good case is the aviation industry, the parts of a modern aircraft are coming from tens of countries all over the world. The driven force why the Airbus or Boeing do this may be the driven force of clusters break the geographic boundary.

6.3 Challenge in Writing Thesis

The main challenge in writhing this thesis is gathering information of the industry cluster cases. It is really difficult find the latest information for each clusters, and the gathered information of each case are not in the same area, therefore in the later analysis part, it is difficult to compare these cases. Besides, the author only have a few years of ship design experience in previous career, the lack of experience in the management area is another challenge in writing the thesis.

7. CONCLUSION

The thesis studied five industry clusters in three countries and went through the detail of the clusters, analyze the structure and the formation process. By comparing the analysis, clusters show positive influence on business performance, especially in the Shanghai Shipbuilding Cluster case, the affect is extraordinary.

There are some major factors in the formation process of clusters, such as geographic factor, historical factor, and policy factor. In different cases, the importance of each formation factor is different. Based on the study, it helps to understand why clusters are formed in the region.

The study also have identified some challenges in these cluster cases, and based on that the common challenges for clusters have been identified. To alleviate the problems, the author suggests the way is to improve the cluster's organization. There are four types of boundaries in the organization, and in cluster, the geographic boundary is the serious one. Break the boundaries and create a global value chain is a way for cluster' future development.

8. REFERENCE LIST

ARIF, B. W. 2012. Industrial clusters, Schumpeterian innovations and entrepreneurs' human and social capital. *Pakistan Economic and Social Review,* 50**,** 71-95.

BARNEY, J. 1991. Firm resources and sustained competitive advantage. *Journal of management,* 17**,** 99-120.

BARNEY, J. B. 1995. Looking inside for competitive advantage. *The Academy of Management Executive,* 9**,** 49-61.

BARNEY, J. B., KETCHEN, D. J. & WRIGHT, M. 2011. The Future of Resource-Based Theory: Revitalization or Decline? *Journal of Management,* 37**,** 1299-1315.

BENITO, G. R. G., BERGER, E., DE LA FOREST, M. & SHUM, J. 2003. A cluster analysis of the maritime sector in Norway. *International Journal of Transport Management,* 1**,** 203-215.

BONTE, W. 2003. R&D and productivity: Internal vs. external R&D-evidence from west german manufacturing industries. *Economics of Innovation and New Technology,* 12**,** 343-360.

BRUN, L. C. 2011. *Increasing stakeholder participation in industry cluster identification*.

CHIESA, V. 2005. *Industrial clusters in biotechnology: Driving forces, development processes and management practices,* Imperial College Press.

COLLINS, G. 2010. China's Shipbuilding Industry Development: A Boost for Naval Ship Production?

CONNOLLY, B. 2002. From Business Network To Industry Cluster.

CONRAD, B. 2011. Aviation Cluster Hamburg Metropolitan Region.

CORTRIGHT, J. 2006. Making Sense of Clusters: Regional Competitiveness and Economic Development. Washington, DC: The Brookings Institution, Metropolitan Policy Program.

CZAMANSKI, S. & ABLAS, L. A. D. Q. 1979. Identification of industrial clusters and complexes: a comparison of methods and findings. *Urban Studies,* 16**,** 61-80.

ELMARAGHY, H. A. 2011. *Enabling Manufacturing Competitiveness and Economic Sustainability: Proceedings of the 4th International Conference on Changeable, Agile, Reconfigurable and Virtual Production (CARV2011), Montreal, Canada, 2-5 October 2011,* Springer.

FELDMAN, M., FRANCIS, J. & BERCOVITZ, J. 2005. Creating a cluster while building a firm: Entrepreneurs and the formation of industrial clusters. *Regional Studies,* 39**,** 129-141.

FELLER, A., SHUNK, D. & CALLARMAN, T. 2006. Value chains versus supply chains. *BPTrends, March***,** 1-7.

FREEMAN, C. 1995. The 'National System of Innovation'in historical perspective. *Cambridge Journal of economics,* 19**,** 5-24.

GALLOS, J. 2008. *Business Leadership: A Jossey-Bass Reader*, John Wiley & Sons.

GEREFFI, G. 1993. *The Organization of Buyer-driven Global Commodity Chains: How U.S. Retailers Shape Overseas Production Networks*, Duke University Program in Political Economy.

HAN, X. 2009. Research on Relevance of Supply Chain and Industry Cluster. *International Journal of Marketing Studies,* 1.

HOGEFORSTER, M. & ACADEMY, B. S. 2012. *Strategies and Promotion of Innovation in Regional Policies Around the Mare Balticum*, Books on Demand.

JUREVICIUS, O. 2013a. *Resource-based view* [Online]. Available: http://www.strategicmanagementinsight.com/topics/resource-based-view.html [Accessed 06.01 2014].

JUREVICIUS, O. 2013b. *Value Chain Analysis* [Online]. Available: http://www.strategicmanagementinsight.com/tools/value-chain-analysis.html [Accessed 06.01 2013].

KETELS, C. H. & MEMEDOVIC, O. 2008. From clusters to cluster-based economic development. *International journal of technological learning, innovation and development,* 1**,** 375-392.

KRENZ, P., BASMER, S.-V., BUXBAUM-CONRADI, S. & WULFSBERG, J. P. 2014. Hamburg Model of Knowledge Management. *Enabling Manufacturing Competitiveness and Economic Sustainability.* Springer.

LUBLINSKI, A. E. 2003. Does geographic proximity matter? Evidence from clustered and non-clustered aeronautic firms in Germany. *Regional Studies,* 37**,** 453-467.

LUNDVALL, B.-A. 2009. Innovation as an interactive process: user-producer interaction to the national system of innovation: research paper. *African journal of science, technology, innovation and development,* 1**,** 10-34.

MARSHALL, A. 1920. *Principles of Economics*, Palgrave Macmillan.

NORDEA 2014. Fact Book First Quarter Result 2014.

PORTER, M. E. 1985. Competitive advantage: creating and sustaining superior performance. New York: The Free Press.

PORTER, M. E. 1990. *Competitive Advantage of Nations*, Free Press.

PORTER, M. E. 1998a. The Adam Smith address: Location, clusters, and the" new" microeconomics of competition.

PORTER, M. E. 1998b. *Clusters and the new economics of competition*, Harvard Business Review Boston.

PORTER, M. E. 2000. Location, competition, and economic development: Local clusters in a global economy. *Economic development quarterly*, 14**,** 15-34.

PORTER, M. E. Microeconomics of competitiveness. Faculty Workshop, December, 2010.

REUTERS. 2012. *Skills shortage constrains Norway's oil industry: study* [Online]. Available: http://www.reuters.com/article/2012/11/28/norway-oil-idUSL5E8MS95R20121128 [Accessed 05.01 2014].

REUTERS. 2013a. *Banks raise bar on loans to China shipyards, as Beijing targets overcapacity* [Online]. Available: http://www.reuters.com/article/2013/07/23/us-banks-china-shipyards-idUSBRE96M0D420130723 [Accessed 06.01 2014].

REUTERS. 2013b. *China lays out plans to restructure ailing shipbuilding sector* [Online]. Available: http://www.reuters.com/article/2013/08/05/us-china-shipbuilding-idUSBRE97406I20130805 [Accessed 06.02 2014].

REUTERS. 2013c. *中国造船业前三季产能利用率仅 50%* [Online]. Available: http://cn.reuters.com/article/chinaNews/idCNCNE9A702720131108 [Accessed 06.01 2014].

ROSENDAHL, T. & HEPS , V. 2013. *Integrated Operations in the Oil and Gas Industry: Sustainability and Capability Development*, IGI Global.

ROTHAERMEL, F. T. 2013. *Strategic Management: Concepts*, McGraw-Hill Irwin.

USAID 2008. VALUE CHAINS AND THE CLUSTER APPROACH.

VIEDERYTE, R. 2013. Maritime Cluster Organizations: Enhancing Role of Maritime Industry Development. *Procedia - Social and Behavioral Sciences*, 81**,** 624-631.

VON HIPPEL, E. 2007. *The sources of innovation*, Springer.

WENWEI, Y. 2011. 长三角船舶产业集群及其发展策略——基于生态学的视角. *中国海洋大学学报（社会科学版）***,** 37-40.

WERNERFELT, B. 1984. A resource‐based view of the firm. *Strategic management journal,* 5**,** 171-180.

WIJNOLST, N. 2006. *Dynamic European Maritime Clusters,* IOS Press.

YONGHONG, T. & JUNWEN, F. 2006. 长三角船舶产业集群结构分析与实证研究. *中国造船,* 47**,** 116-124.