ERASMUS MUNDUS MSC PROGRAMME

COASTAL AND MARINE ENGINEERING AND MANAGEMENT
COMEM

MEGA CONTAINER SHIPS:
IMPLICATIONS TO PORT OF SINGAPORE

City University London
25 June 2012

Liyenita Widjaja
110047669 (City University)
4128761 (TU Delft)

The Erasmus Mundus MSc Coastal and Marine Engineering and Management is an integrated programme organized by five European partner institutions, coordinated by Delft University of Technology (TU Delft).
The joint study programme of 120 ECTS credits (two years full-time) has been obtained at three of the five CoMEM partner institutions:

- Norges Teknisk- Naturvitenskapelige Universitet (NTNU) Trondheim, Norway
- Technische Universiteit (TU) Delft, The Netherlands
- City University London, Great Britain
- Universitat Politècnica de Catalunya (UPC), Barcelona, Spain
- University of Southampton, Southampton, Great Britain

The first year consists of the first and second semesters of 30 ECTS each, spent at NTNU, Trondheim and Delft University of Technology respectively.
The second year allows for specialization in three subjects and during the third semester courses are taken with a focus on advanced topics in the selected area of specialization:

- Engineering
- Management
- Environment

In the fourth and final semester an MSc project and thesis have to be completed.
The two year CoMEM programme leads to three officially recognized MSc diploma certificates. These will be issued by the three universities which have been attended by the student. The transcripts issued with the MSc Diploma Certificate of each university include grades/marks for each subject. A complete overview of subjects and ECTS credits is included in the Diploma Supplement, as received from the CoMEM coordinating university, Delft University of Technology (TU Delft).

Information regarding the CoMEM programme can be obtained from the programme coordinator and director

Prof. Dr. Ir. Marcel J.F. Stive
Delft University of Technology
Faculty of Civil Engineering and geosciences
P.O. Box 5048
2600 GA Delft
The Netherlands

School of Engineering and Mathematical Sciences

Mega Container Ships:
Implications to Port of Singapore

by

Liyenita Widjaja

A Dissertation Submitted
in Partial Fulfilment of the
Requirements for the Degree

MSc in Maritime Operations and Management

Supervisor:
Dr. Khalid Bichou

London
June 2012

Declaration

I certify that this dissertation is my own independent work, and I have read and complied with plagiarism guideline as set out by the university. I understand that the university may make use of plagiarism detection software, and I authorise the university to store my work on a database accessible by others.

_____ **Candidate**
Liyenita Widjaja
Date :

_____**Supervisor**
Dr Khalid Bichou
Date :

Project Title: Mega Container Ships: Implications to Port of Singapore

Student: Liyenita Widjaja
Supervisor: Dr. Khalid Bichou
Submission date: 25 June 2012

Abstract

Today, 90 per cent of goods in the world trade are carried by shipping. There is no doubt that seaport is a vital part of shipping. With the technological advancement in ship technology, seaports are also required to catch up in their port technology and management system in order to be able to stay competitive in the market. Shipyards are able to deliver a mega ship within 18 to 24 months while it takes years to planning and developing a new terminal. Mega container ships (Maersk Triple-E class vessels) are due to be delivered next year, and it is foreseen to be deployed in the Asia – Europe route. Singapore is strategically located within the route and hence has a great potential to be one of the port of calls.

This study is based on interviews and a single case study that provides background information and the current state of affair of the port. The information is then further analysed by performing Multi-Criteria Analysis to identify the short term and long term impacts of mega container ships to the port. SWOT analysis is also performed to assess the port's competitiveness in relation to mega container ships.

The study found that mega container ships have positive impacts to the port both in short term and long term. In addition, the port is very competitive, and it has a great potential of attracting mega ships to come by having the supporting assets necessary.

Acknowledgement

The author would like to express her utmost gratitude to her supervisor, Dr. Khalid Bichou, for the opportunity to be able to work in this project. The author would also like to thank him for his continuous support and guidance throughout this project.

The author would also like to thank Assoc. Prof. Chiew Sing Ping, for his help during the author's short visit in Singapore for this project. His support has enabled the author to meet the right people and gather relevant information on time.

The author is also grateful for the opportunity to be a part of CoMEM program, and would like to thank all the personnel involved in organising and putting together such a wonderful program.

Lastly, the author would like to thank her family and friends. Their continuous support and motivation has enabled the author to complete this project.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

AGV	Automated Guided Vehicle
CBD	Central Business District
GDP	Gross Domestic Product
JTC	Jurong Town Corporation
LSCI	Liner Shipping Container Index
MCA	Multi-Criteria Analysis
MOE	Ministry of Environment
MPA	Maritime and Port Authority
PKA	Port Klang
PSA	Port Singapore Authority
PTP	Port Tanjung Pelepas
RBV	Resource Based View
SEA	South East Asia
SWOT	Strength, Weakness, Opportunities, Threat
TEU	Twenty-foot Equivalent Unit
UNCTAD	United Nations Conference on Trade and Development
URA	Urban Redevelopment Authority

Chapter 1 – Introduction

1.1 Background

Today, 90 per cent of goods in the world trade are carried by shipping. Containerization has played an important role in carriage of good by shipping, ever since the introduction in 1950s. Container ship itself has undergone quite a lot of changes, especially in terms of its size. There is no doubt that seaport is a vital part of shipping. All ships need seaports in order to enable them to load and discharge cargo. Hence, with the technological advancement in ship technology, seaports are also required to catch up in their port technology and management system in order to be able to stay competitive in the market. An increasing coherence of the world liner system has been an important consequence of containerisation which, over the last 50 years has benefited from and contributed to the structural expansion of world trade in manufactured goods (McLellan, 1997).

Globalisation has encouraged more investors to build their factories in the developing countries, which lead to a high quality and time competition between the different companies. With increasing production, demand for transportation of the goods also increases, especially from the Far East where most manufacturing takes place nowadays. Liner shipping is a rising method to transport and exchange goods all over the world.

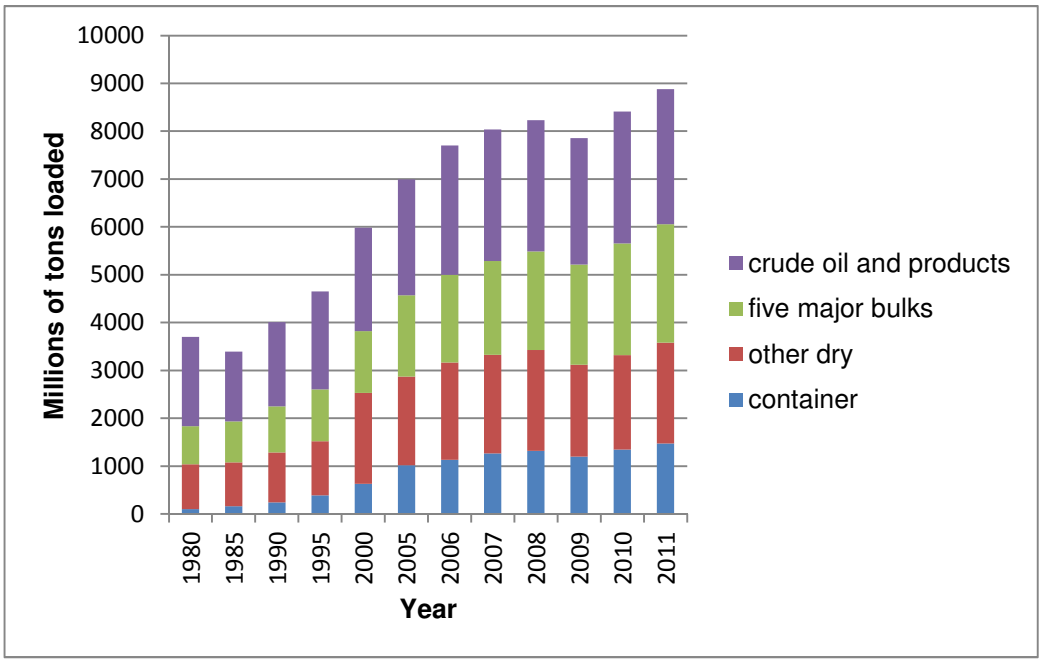

Figure 1 International Seaborne Trade (Source: UNCTAD, 2011)

Twenty ships of 18,000 TEUs capacity (also known as the Maersk Triple-E class vessel) are currently on order, where the first ten ships are scheduled to be delivered on 2013. These ships will be deployed on the Europe – Asia trade (Maersk Line, 2011). Europe – Asia is one of the most important trade lanes, as a result, the container ports in Asia have grown considerably fast, making them the top ports in the world today in terms of container handling. Port of Singapore is strategically located in the Europe – Asia route, and it is the main transhipment hub in the South East Asia region. With the ships coming in the near future, it is important for the port to stay competitive. The main challenge faced by the ports is that implementing new terminal can take years, while shipyards are able to deliver a new mega container ship in only 18 to 24 months, therefore planning is of critical importance (Lloyd's List, 2011). This statement is agreed by Haley (2011), who stated that container lines continue to order larger ships in to achieve 'economies of scale' and lower slot cost, but this poses a challenge to port manager who are not able to expand their container handling capacity as easily and as fast.

For the purpose of this project, we restrict the discussion of the implications to the port operation and management side, concentrating on assessing Port of Singapore's competitiveness in terms of attracting mega ships to come to the port. The analysis will also consider other parties involved in the port operations, e.g. port agencies, liner shipping companies, and academicians.

1.2 Objectives

The main objective of this study is to identify the impacts that mega container ships pose to the Port of Singapore, especially in the port management aspect. This study attempts to assess Port of Singapore's competitiveness as compared to other main ports in the region, in attracting mega container ship. Today, not many ports in the world are able to accommodate ship of this size. Singapore, having the experience of handling large volume and the advanced port infrastructure, hence has a great potential to receive the mega ships. However, the main objective for the port itself is not only to attract mega ship, but also to increase their market share without compromising the profit. Therefore, the order of the project is to first analyse the impact that mega ship would bring to the port, and then to propose appropriate strategies for the port to manage the impacts.

1.3 Scope and Limitations

This study attempts to systematically analyse and present the subject of port operations and management in regards to the port's competitiveness in attracting mega container ships. The scope includes but not limited to the study of the current operation of the port, future port redevelopment plans, and externalities affecting the port operation.

Limitations in this study include practical and analytical issues, including the research design and methodology. The limitations associated with this study are summarized herein:

- This project focused mostly on the competitiveness of Port of Singapore, but it is also important to consider other issues concerning the deployment of mega container ships from the point of view of other parties involved in the operation of this mega container ships;
- The time and size restrictions from the university guidelines for the construction of a Master of Science dissertation, which consequently affects the design of the research, particularly defining the scope and extent of the study;
- Subjectivity issue, especially when using interviews as a mean of collecting primary data. As the interviewees come from different background and interests, they may have different opinions and views regarding the issue;
- Limitations on different types of data available about Port of Singapore's operations, as well as data about the economy of Singapore;
- Validity and generalizability of the research. Since the study only focuses on one port, the findings may not be applicable to other ports.

1.4 Organisation of Report

This report comprises information relevant to the study of the implications of mega container ships to the Port of Singapore. It also recorded the result of a series of interviews conducted to different people related to the port's operation, as well as an analysis of secondary data available from various sources. The information in this report is divided into six chapters, including this first chapter that briefly expresses the needs, objectives, and the extent of this study.

Chapter 2 provides an extensive literature review relevant to the subject of inquiry. This chapter describes the history of development of container ships, followed by an explanation of what is meant by mega container ships in this study, the economics and routing of mega container ships, as well as a wide range of issues and challenges associated to port operation and management.

Chapter 3 reviews the research methodology used in the study. This chapter explains the background information about different research methods, followed by a more detailed description on the research approach applied in the project, including the interviews, single case study, multi-criteria analysis (MCA), and SWOT analysis.

Chapter 4 presents the primary and secondary data obtained in the study. A detailed discussion, analysis, and interpretation of these data are also presented in this chapter.

Chapter 5 concentrates on the MCA and SWOT analysis. MCA analysis is used to determine the impacts of mega container ships to the port, both in short term and long term. Subsequently, SWOT analysis is performed to assess the port's competitiveness and to identify required strategies for the port to deal with the potential impacts.

The last chapter encompasses the summary of results and findings of this study, and provides conclusions and recommendation for further studies on container port operation and management.

Chapter 2 – Literature Review

2.1 History of containerisation

Today, our daily commercial goods can be made anywhere across the globe. The international flow of goods is made possible by containerised shipping, which is a way of packing and moving cargo that has significantly reduced the cost of freight transportation. Containerisation is truly an extraordinary story of how an idea of using standardised size boxes to move goods from origin to destination. Not only has it significantly changed the concept of shipping as a port-to-port enterprise, but it also helped unleash the forces of globalisation. The idea of containerisation was first introduced by Malcom McLean in 1950s. McLean first launched the modern era of containerised shipping by loading 58 reinforced truck trailers, with their wheels and undercarriages removed on the deck of a converted tanker. This ship sailed on 26 April 1956 from Newark to Houston (Donovan & Bonney, 2006).

The basic idea underlying the development of containerisation is the packing of cargo into uniformly sized boxes (containers) and then designing all carrying vehicles, i.e. road, rail, ship, for the rapid, safe and efficient transport of these boxes (Alderton, 2011). Brief history of containerisation is summarized on Table 1.

1950s	First generation container ships (approximately 10,000 DWT) – pre-ISO size containers
1964	First purpose-built container ship – *Kooringa*
1966	First trans-Atlantic container service began, mainly with converted ships
1967	Birth of large container consortia, e.g. ACL (Associated Container Lines), Dart, ACT, OCL
1969	First OCL ship – *Encounter Bay*'s maiden voyage
1970	167 container ships in operation
1971	*The Frankfurt Express* – first Panamax size with more than 2,000 TEUs capacity
1977	507 container ships in operation
1982	718 container ships in operation
1984	'Round the world' service introduced by USL and Evergreen. The ships in the fleet have over 3000 TEUs capacity
2000	2,590 container ships in operation with total DWT 69.1 million tons and average age of 10 years

Table 1 Development of Containerization (Alderton, 2011)

2.2 What is a Mega Container Ship?

The idea of economies of scale, i.e. lowering slot cost with larger ship size is the main driving force behind the evolution in ship size. The evolution of container ship size is described on Figure 2. Mega container ship is the current largest container ship with capacity of up to 18,000 TEUs, 16 per cent more than the previous world record, Emma Maersk with 15,500 TEUs capacity as illustrated on Figure 2. There are twenty ships on order; the first 10 vessels will be delivered 2013 and 2014, followed by the second 10 vessels to be delivered in 2014 and 2015. These ships are owned by Maersk, hence the term 'Maersk Triple-E' class.

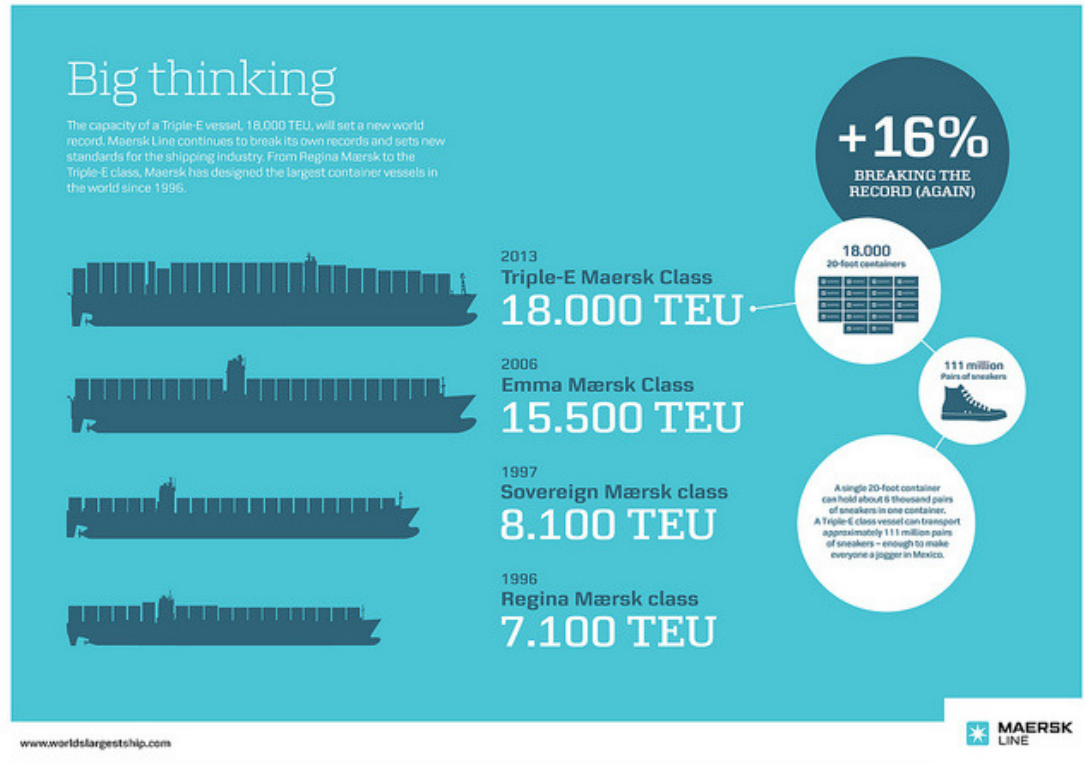

Figure 2 Maersk's container ships evolution

Maersk Triple-E class vessels are expected to be deployed on the same route as its predecessor – Emma Maersk. The specific port of calls for Triple-E class vessels has not been finalised yet, but it is likely that it will revolve around main ports in China, South East Asia, and Europe. Maersk Line believes that demand on the Asia – Europe trade will increase 5-8 per cent per year during 2011 to 2015. By introducing the Triple-E vessels from 2013, Maersk Line will be able to meet the increasing demand as well as to sustain its market share (Maersk Line, 2011).

Triple-E stands for *Energy Efficiency, Economy of Scale*, and *Environmental Performance*. Triple-E class ships are designed and optimised for lower speeds,

unlike Emma Maersk which is designed for higher speed. Lowering the speed from 25 knots to 17.5 knots can reduce CO_2 emission by up to 50 per cent compared to the existing industry average on Asia – Europe trade. It is also equipped with a waste heat recovery system, saving up to 10 per cent of main engine power, making it more energy efficient. Albeit being more energy efficient and environmentally friendly, Triple-E class vessels might not be able to cope with the tight schedule when the demand gets high, due to its lower speed.

Economies of scale is achieved by offering more space, lowering the cost per slot up to 20 – 30 per cent compared to other ships in the Asia – Europe trade. The hull form of Triple-E class ships are also designed to give more container slots. Triple-E vessels' hull shape is more U-shaped compared whereas Emma Maersk's hull is more slender V-shaped. The difference in hull shape with the previous Emma Maersk is shown on Figure 3.

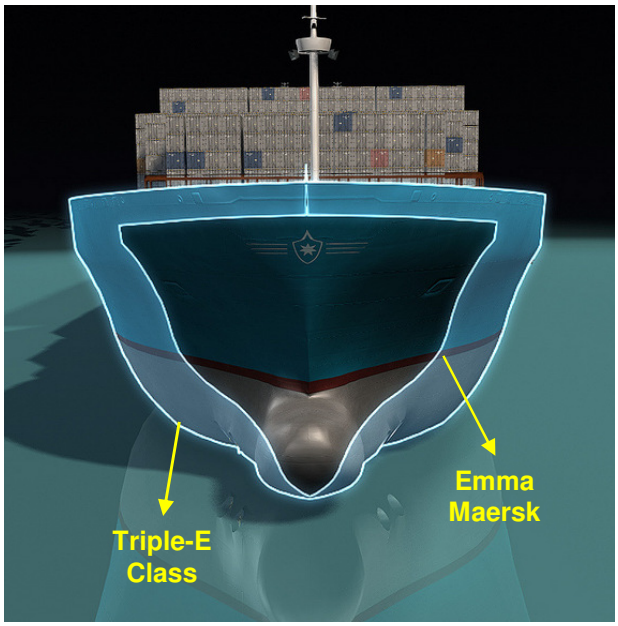

Figure 3 Hull shapes of Emma Maersk and Triple-E Class

The specifications of the ship design are summarized on Table 2.

Length (m)	400
Beam (m)	59
Draft (m)	14.5
Tonnage	165,000 DWT
Max. Speed (knots)	23
Propulsion	Twin MAN engine – 43,000 hp each

Table 2 Technical specification of Maersk Triple-E Class

The driving force behind the trend towards larger container ships is the continued growth in container shipping and increased deployment of mega ships on major trade routes. This trend makes it more difficult when it comes to choosing between hub port and feeder port strategies. The operation of mega ships is a time-sensitive issue, i.e. it is necessary that the ships are loaded at full capacity in order to minimize dwelling time at major hub ports. By recognizing demand growth and assuming that the market share of further demand could be approved by these ships, it is possible to estimate future fleet development (Dragovic, et al., 2009).

2.3 The Economics and Routing of Mega Container Ships

Imai et al. (2006) performed an analysis to determine the economic viability of mega container ships by applying non-zero sum two-person game to analyse competition in shipping industry. The study conducted a comparison between mega container ships operating under hub-and-spoke network to ordinary container ships operating under multi-port-calling network on Asia – Europe and Asia – North America route. It was concluded that for Asia – Europe, mega container ships are competitive. On the other hand, for Asia – North America, mega container ships are found to be viable, only when feeder cost and freight rate are low. By empirical investigation, (Lam & Yap (2011) shown that the choice by liner shipping services to call at a port can be affected by the combined competitive offering of a group of ports instead of a single entity.

With larger vessels, it is even more significant to design the route network, in order to realise a good utilisation of the capacity. Not all ports are able to accommodate the large vessels due to draft, loading and unloading facilities, or capacity restriction. Moreover, it can be inconvenient to call too many ports on a round-trip with the large vessels as each call will incur additional expenses due to the extra time spent in port. This has led to more use of hub and spoke networks, where the hub part is maintained by large vessels, and the spoke part of the network is sustained by smaller feeder lines (Gelareh & Pisinger, 2011).

Routing problem is a complicated issue, as it is concerned not only about the port of origin and destination, but rather designing a complex shipping network in between the two ports. Tran (2011) did an inquiry on port selection on liner routes from logistics perspective, where the efficiency of mega vessels was also determined. The findings from the study indicate that ship cost or port tariff plays only a part in

the total cost of cargo transportation. The deployment of mega vessels does not necessarily mean that the number of port calls will be reduced, but it was found to increase in total. Even though reducing the number of port of calls decreases the ship cost, inventory cost, and port tariff, it is important to note that inland and feeder transport cost may be higher. Mega ships are found to have only a marginal benefit when it is put in an entire network, mainly due to the extra time spent at port, hence increasing ship cost and inventory cost.

Bichou & Bell (2007) performed an analysis on channel conflict and power between ports and shipping lines, where channel is defined as *'the network of organisational contacts a firm operates to achieve its distribution objectives'.* The study found that channel conflicts happens when one member of the channel aims to bring harm or achieving gains at other member's expense by intervening with the latter's goal. There are three types of conflicts identified, i.e. horizontal channel conflicts, inter-type channel conflicts, and vertical channel conflicts. Conflict between ports and shipping lines can be categorised as vertical channel conflict, when there are goal incompabilities between the two members. Ports are seeking maximum utilisation of their infrastructure (cranes, yards, berth, etc) while shipping lines seek for minimum turn around time. A good example of goal conflict between the two is when Maersk opted to shift their transhipment operations from Singapore to Port Tanjung Pelepas as they could not get dedicated berths in Singapore.

2.4 Competition between Shipping Lines

Gadhia et al. (2011) studied the level of internationalisation of shipping lines, and defined 'internationalised' container shipping company port network as including not only the major ports, but also many smaller ports in every region around the world in their network. The study found that there are only 3 shipping lines among the top 19, which are truly 'internatonal', which are Maersk Line, MSC, and CMA CGM. Not only have these 3 global players created networks that span all three core regions, but they also have the most number of ships.

In any business, strategy is a fundamental component in the battle to concurrently gain and defend market share. These strategies include being aggressive, using a complex list of actions, and being unpredictable. According to Warren (1999), companies may involve in three types of rivalry to acquire market share and gain customers within an industry. The first type is the development of potential

customers that can be hasty, but in the long run it will slow down as the group of potential customers begins to shrink. This has the consequence of quickly developing a company's resources and at the same time denies them to competitors. As the industry matures, the second type of rivalry emerges with customers swapping between companies due to improvements, additional attributes, refinement of services and even price-wars. Lastly, the rivalry is for customers that are shared. In the container shipping industry, shipping companies also strive to gain customers and increase their market share. Unfortunately, in a market where the service provided is somewhat homogenous, their competitive options are restricted. They can compete by horizontal expansion, which is acquiring other companies within the industry, and/or by vertical expansion, which is spreading their activities into related areas such as logistics providers, or with other activities such as terminal operators.

The economic crisis of 2008 to 2010 has demonstrated the need for considerable adjustments in the best interests of container lines. Capacities were shifted quickly to emerging and less affected markets to allow a faster recovery of globally organised companies. Panayides & Wiedmer (2011) described the structure and conduct of strategic alliances in container liner shipping. There are numerous forms of alliances in liner shipping. The most pronounced type of alliance is what has been denoted as the strategic or global alliances, which is a fairly new type of co-operative agreement in shipping. Strategic alliances point towards co-operation in the deployment of ships over particular routes including type/size of ship, sailing schedules and itineraries, use of shared terminals and container co-ordination on a global scale. Alliances in shipping do not take in joint sales, marketing or price fixing, joint ownership of assets, combining of revenues or the sharing of profits/losses and joint management and executive functions.

Examples of strategic alliances are the formation of G6 alliance and MSC – CMA CGM partnership in response to the Daily Maersk service. Maersk managed to increase their market share from 21 per cent to 25 per cent since the launch of Daily Maersk service (Leach, 2012). The G6 alliance is projected to have around 24 per cent of Asia – Europe capacity, the same as the MSC – CMA CGM partnership, with Maersk Line's independent operation consisting of about 18 to 19 per cent of capacity (Barnard, 2012).

2.5 Port of Singapore

Singapore is an international maritime centre; it is home to more than 120 domestic shipping groups, contributing to some 7 per cent of Singapore's gross domestic product, and employing more than 170,000 people. Despite the uncertain economic climate in Europe and other part of the world in 2011, Singapore managed to maintain its position as the second busiest container port in the world, handling up to 735 million DWT container ship calls, 29.4 million TEUs, and registered growth of 6.1 per cent, reaching a new record volume in the year (Lloyd's List, 2012). In 2012, Singapore handled 7.5 million TEUs in the January through March period, up 6.6 per cent compared to the same period in the previous year, making Singapore tied with Shanghai. Shanghai also posted 7.5 million TEUs in throughput for the first quarter of 2012, but that figure only represented an increase of 3 per cent over the same quarter in 2011 (Leander, 2012).

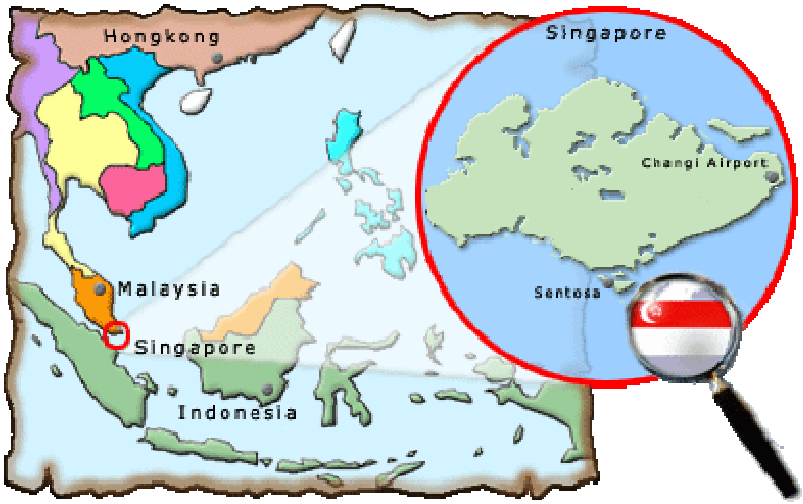

Figure 4 Singapore's strategic location

As the Triple-E class vessels are to be deployed on the Asia – Europe route, Singapore has the advantage of its strategic location in the route, as almost all ships trading on Asia – Europe route will pass through the Strait of Malacca, and subsequently through Singapore. Port of Singapore has two container terminal operators, i.e. Port of Singapore Authority (PSA) and Jurong Port. In terms of container handling, PSA accounted for about 98 per cent of the market share in 2004, while Jurong Port picked up most of the remaining 2 per cent. PSA Singapore is a wholly owned subsidiary of Temasek Holdings (Private) Limited, which is a government-owned investment holding company. Jurong Port is 100 per cent owned by Jurong Town Corporation (JTC), which is a statutory board under the purview of the Ministry of Trade and Industry under the government of Singapore (Lam & Yap,

2008). The terminal operators are controlled by the Maritime and Port Authority of Singapore (MPA), who sets the regulations and standards for the port operation. The port of Singapore has established itself as the region's premier container hub port. The port ranks second in the world in terms of container traffic (Containerisation International, 2011), and it is among the world's busiest container ports in Asia region are shown on Table 3.

Rank 2011	Rank 2010	Rank 2009	Port	Country	Throughput 2011 (TEUs)	Throughput 2010 (TEUs)
1	1	**2**	Shanghai	China	31,700,000	29,069,000
2	2	**1**	Singapore	Singapore	29,937,700	28,431,100
3	3	**3**	Hong Kong	China (SAR HK)	24,404,000	23,699,242
4	4	**4**	Shenzhen	China	22,569,800	22,509,700
5	5	**5**	Busan	South Korea	16,184,706	14,194,334
6	6	**7**	Ningbo	China	14,686,200	13,144,000
7	7	**6**	Guangzhou	China	14,400,000	12,550,000
8	8	**8**	Qingdao	China	13,020,000	12,012,000
9	9	**9**	Tianjin	China	11,500,000	10,080,000
10	10	**10**	Kaohsiung	Taiwan	9,636,289	9,181,211
11	11	**11**	Port Klang	Malaysia	9,603,926	8,870,000
12	12	**12**	Tanjung Pelepas	Malaysia	7,500,000	6,530,000

Table 3 World's busiest container port – Asia region (Source: Containerisation International)

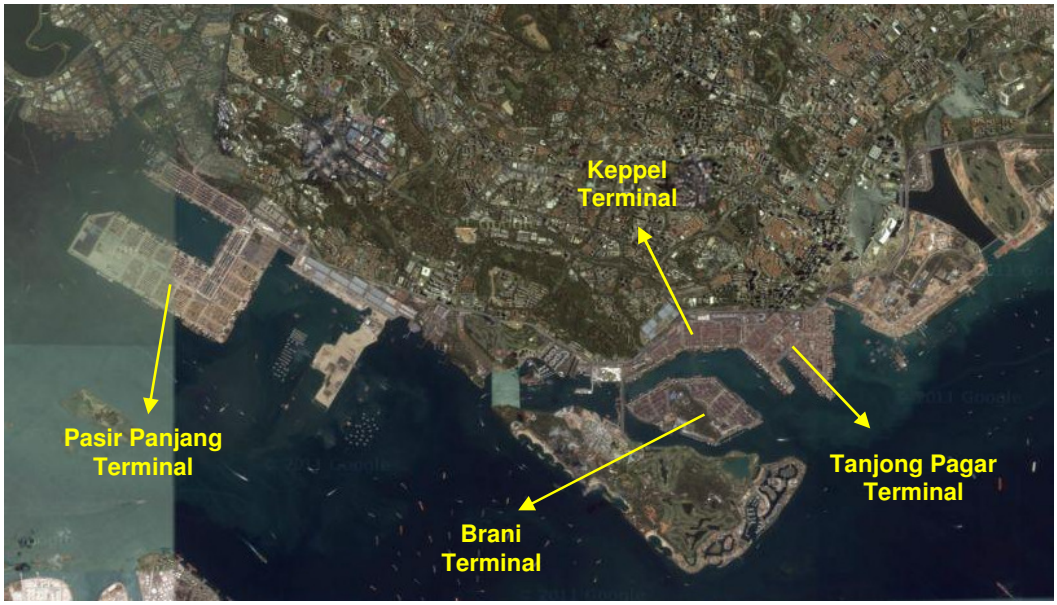

Figure 5 Port of Singapore Layout

About 85 per cent of the traffic handled in the Port of Singapore is transhipment, which is expected, given the size of domestic market in Singapore (PSA Corporation). To maintain its position as the region's hub port, the port of Singapore has adopted a two-pronged strategy: capitalizing on its area of comparative strengths, and forging more cooperative alliance with other ports (Sien, et al., 2003).

PSA Singapore Terminals runs 4 container terminals (Figure 5) at Tanjong Pagar, Keppel, Brani and Pasir Panjang, with a total of 54 container berths. All these terminals operate as one seamless and integrated facility. Pasir Panjang Terminal is the most advanced terminal, with berths up to 16 metres deep and with quay cranes capable of reaching across 22 rows of containers to accommodate the world's largest container ships. The terminal's bridge crane system also allows each operator to handle up to six cranes. The current design capacity of the terminals is 35,000,000 TEUs. Details of each terminal's facilities are given on Table 4.

	Pasir Panjang	Tanjong Pagar	Keppel	Brani
Container berths	23	8	14	9
Quay length (m)	7,900	2,300	3,200	2,600
Area (ha)	335	85	100	80
Max. depth at chart datum (m)	16	14.8	15.5	15
Quay Cranes	87	29	42	32

Table 4 Port of Singapore's terminal facilities

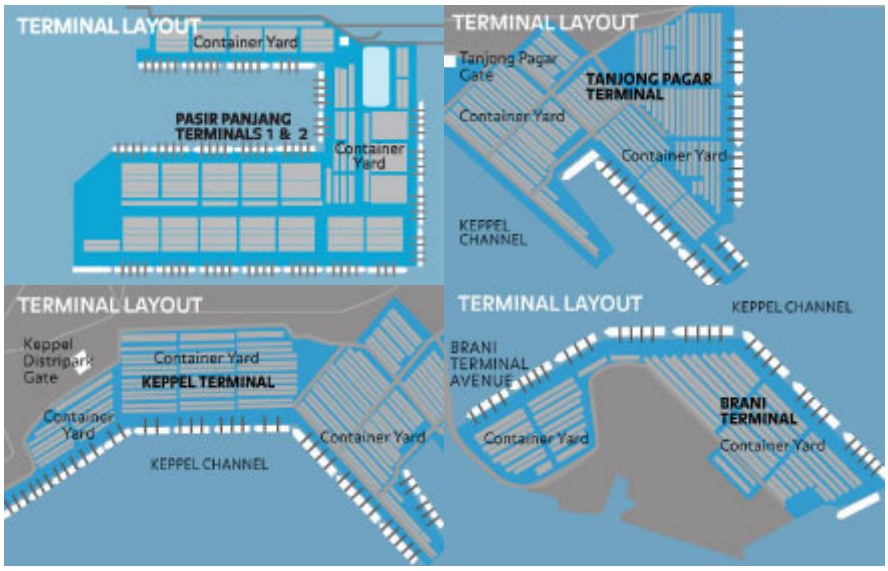

Figure 6 Individual terminal layout

Compared to other ports, the Port of Singapore has realised a sustainable competitive advantage by forming a set of resources that other ports would find very challenging to match. These resources consists of natural resources (naturally sheltered harbour and deep access channel), other resources can be replicated at a cost (comprehensive infrastructure and well-trained personnel), and some others are particularly valuable in Singapore, but less useful in other ports (scheduling

systems for multiple cranes to handle the complexity of multi-tier stacking of containers) (Gordon, et al., 2005).

2.6 Port Competition in South East Asia

As a node in supply chain systems that meet between hinterlands, the performance of a port will affect the economic development of both the origin and destination surroundings, as well as having a direct influence on the competitive advantage of the port's users (Lam & Yap, 2011). According to Voorde & Winkelmans (2002), seaport competition refers to "*competition between port undertakings, or as the case may be terminal operators (the competing players involved in the organisation of entire transport chains) in relation to specific transactions (the object, taking into account the origin and destination of the traffic flows concerned*)." Port competition can be extended further to three different levels:

- Level 1: competition between operators with regard to a specific traffic category and within a given port, i.e. intra-port competition at operator level
- Level 2: competition between operators from different ports, i.e. inter-port competition at operator level
- Level 3: competition between port authorities, i.e. inter-port competition at port authority level

The competitive environment for container ports has changed significantly in recent years especially in the area of container shipping. In this business, a port will acquire a significant share of the business only when it can exhibit a combination of attractive rates, infrastructures, and inland connection that create a clear competitive advantage for a specific group of customers (Dragovic, et al., 2009).

Until the late 1970s, most ports in the world were operated and managed within a relatively limited competitive environment. Geographical location and the depth of navigational channel were sufficient to provide the port with a competitive advantage. However today, a port's competitive edge is recognised by the provision of high quality and value added service to ship and cargo interests using the port (Institute of Chartered Shipbrokers, 2011). Singapore is one of the largest and busiest ports in the world, and it is also one of the main hub ports for transhipment. It is located strategically on the Asia – Europe trade route, which is one of the main trade routes in world trade. As vessel grows in size, liners tend to call on fewer ports

as compared to smaller ships therefore it is of critical importance to remain competitive for future traffic of mega container ships.

Lam & Yap (2008) performed annualized slot capacity analysis to Port Klang, PTP, and Port of Singapore to describe the competition dynamics between ports in Southeast Asia in a quantitative manner. The analysis found that the competition from Port Klang and PTP has a negative impact on Singapore's transhipment performance, with PTP found to be the greatest challenge to Port of Singapore. On 18 August 2000, Maersk announced that they were going to move all transhipment operations from Singapore to Port Tanjung Pelepas (PTP) in Malaysia.

Container ports in Southeast Asia accounted for an approximately 30 per cent of the world's transhipment traffic in 2004. It is expected that the share of the region's transhipment trade will rise to 32.5 per cent in 2015. The prospect offered by this large and expanding market encouraged major container terminal operators located in the region to compete intensively for this business by attracting major container shipping lines that operate along key east–west sailing routes to hub at their terminals (Lam & Yap, 2008).

2.7 The Challenges to Ports Imposed by Mega Container Ships

Ports are the points where international markets and national economies meet. Therefore the governments are challenged to integrate the social and economic development of their countries while adequately managing the international trade and technological developments (UNCTAD, 1996). The development of new vessel technology and growth in vessel sizes has a significant effect on the design and provision of new port facilities. Issues incorporated to the issue range from the requirements of navigational access, i.e. channel width and depth and air draft issues, and further extends to the landside operations and space requirements within the port area (Cork & Holm-Karlsen, 2002).

Based on a study done by Baird (1999), container carriers suggested that terminal operators have to provide more cranes / ships, install larger / faster cranes (both in yard and quay), increase terminal stacking capacity, introduce terminal automation, and deepen the berth / channel depth to be able to effectively handle next generation ships. The statistics of the growth of container ships are given on Figure 7 and Table 5.

Christian Moller Laursen, Vice President and CFO of APM Terminals, stated that the challenges of larger container vessels will require ports to leap into the 'next league' in design, development and management. He further elaborated that designing and implementing new terminal can take years, while shipyards are able to deliver a new mega container ship in only 18 to 24 months, hence planning is of critical importance (Lloyd's List, 2011). This statement is agreed by Haley (2011), who stated that container lines continue to order larger ships in to achieve 'economies of scale' and lower slot cost, but this poses a challenge to port manager who are not able to expand their container handling capacity as easily and as fast.

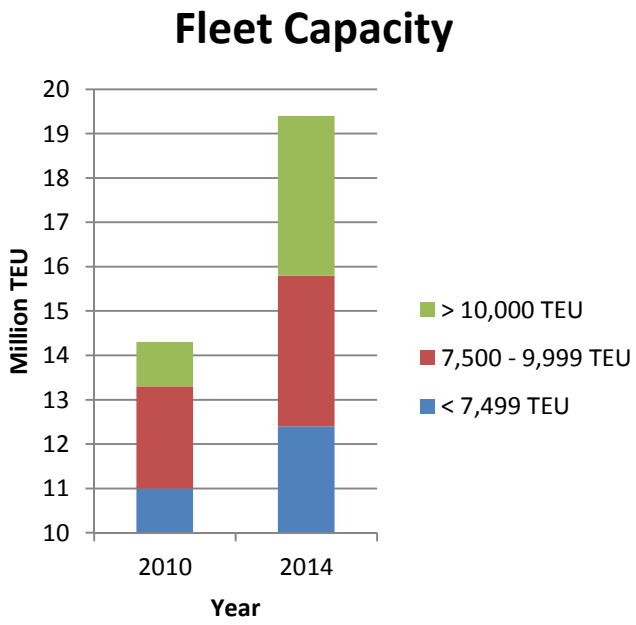

Figure 7 World container fleet development to 2014 (Source: Lloyd's List, 2011)

TEU Size range	In service today		On order 2011		On order 2012		On order 2013		On order 2014		On order 2015		Total on order	
	Ships	TEU	Ships	TEU	Ships	TEU	Ships	TEU	Ships	TEU	Ships	TEU	Ships	TEU
0-1,499	1,852	1,501,002	26	22,048	36	33,588	26	22,646	0	0	3	0	91	78,282
1,500-2,999	1,296	2,799,021	12	23,944	25	54,201	44	93,078	0	0	1	1,700	82	172,923
3,000-4,999	946	3,818,773	22	88,798	67	284,251	59	243,633	4	19,068	0	0	152	635,750
5,000-7,999	589	3,535,740	10	63,130	28	183,456	29	184,146	1	6,600	0	0	68	437,332
8,000-9,999	257	2,203,983	3	25,139	26	218,473	54	460,844	27	231,356	0	0	110	935,812
10,000-12,499	38	414,458	4	45,000	14	154,462	2	20,000	6	60,124	3	30,000	29	309,586
12,500-15,999	64	875,490	11	144,608	49	649,407	25	330,954	24	314,650	0	0	109	1,439,619
Over 16,000	0	0	0	0	6	96,000	5	90,000	8	144,000	7	126,000	26	456,000
Total	**5,042**	**15,148,467**	**88**	**412,667**	**251**	**1,673,838**	**244**	**1,445,301**	**70**	**775,798**	**14**	**157,700**	**667**	**4,465,304**

Table 5 Shipbuilding Statistics (Source: Containerisation International)

Today, liner carriers and container terminal operators have become a very crucial part in the international supply chains, which includes complex logistics models. The development in supply chains and logistics models encourages liner carriers and container terminals to reassess their role in the logistics process, shown by the trends in mega ships and mega container cranes in ports. These performances require new ideas and concepts in container terminal planning, so as to catch up with the development of the mega container ships (Dragovic, et al., 2009)

2.8 Models from Previous Studies

2.8.1 Resource Based View Analysis

Gordon et al. (2005) did a resource-based view (RBV) analysis to assess the competitive advantage at the Port of Singapore. The RBV theory defines firm resources as *"all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm",* and proposes that a firm has a competitive advantage when it creates a successful strategy based on firm resources that cannot be duplicated by a current or potential competitor. He believed that RBV helps explain and interpret the contribution of technology to the Port of Singapore. RBV was used in the analysis to assess the resources owned by PSA that cannot be created or substituted by its competitors, hence creating a competitive advantage for PSA.

2.8.2 Port Performance and Efficiency Model

It is evident that ports form a vital relation in the overall trading chain. As a result, port's performance and efficiency will determine its international competitiveness to a large extent. Hence, it is of critical importance to understand the determining factors of port competitiveness, and to assess its performance relative to other ports in order to formulate appropriate business strategies (Tongzon, 1995).
Tongzon (1995) attempted to quantify port performance and efficiency, by looking at throughput and evaluate efficiency depending on a specific port operation. For container terminal, port efficiency is measured by the number of containers loaded and unloaded when a ship is at berth. He further outlined the determinants of port throughput which are port location, frequency of ship calls, port charges, economic activity, and terminal efficiency. As for terminal efficiency, the determinants are container mix, work practices, crane efficiency, and vessel size and cargo exchange

(economies of scale). The functional relationship can be expressed with the following equations:

$$TH = f\,(LOC, FS, EA, CH, E)$$
$$\quad\;\; + \quad + \quad + \quad - \quad +$$

$$E = g(CONMIX, BRLWT, GWLN, CHWH, TEUCH, CE)$$
$$\quad\;\; + \quad\quad - \quad\quad - \quad\quad + \quad\quad + \quad\quad +$$

Where:

TH = number of containers (TEU) in a year;
LOC = location represented by a dummy variable;
FS = frequency of ship calls (all);
EA = level of economic activity measured by respective countries' GDP
CH = average government and port charges;
E = terminal efficiency (i.e. average number of containers per berth hour);
CONMIX = average container mix represented by the proportion of 40-foot containers;
BRLWT = average delays in commencing stevedoring represented by the difference between the berth time and gross working time;
GWLN = average delays during stevedoring represented by the difference between gross working and net working time;
CHWH = average crane hours per working hours;
TEUCH = average crane productivity represented by the number of containers lifted per crane hour;
CE = average vessel size and cargo exchange.

The positive and negative signs below the variables specify the expected direction of the effect of independent variable to the function. For the purpose of determining port performance and efficiency, the functions are expressed as follows:

$$TH = A\, LOC^{\alpha 1}\, FS^{\alpha 2}\, EA^{\alpha 3}\, CH^{\alpha 4}\, E^{\alpha 5}$$

$$E = A\, CONMIX^{\beta 1}\, BRLWT^{\beta 2}\, GWLN^{\beta 3}\, CHWH^{\beta 4}\, TEUCH^{\beta 5}\, CE^{\beta 6}$$

where A is a constant term, and the error terms are assumed to be normally distributed with constant variances. The study found that crane productivity has a dominant contribution to terminal efficiency.

2.9 Conclusions from Literature Review

Based on the literature review and theoretical background presented on this chapter, some hypotheses can be drawn to respond to the research question of

current inquiry. It appears that there is a close relationship between the shipping lines and ports, as they have powers and influence over each other. In terms of operation, bigger vessel may offer greater efficiency for the port. The author aims to analyse the impacts of mega container ships to Port of Singapore, both in short term and long term, focusing on the port's competitiveness as well as the impact to the Singapore community in general. Analysis on the port's current operations and future development plan and strategies is performed to determine the port's competitiveness in the region, whether or not the mega ships will call to Port of Singapore. The next chapter provides a complete description of research methodology and approaches applied by the author in conducting the research process.

Chapter 3 – Research Methodology

In order to obtain a meaningful result for further analysis, an appropriate research methodology has to be designed and planned prudently. Failing to do so will definitely undermine the overall quality of research, and may even create a misleading outcome of the whole investigation. It is therefore of utmost importance to make sure that the adopted research methodology is suitable to achieve the objectives of the project.

In previous chapter, a few models from previous studies were presented and deliberated briefly. This chapter elaborates the research methods which will be applied in this inquiry.

First of all, it is important to identify whether the research is characterized as a 'qualitative' or 'quantitative' research. What is the definition of qualitative research and quantitative research, and how do they differ from each other? Silverman (2010) identified the differences in methodology used in quantitative and qualitative research as summarized in Table 6.

	Methodology	
Method	**Quantitative research**	**Qualitative research**
Observation	Preliminary work, e.g. prior to framing questionnaire	Fundamental to understanding another culture
Textual analysis	Content analysis, i.e. counting in terms of researchers' categories	Understanding participants' categories
Interviews	'Survey research' : mainly fixed-choice questions to random samples	'Open-ended' questions to small samples
Transcripts	Used infrequently to check the accuracy of interview records	Used to understand how participants organize their talk and body movement

Table 6 Different uses for four methods (Source: Silverman, 2010)

Most qualitative studies are concerned with interpretation and understanding, whereas many quantitative approaches deal with explanation, testing of hypothesis, and statistical analysis (Eriksson & Kovalainen, 2008). In this study, a qualitative

research approach will be adopted, along with some quantitative analysis of secondary data.

3.1 Sources of Data

3.1.1 Primary Data: Interviews

Most qualitative studies are constructed on asking respondents questions or making observations in the field. Interview studies which are based on a relatively small number of cases and use open-ended questions are usually considered as examples of qualitative research. Qualitative interview studies tend to be conducted with small numbers and with rather informal pattern of questioning where the interviewee is allowed to set the pace of the interview. (Silverman, 2010).

First hand-data gathering collects data from primary sources for the first time as part of an experiment, survey, or personal observation (Beach & Alvager, 1992). For the purpose of this study, primary data are obtained directly from the subjects involved in the subject matter, in this case, different organizations and / or individuals involved either directly or indirectly in port operations, through the use of interview studies. For container terminal operation, these organizations comprise of port authority (the regulator), port operator, shipping lines, etc. In this study, the author attempted to interview people from MPA, PSA, and also maritime academic experts to gain a better insights and wider perspective to the problem.

Primary data has the benefit of being more representative of the state of affairs as the researcher who gathers the information is aware of the condition under which the data is acquired. However, it is normally assumed that there may be ambiguities in this process – confusions of the meanings attached by the researcher and those understood by the subject (Beach & Alvager, 1992).

3.1.2 Secondary Data: Single Case Study

Case study research has a long history across academic disciplines, with the central feature of the construction of ‘the case’ or ‘several ‘cases’. The main purpose of case study is to investigate the case in relation to its historical, economic, technological, and social context (Eriksson & Kovalainen, 2008).

Secondary data are data that have been collected previously and reported by some individual other than the researcher (Beach & Alvager, 1992). This data are usually readily available to be accessed in the form of books, documents, reports, Internet source, or other media. In this study, the numerical (quantitative) data about ports, especially on container terminals, alongside data concerning the economy of Singapore, are obtained from reports and online sources, where most of the statistical data about Singapore are obtained from the Department of Statistics Singapore website.

3.2 Data Analysis

3.2.1 Primary and Secondary Data Analysis

The main questions addressed when collecting primary and secondary data are designed such that the data would reflect the current state of the port and any foreseeable redevelopment plans. The data is selected in order to enable the author to assess the short term and long term impact, as well as to identify the port's competitive position. However, the data availability and collection are restricted by the number of respondents of interview, and the confidentiality restriction from the port's personnel. Therefore, all numerical data are collected from external resources, and not directly from the port authority.

The analysis of primary data provides an insight of the port's current operation, in conjunction with the port's redevelopment plans. The secondary data describes the performance of port of Singapore over the past decade. The analysis attempts to recognise the trend in the economy, consequently identifying the potential impact that it may bring in relation to port operation.

3.2.2 Multi-Criteria Analysis (MCA)

Multi-criteria analysis establishes preferences between different alternatives with reference to a set of objectives that has been identified beforehand, and for which it has created quantifiable criteria to evaluate the extent to which the objectives have been realised. MCA techniques can be used to identify a single most preferred alternative, to rank a number of alternatives, to select a limited number of alternatives for further assessment, or simply to differentiate acceptable from unacceptable possibilities. MCA puts emphasis on the judgement of the decision makers in establishing objectives and criteria. In addition, it is also the decision

makers who will assign the relative importance weights and judge the contribution of each alternative to every performance criterion. Hence, subjectivity is a matter of concern (Department for Communities and Local Government, 2009).

A standard feature of MCA is a performance matrix, or consequence table, in which each column describes an alternative and each row describes the performance of the options against each criterion. The individual performance assessments are often numerical, but may also be expressed as 'bullet point' scores, or other codes. The MCA process is described graphically on Figure 8.

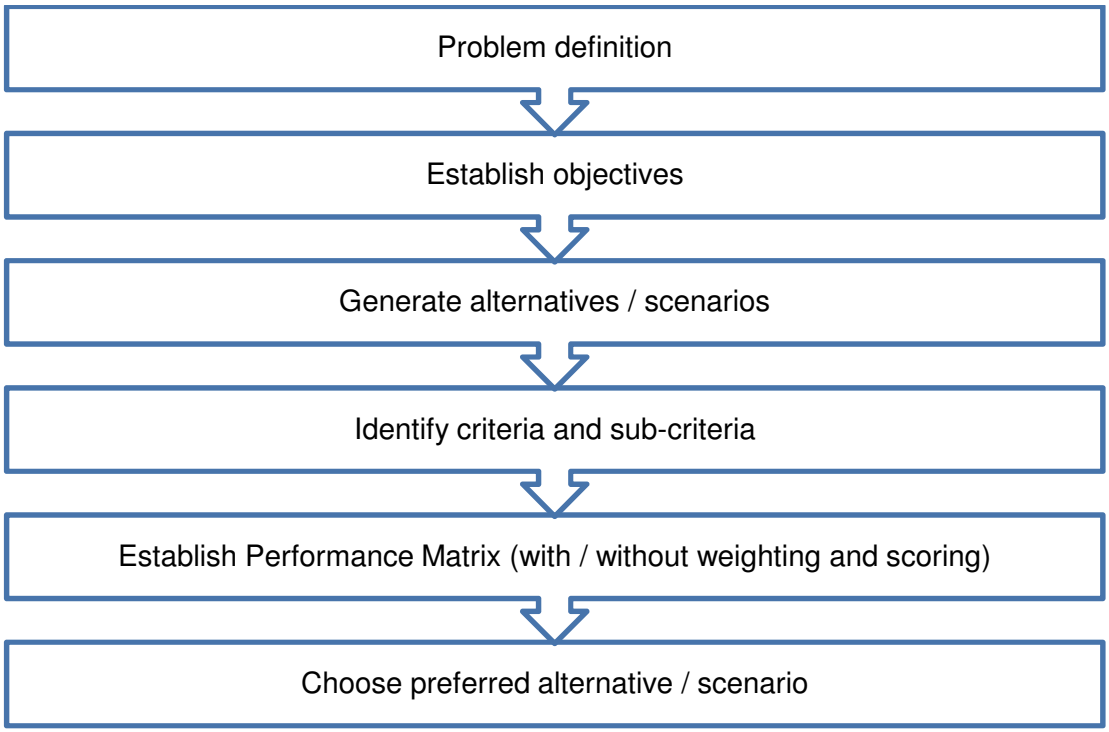

Figure 8 MCA Flowchart

In this study, MCA is used in order to differentiate the short term and long term of mega container ships to the port's operation, as well as to the Singapore community in general. The author aims to apply four different scenarios to determine the impact of mega container ships to the Port of Singapore, using different evaluation criteria, based on various stakeholders' interests. As the route followed by the Triple-E class vessel is not yet finalised, the scenario will take into account the possibility that the ship may or may not be calling to port of Singapore. The first two scenarios will determine the short term impact to the port, where the port is operating at its current state. On the other hand, the other two scenarios will identify the long term impact of mega container ships to the port, as there is currently a port expansion and relocation plan. Details on the extension and relocation plan are explained in Chapter 4.

3.2.3 SWOT Analysis

Port competition strategy must be built by identifying the sources of competitive advantage. A good technique to understand competitive advantage is to undertake a SWOT (Strength, Weakness, Opportunities, Threat) analysis, which is a strategic planning method to determine the strengths, weaknesses, opportunities, and threats in relation with a business practice or a project.

The purpose of SWOT analysis is to identify the key external and internal factors that are important to achieving a set of objectives of an organization, or a project. One important point after conducting SWOT analysis is to matching strengths to opportunities, as well as to convert weaknesses or threats to strength or opportunities. A scan of internal and external setting is therefore a crucial part of the process. Strength and weaknesses are internal factors, they are skills and assets (or lack of them) that affects the value of the company, relative to other competitive factors. On the other hand, opportunities and threats are external factors, which are not created by the company itself, but they are a result of fluctuations in market dynamics or activities of competitors (Assen, et al., 2008). Opportunities and threats can both be classified according to its potential impact and probability as described on Figure 9.

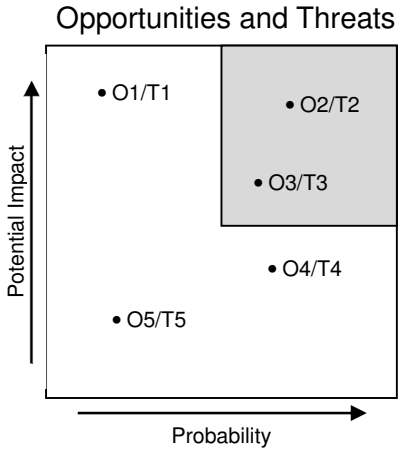

Figure 9 Impact and Probability Analysis (Source: Assen, et al., 2008)

In the case of port, the strengths and weaknesses relate to internal factors of the port, while the opportunities and threats relate to external factors. The main factors determining a port's strengths and weaknesses are location, nautical constraints, hinterland transport connection, physical assets of the port, port and distribution costs, experience and know-how, manpower, performance, adaptability and

resource, complementary and value-added services. On the other hand, factors contributing to opportunities and threats to a port are market identification, assessment of the port's customers' value chain, technological assessment, and legal and regulatory assessment (Institute of Chartered Shipbrokers, 2011).

The four elements of a SWOT can then be constructed in a SWOT matrix, which is shown of Figure 10. After identifying the four elements, the organisation is then able to identify appropriate strategies based on the identified strengths, weaknesses, opportunities, and threats. There are four different strategies which can be adopted based on the SWOT matrix, i.e. the SWOT strategies matrix, as shown on Figure 11.

	Helpful (to achieving the objectives)	Harmful (to achieving the objectives)
Internal Origin (attributes of the organization)	**S**trengths	**W**eaknesses
External Origin (attributes of the environment)	**O**pportunities	**T**hreats

Figure 10 SWOT Matrix

In this study, the author attempts to apply SWOT analysis to Port of Singapore to assess the competitiveness of Port of Singapore, in relation to mega container ships. In addition, different strategies are also presented and analysed in order to get a better impression on the current situation.

	Strengths (S)	Weaknesses (W)
Opportunities (O)	***SO strategies*** using strengths to take advantage of opportunities	***WO strategies*** taking advantage of opportunities by overcoming weaknesses or making them relevant
Threats (T)	***ST strategies*** Using strengths to avoid threats	***WT strategies*** Minimising weaknesses and avoiding threats

Figure 11 SWOT strategies matrix (Source: Assen, et al., 2008)

3.3 Research Validity, Reliability, and Generalizability

Due to the nature of the primary and secondary data, the result and analysis validity and reliability are limited to a certain extent. For the primary data, as it is collected from different people with different background and interests, the results may be subjective depending on the interest of each individual or organization. 'Open-ended' questions may leave respondents a little unsure of what to respond, or with less time to consider their response (to the question). As for the secondary data, data are collected through existing resources that are reliable to a certain extent. It is not possible to claim a perfectly valid research, nonetheless the implementation of a well-thought-out methodology should minimise invalid results and conclusions.

A port-type research project may involve many aspects of the port operation. As the study concerns only one port, it is hard to assure the generalizability of the study. However, the same methods of analysis may be applied to other ports with adjustments, depending on the objectives of the port of concern.

The next chapter presents the products of the methodologies adopted. All the information gathered from interviews, the data analysis and interpretation are presented accordingly.

Chapter 4 – Data Collection, Analysis and Discussion

Earlier in this paper, it was mentioned that the focus of this study is the impact of mega container ships to the Port of Singapore, focusing on the port's competitiveness. The first batch of mega ships will be delivered in 2013, which is relatively in the near future, and it will be deployed in the Asia – Europe route. However, Maersk has not yet finalised and published the list of port of calls for the ship, and since Singapore is strategically located within the route, Singapore has a great potential of being one of the ports of call, given the advanced facilities and efficiency that it possesses.

In this chapter, results from interviews as a primary data are presented, in addition to a quantitative analysis of secondary data available from internet sources. For simplification purpose, Port of Singapore will be referred as PSA, Port Klang as PKA, and Port Tanjung Pelepas as PTP throughout this chapter.

4.1 Results from Primary Data: Interviews

This section deals with data obtained directly from participants from different background and interests with respect to the subject of inquiry. The author conducted personal interviews in order to obtain relevant information.

The author had the chance to visit Singapore to interview a number of individuals who are involved (directly or indirectly) to PSA's operation. Subjects of interview vary from academician, ex-port authority, and port agency. The main concern that the author encountered when trying to contact PSA personnel is that they are reluctant to release information to research students. From the interviews, it is found that different organisations have different interests on the subject, due to the diverse nature of port operation itself. In this study, responses were obtained from 4 interviewees, with the list of interviewees presented on the Appendix. This section encapsulates the outcome of the interview regarding PSA's current operation and future redevelopment plan, as well as the potential of mega container ships calling at PSA.

In Singapore, the responsible authority for planning port design and location are the Urban Redevelopment Authority (URA), and the Maritime and Port Authority (MPA). Port of Singapore Authority (PSA) is solely the operator of the port. PSA used to run

the Singapore ship registry until 1996 when PSA was corporatized and became PSA Corporation Limited. Now, all ship registries are governed by MPA.

URA and MPA have decided to relocate all the port operations at the terminal at the city area (Tanjong Pagar, Keppel, and Brani Terminals) to Tuas area on the west end of Singapore, which is the industrial area of Singapore. The terminals in central Singapore are projected to be developed to a multi-million resorts, commercial and residential area, just like the Resort World Sentosa which has casino, hotels, theme parks, etc. This port redevelopment and relocation project is expected to be completed in 2025. The main reason underlying this plan is the increasing land price, especially around the CBD area where the terminals are currently located. It is evident that in Singapore, one of the biggest problems is the scarcity of land. Singapore has extended its area from 581.5 square kilometres in 1960s to 710 square kilometres today, by land reclamation.

The redevelopment plan of the port, where the Pasir Panjang terminal will be expanded is shown on Figure 12. With this extension, Singapore expects to expand their container terminal handling capacity by 14,000,000 TEUs; foreseeing up to 50,000,000 TEUs design capacity. The new terminals will also be equipped with power plugs for ships at berth in order to save bunkers for power supply when ships are at berth.

Figure 12 Pasir Panjang terminal extension plan

Figure 13 Keppel, Tanjong Pagar, and Brani terminal relocation plan

The central quality that Singapore has is connectivity. As Singapore is a major transhipment hub, it has a lot of sailing frequencies daily to numerous major and minor ports across the world. PSA is also more experienced in handling big volume, making it superior to its main rival in the region, PTP and PKA.

For port agents representing shipping lines other than Maersk Line, if the mega ship is to call at port of Singapore, this will have a negative influence to their market share as it will bring about more competition. Maersk Line is already trying to increase their market share by introducing the daily Asia – Europe service, so called the 'Daily Maersk'. In response to this, smaller shipping lines form alliances and / or mergers in order to maintain their market share. For Maersk Line itself, the introduction of this mega ship will necessitate the company to improve their shipping network and catchment area to fill up the capacity of the ship. Otherwise, economies of scale will not be achieved.

PSA has a high efficiency rate, together with a very advanced IT system (e.g. PORTNET®, CITOS). PSA has attempted to make the port fully automated by deploying Automated Guided Vehicle (AGV) in the port, but it was not successful. It was found that AGV is not as flexible compared to manpower, when change is necessary, given the big volume that PSA is handling. If mega ships come to PSA, it will surely be able to handle them. Besides, if the mega ships call at port of Singapore, it will obviously increase PSA container throughput, which will create more revenue for the port operator (PSA). But for MPA, they are not really concerned about the throughput. Instead, MPA is more concerned about the number of ship arrivals to the port.

Asia's economy is currently growing at a relatively fast pace. The economic outlook for Asia – Europe trade is foreseen to be growing in the next few years, hence there is a great potential that if the mega ship comes to Singapore, it will boost the economy.

4.2 Results from Secondary Data: Single Case Study

This section describes the state of affairs of PSA and Singapore's economy for the past decade, encompassing quantitative data obtained from statistics data. The author attempts to evaluate the port's performance from previous data, analysing the trends, and consequently foreseeing possible future settings.

As has been discussed in previous chapters, Singapore is the main transhipment hub in South East Asia (SEA) region. The port facilities are described on Chapter 2, and the port is currently undergoing redevelopment with extension of Pasir Panjang terminal. Singapore's container throughput and economic data from the year 2005 are summarized on Table 7.

	Throughput		Vessels Arrival	LSCI	GDP Growth	Export		Import	
	Volume	Growth				Value	Growth	Value	Growth
2005	23,192,200	6.9%	18,415	83.87	7.4%	387,554.3	10.7%	341,383.8	8.2%
2006	24,792,400	12.7%	19,161	86.11	8.8%	431,559.2	11.3%	378,924.1	11.0%
2007	27,935,500	7.1%	19,946	87.53	8.9%	463,402.8	7.4%	403,343.5	6.4%
2008	29,918,200	-13.5%	20,589	94.47	1.7%	477,371.5	3.0%	442,217.5	9.6%
2009	25,866,600	9.9%	18,005	99.47	-1.0%	428,388.2	-10.3%	385,902.8	-12.7%
2010	28,431,100	5.3%	18,967	103.76	14.8%	519,026.4	21.2%	448,280.9	16.2%
2011	29,937,700	8.7%	19,290	105.02	4.9%	533,608.1	2.8%	453,844.5	1.3%

Table 7 Singapore's container traffic and economic indicators (Source: Department of Statistics Singapore, 2012; UNCTAD, 2011)

Liner Shipping Container Index (LSCI), is a measure of a country's integration level to global liner shipping network, where index 100 is the highest score based on China's LSCI on 2004. The current version of the LSCI is generated from five components, namely the number of ships, the total container-carrying capacity of those ships, the maximum vessel size, the number of services, and the number of companies that deploy container ships on services from and to a country's ports. For each five components, the index is generated by dividing a country's value to the maximum value of that component in 2004, and for every single country, the average of the five components is calculated. This average is then divided by the maximum average for 2004 and multiplied by 100. In this way, the index generates the value 100 for the country with the highest average index of the five components in 2004 (UNCTAD, 2011).

In 2004, Singapore's LSCI score was 81.87, and it has attained a total of 28.3 per cent increase to a value of 105.02 in 2011. It is evident that Singapore is constantly improving its integration to the global liner shipping network, as can be seen that even during the Asia economic crisis on 2008, the LSCI score of Singapore was increasing.

In terms of economy, the economic crisis in Asia in 2008 had obviously posed a negative impact to Singapore economy. It can be seen from the decline in GDP growth, export and import, as well as the container traffic in the port. However, Singapore seemed to have picked up pretty quickly as shown by the significant growth in the following year.

Port of Singapore's market share data from the year 1985 to 2000 are shown on Figure 14. From the data, it appears that Singapore's market share has grown in a considerably fast pace, even though the economic crisis in 1998 seemed to have a negative effect. For the recent years, a similar trend should be expected, as Singapore remains as one of the most eminent ports in the world, even though the rise of the Chinese ports obviously has influenced Singapore's market share. Tongzon (2011) identified that the rise of Chinese ports did not have a significant impact to port of Singapore. He found that the relationship between the Chinese ports and Singapore port are found to be complementary, rather than competitive. However, as the major underlying reasons behind choice of ports in liner routes evolve, this relationship may turn to a competitive relationship.

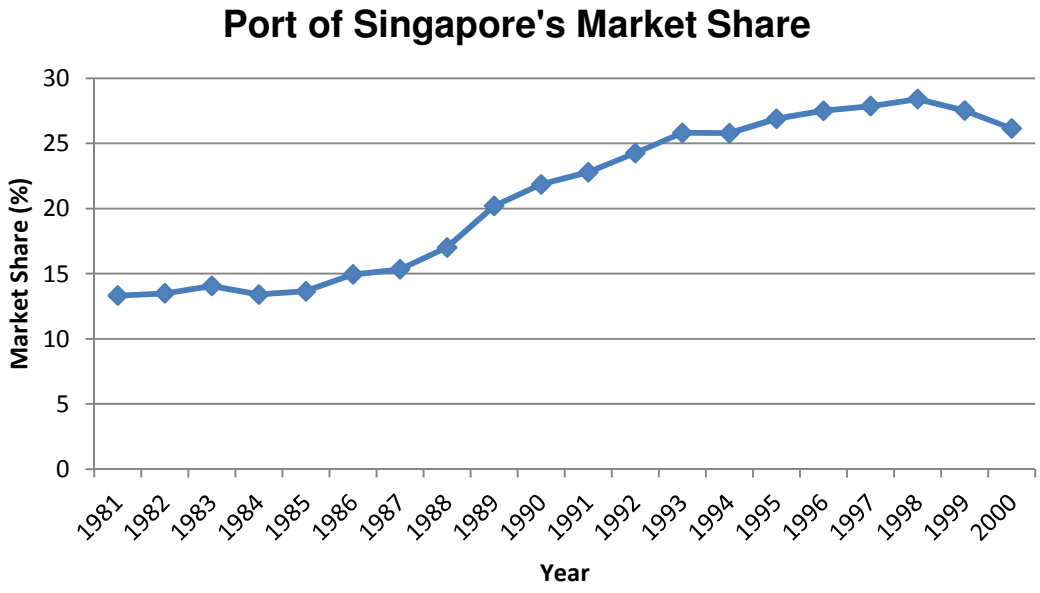

Figure 14 Port of Singapore's market share (Source: Chou, et al., 2003)

Port of Singapore's container traffic for the past five years, compared to its main competitors (PTP and PKA), are shown on Figure 15. It can be seen that Singapore's traffic has not improved as well as the other two ports. Even when the other ports experience a decline in container traffic, PTP managed to increase their port throughput. It is also important to note that for the Daily Maersk service which runs daily Asia – Europe route, PTP is one of the ports of call instead of Singapore. On the year 2000, Maersk started to operate APM Terminal in PTP, moving a large part of its operation from PSA to PTP. It is believed that the main reason behind the rearrangement is Singapore's unwillingness to allow private terminal operators in the port.

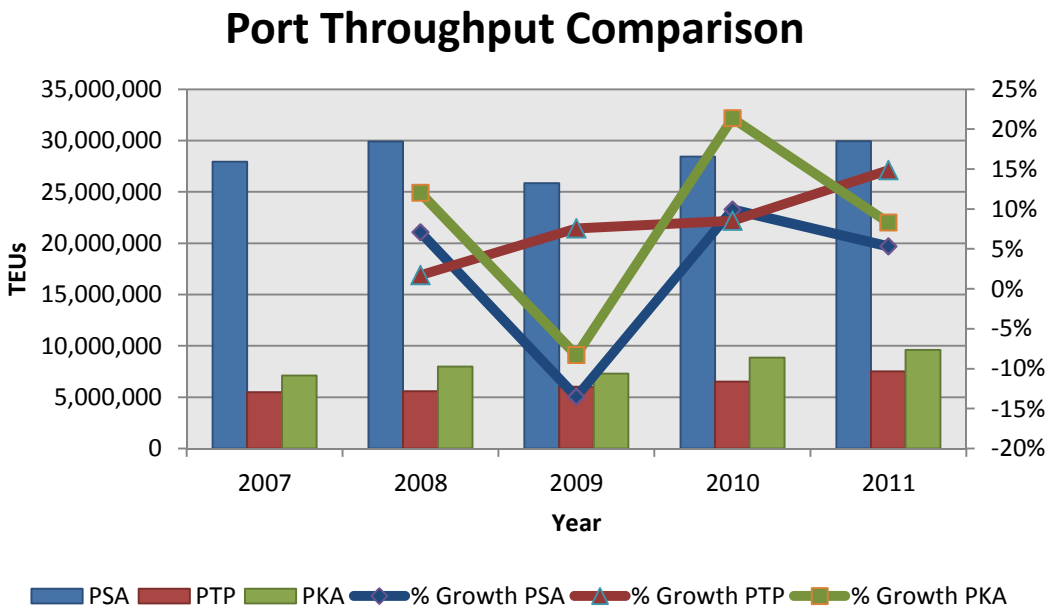

Figure 15 Comparison of port throughput 2007 – 2011 (Source: Containerisation International)

4.3 Discussion of Results from Primary and Secondary Data

From the primary and secondary data, it is shown that PSA plays an important role of carriage of goods within the Asia – Europe route, especially due to its strategic location. PSA has very good infrastructure which is able to accommodate the world's current largest ship, and it continues to try to improve the port by port extension. Singapore faces heavy competition not only from PKA and PTP in the SEA region, but also from the rapid rise of Chinese ports. Even though at present, the relationship between Singapore and the Chinese ports are complementary, it may turn to a competition depending on the trend behind the choice of ports by liner

shipping companies. With the coming of mega container ships, it offers a great potential for Singapore to increase its market share.

In addition, Asia's economy is developing at a relatively fast pace. This means that there is a decent prospect that the demand for transport will increase, which consequently will offer Singapore another advantage of being the main transhipment hub in the region. Even though Singapore's market share has been preceded by Shanghai, it does mean that Singapore will not be able to increase its market share.

The next chapter presents MCA and SWOT analysis based on the information gathered in this chapter, in order to analyse the impact of mega container ships to Port of Singapore, and to propose strategies that can be adopted by the port in response to the potential impacts.

Chapter 5 - Multi-Criteria Analysis and SWOT Analysis

MCA is performed to analyse the impact of mega container ship to Port of Singapore both short term and long term, while SWOT analysis is conducted to assess the port's competitiveness and propose feasible strategies for the port.

5.1 Multi-Criteria Analysis (MCA)

Based on the objectives of the study which is to identify the impacts of mega container ships to Port of Singapore in terms of competitiveness, a multi-criteria analysis is done based on 4 different scenarios as summarized on Table 8. These scenarios have different impacts on different stakeholders related to the port operation and management in Singapore. The assessment takes into account economic, social, and environmental aspect of port operation, based on the information from previous chapters.

Scenario	Port Facilities	Mega Container Ships Call at Port
1	Current	Yes
2	Current	No
3	After port extension and relocation	Yes
4	After port extension and relocation	No

Table 8 MCA Scenarios

Different stakeholders are involved in the port operation and management in Singapore, each of which has different interest on the issue. The stakeholders identified by the author are the National Government of Singapore, PSA, MPA, URA, Ministry of Environment (MOE), Maersk Line as the owner and operator of mega ships, as well as other shipping lines.

National Government of Singapore

National Government of Singapore's main interest is the general welfare of the nation, including all aspects from economic, social, health, etc. The National Government can be seen as the highest authority in the country, where every

decision making process will be influenced the National Government. In terms of social welfare, with the coming of mega container ships to Singapore may improve Singapore's economy, which should be of a great interest for the government.

PSA

PSA is the main port operator in Singapore. It handles up to 98 per cent of the total container traffic in Singapore. The big ships that come to Singapore are currently handled by PSA. If mega ships come to Singapore, PSA will definitely be benefited from the additional cargo handling offered by the mega ships.

MPA

MPA acts as the regulating body in all kinds of maritime operations in Singapore. It has a high influence on any decision making process for the port. MPA also has a very high interest on PSA operation and management. MPA however is not concerned about the amount of container handling. Instead, it is more concerned about the number of vessel arrivals.

URA

URA has an indirect effect to the port's operation as it is the body that regulates the national land use, planning, and conservation. As the land price where the terminals are currently located in CBD area is increasing, URA has the authority to relocate the terminals to the industrial area of Singapore.

MOE

MOE is concerned about the environment, and it is aiming to make the port a 'green' port. The main concerns of MOE are environmental effects of the port operation, alongside the port extension and relocation as it will involve demolition and construction of new resort area.

Maersk Line

As the sole operator of the mega container ships, Maersk Line has the privilege of choosing their port of calls in the Asia – Europe trade route. Its main interest is to minimise the port turnaround time, as this will enable the ship to keep up with the schedule, consequently preventing loss due to delays.

Other Shipping Lines

Other shipping lines obviously see the coming of mega ships as a competition. When Maersk introduced the Daily Maersk service in the Asia – Europe route,

Maersk managed to increase their market share from 21 per cent to 25 per cent since the launch of Daily Maersk service (Leach, 2012). Now with the coming of mega container ships which will also be deployed in the same route, it is a question whether Maersk will further increase their market share, and how the other shipping lines attempt to retain their market share.

The stakeholders described above can be classified based on their power and interest on the project, as shown in the power-interest matrix shown on Figure 16. This matrix shows the combination of the interest a stakeholder may have in the project with the amount of power they have to influence the scope of the project.

It is clear that the governmental organizations are very important in this project since they have the most power. The port operator and the shipping lines have most interest in the project since they will be affected the most when the project is executed. Based on this matrix, the project management staff will be able to identify the appropriate actions for the different parties. All interests and concerns obtained from this stakeholder analysis are then converted into criteria which are used as the evaluation criteria for MCA.

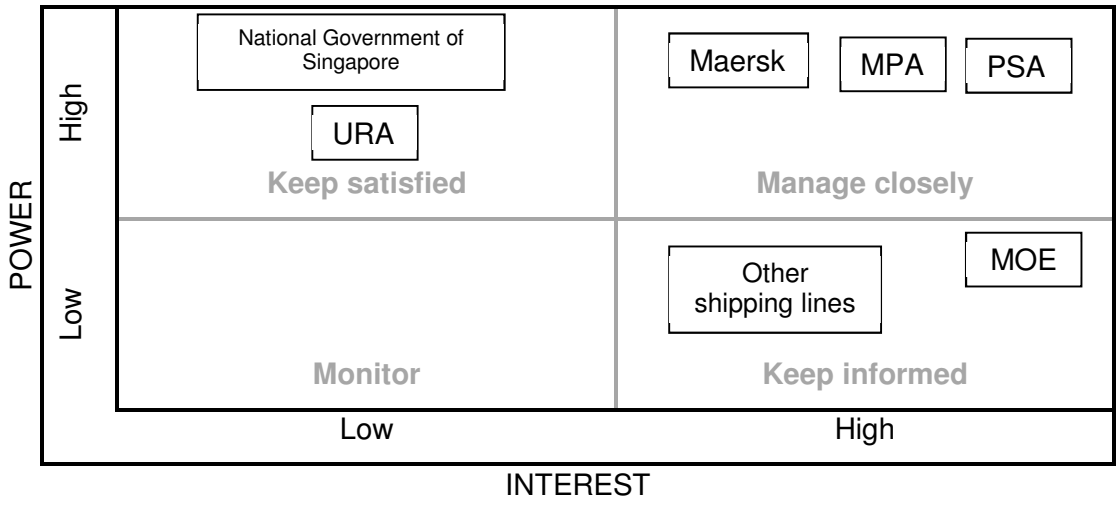

Figure 16 Power – Interest Matrix

The evaluation criteria for MCA are divided to two broad categories, i.e. in the national scale, and local to the port. The criteria are further explained as follows.

National Scale

Contribution to Singapore's economy	The port contributes 7 per cent of the gross domestic product and provides employment opportunities

Tourism	Relocation of terminal in central area to Tuas area, which will be converted to a commercial resort area, will enhance Singapore's tourism industry
Environmental impact	Emissions from port operation (land based facilities and ships), environmental disruption due to the construction of port extension and relocation
Local Port	
Investment cost	Cost involved in demolition of old terminals and construction or development of new terminals
Maintenance cost	Cost involved in maintaining the port facilities and infrastructure
Port revenue	Additional port revenue gained from extra container handling

Contribution to Singapore's economy and port's revenue are the two main criteria that have the highest importance, while the other criteria share the same weight of importance. The scale used in scoring for the MCA ranges from -2 to 2, with -2 being the worst case, 0 being neutral, and 2 being the best, with respect to the port's current situation. The results of MCA from each scenario are summarized on Table 9. It is important to note that the numbers on the scale are not meant to be quantifiable; it is only a way of simplifying qualitative analysis.

	Weighting	Scenario 1	Scenario 2	Scenario 3	Scenario 4
National					
Contribution to Singapore's Economy	30%	0	1	1	2
Tourism	10%	-1	-1	2	2
Environmental impact	10%	0	-1	-1	-1
Port					
Investment cost	10%	0	0	-1	-1
Maintenance cost	10%	0	0	-1	-1
Port revenue	30%	0	1	1	2
Total score	**100%**	**-0.1**	**0.4**	**0.5**	**1.1**

Table 9 MCA Performance Matrix

5.1.1 Scenario 1

The first scenario presented is the scenario with the current facilities of Port of Singapore, but the mega ships do not come to Singapore. It is a short term impact to the port, where the port continues to operate the way it has been operating today, with no effort to improve the port infrastructure for future bigger ships.
In this scenario, there is no immediate impact to the port's operation. As the port will be operating normally as it is now, the contribution to Singapore's economy can be predicted to remain the same, and the only negative impact will be in the tourism sector as the potential of building commercial resort in the central area will not be realised.

In this scenario it is important to note that there is no investment cost neither maintenance cost involved in regards to port extension and relocation. However, there might be some maintenance cost involved regarding the environmental sustainability, which is not considered in great detail in this project.

5.1.2 Scenario 2

The second scenario is if the mega container ships come to Singapore with the port's current facilities. In this scenario, the port of Singapore will have an increased container handling activity with the coming of the ships.

In this scenario the main contribution coming from the port will be the increase in port revenue, due to the additional containers to be handled, coming from the mega container ships calling at the port. Port revenue is directly related to the contribution to the country's economy; hence an increase in port's revenue will also make a positive contribution to the economy.

Apart from the monetary issue, the second scenario will most likely to bring a negative impact to the environment and tourism. If the current port facilities are not improved to cater for the emission brought by the mega ships coming in and the extra cargo handling operation, albeit not a great extent, it is necessary to be addressed in the long term planning.

In addition to the environmental impact, there will be a negative impact on tourism as the central area will not be developed to a commercial resort. However, there won't be any investment cost or maintenance cost associated with the relocation of the port and the construction of the resort.

5.1.3 Scenario 3

The third scenario can be considered as a long term impact on the port, as the development of the port is already underway, but is not completed yet. This scenario is similar to scenario 1, except that the port facilities will be the upgraded port where the Pasir Panjang terminal is already extended, and the terminals in the city area relocated to Tuas area, assuming that the central area is already developed to a commercial resort (circa 2025).

In this scenario, the long term impact to the port is identified with a greatly positive impact to tourism, generated from the commercial resort at the former location of Keppel, Tanjong Pagar, and Brani terminals.

Contribution to Singapore's economy will be mainly from the tourism area, and some from the extended port, but without any contribution from the mega container ships. There will be investment cost and maintenance cost both for the extended port and the resort. The environmental impact in this scenario will be negative from the demolition and relocation of the old terminals, as well as the construction of the resort and port in the new area.

5.1.4 Scenario 4

The last scenario is also a long term impact to the port, where the port facilities would have been improvised and the central area developed to a commercial resort area.

In this scenario, it is shown that in the long term, combination of tourism and the extra revenue coming from mega container ships offers a great advantage to the port, as well as a significant contribution to Singapore's economy in general.

However, the cost involved in this scenario is the greatest, both in terms of investment and maintenance cost. There is a great deal of investment cost involved in relocating and extending the port, in addition to the construction of the resort. Besides, the environmental impact of this scenario will also be negative, as a combination from the resort and the additional port operation activities.

From the MCA, it is evident that in the short term, mega container ships will have a positive impact to the port and the Singapore economy, albeit not in a great scale as compared to the long term impact, where tourism will be an additional advantage.

5.2 SWOT Analysis

This section explains in detail the result of SWOT analysis performed for PSA. SWOT analysis is a simple and useful tool to analyse SWOT of an organisation in order to achieve an objective. For the purpose of this study, the objective used for the SWOT analysis will be to increase the port's market share without compromising profit.

The SWOT matrix of Port of Singapore is shown on Figure 17, identifying the strengths, weaknesses, opportunities, and threats. Based on the SWOT matrix, it is apparent that Singapore has a great potential and opportunities supporting the objectives. The coming of mega container ships in near future can be seen as a significant opportunity for the port to increase its market share, and consequently, increased revenue from the additional containers. Based on the model done by Tongzon (1995), it was shown that average vessel size and cargo exchange has a positive contribution to port's efficiency. In this case, mega container ships will increase the average vessel size and cargo exchange, which creates the opportunity of increased efficiency. The probability and impact analysis of the opportunities and threats is also performed and the results presented on Figure 18.

	Helpful (to achieving the objectives)	Harmful (to achieving the objectives)
Internal Origin (attributes of the organization)	• Strategic location • High efficiency • Advanced infrastructure • Natural channel depth • Natural sheltered harbour • Very good connectivity • Experienced in handling large volume	• Land restriction • Limited hinterland connection • High cost (compared to neighbouring countries) • Closed market (no private terminal operators allowed)
External Origin (attributes of the environment)	• Mega container ships coming in near future (O1) • Potential revenue from additional containers to be handled (O2) • Increasing efficiency (O3) • Increasing Asia – Europe trade (O4)	• Competition from other ports (T1) • Economic crisis (T2)

Figure 17 SWOT Matrix for Port of Singapore

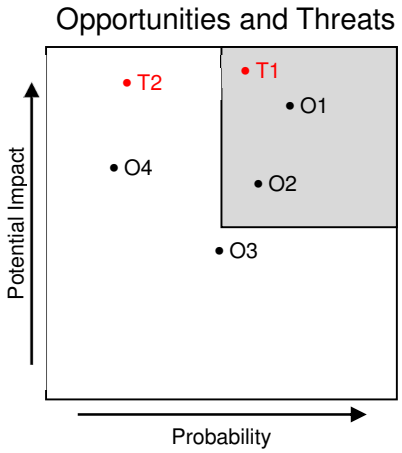

Figure 18 Impact and Probability analysis for Port of Singapore

Competition from other ports is inevitable, but Port of Singapore has the advantage of its excellent connectivity, along with advanced infrastructure and experience in handling large volume. Economic crisis has high impact to the port operation, but the probability is very difficult to estimate. Currently, the economic outlook in Asia seems to be promising, but it is important not to over invest in the port due to the current high demand, because port planning and development is a long term process and the economic condition may or may not be favourable when the port development is completed.

From the SWOT matrix, a list of strategies for the port to achieve the objective of increasing market share without compromising profit is established, as shown on Figure 19.

	Strengths (S)	Weaknesses (W)
Opportunities (O)	***SO strategies*** • Improving the infrastructure to handle mega containerships • Port expansion	***WO strategies*** • Opening the market to private terminal operators
Threats (T)	***ST strategies*** • Securing long term contracts with shipping lines	***WT strategies*** • Reducing cost • Improve connectivity

Figure 19 SWOT strategies for Port of Singapore

SO Strategies

SO strategy is the ideal combination, where it makes use of the port's strength to take advantage of the opportunity. In this case, the port's advanced infrastructure and experience in handling large volumes is a significant asset that can attract mega ships to come to the port. By having mega ships in the port, it will consequently increase the port revenue and efficiency.

ST Strategies

In ST strategy, the port should attempt to use its strengths to avoid threats. At the moment, the biggest competition for the port in the SEA region is competition from PTP. As seen from previous case where Maersk removed a large part of the operation from Singapore to PTP, an appropriate strategy may be by securing long term contract with shipping lines. Singapore has the benefit of having better connectivity compared to PTP which may be preferred by some shipping lines. To prevent the shipping lines from diverting their port of call to PTP, Singapore may attempt to secure a long term contract with the shipping lines, hence enabling Singapore to have an extent of assurance of the container traffic that it will handle.

WO Strategies

WO strategy is meant to overcome weaknesses by taking advantage of opportunities. In this instance, it can be referred back to the case of Maersk relocating the operation to PTP in 2000, which is believed to be caused by Singapore's reluctance to allow private terminal operators. If Singapore opened its market to private terminal operators, there is an opportunity that more investors would come and invest at the port.

WT Strategies

WT strategy can be considered as a 'defensive' strategy, which is meant to minimize threats and overcome weaknesses. Compared to other ports in SEA region, Singapore imposes a relatively high cost, which may cause some shipping lines to choose other cheaper ports. Singapore may try to reduce cost to attract more ships and to minimise competition from cheaper ports. Singapore already has an excellent connectivity in terms of feeder services, but hinterland connection is still lacking. Even though hinterland connection does not play a great role in the port's operation, it can be considered as a possible strategy to attract more ships to come to the port.

Based on the SWOT analysis, it is shown that Port of Singapore is potentially very competitive in attracting mega container ships. As the main objective is to increase

market share, mega container ships has a great importance in contributing to this objective. The strategies that can be adopted by the port are shown on Figure 17. The most ideal solutions are the SO and WO strategies, while the other two strategies are more concerned on minimising threats, especially the one with greater impact to the port. After performing SWOT analysis, the next phase is to implement and monitor strategy. However it is only possible to be done at a later stage, when the mega ships will be delivered and official port of calls announced.

5.3 Conclusions of MCA and SWOT Analysis

MCA analysis shows that mega container ships have a positive impact to the port both in short term and long term. In short term, mega container ships will bring extra revenue to the port, increasing its market share and efficiency. However, there will be no contribution to economy from the tourism sector as the terminals in the CBD area will still be operating as the way they are. In long term, not only is there an increase in port revenue from mega container ships, but there will also be a contribution from tourism to Singapore's economy. Based on this analysis, the coming mega container ships can be seen as a great opportunity for port of Singapore, which is applied in the SWOT analysis.

SWOT analysis demonstrates a great potential for the port to increase its market share, given the strengths that it exhibits. Even though there are threats and weaknesses that may influence the port, the port is still at a competitive position to attract mega ships, and consequently increasing their market share.

The next chapter sums up the findings of this inquiry, as well as presenting recommendations for future research in relation to the current project.

Chapter 6 – Conclusions and Recommendations

6.1 Conclusions

The principal objective of this study is to identify the impacts of mega container ships to Port of Singapore's operation and management. Rather than focusing on the infrastructure of the port, the study is more concerned on identifying the impacts to analyse the strategic planning of the port, especially in assessing the competitiveness of the port. It is intended to demonstrate the importance of the relationship between the change in ship and port technologies which are complimentary to each other.

The study was conducted by adopting a structured and logical approach and methodology, involving points of views from different parties involved in the port operation. Even with time and data availability constraint, the author has attempted to collect and analyse valid and reliable information with interviews and information from online resources.

There are benefits and drawbacks of using interviews in this project. It has allowed the author to get a better insight of the current situation of Port of Singapore, even though there are difficulties contacting the relevant people and getting responses. The reluctance from some parties to give information for the research has limited the extent of the data, yet it has provided a valid and reliable data.

MCA and SWOT analysis were performed in order to give a better representation of the impacts of mega container ships to the port, as well as to identify the port's competitive position and to propose strategies for the port to deal with the impacts. From the MCA, it is found that mega container ship has a positive impact to the port in the short term only for the port, and in the long term there is also an additional positive impact from tourism, due to the relocation of the port to the industrial area, which will be replaced by a commercial resort.

The SWOT analysis managed to recognise a great potential of Port of Singapore to attract those mega container ships, with the final objective of increasing its market share without compromising profit. It is found that mega container ship is a great opportunity for Port of Singapore as it offers additional cargo handling, which may improve the port's overall efficiency, alongside with increased revenue and market

share. However, it is important to monitor the competition from the port's main rivals, namely Port Tanjung Pelepas and Port Klang of Malaysia.

In short, mega container ship can be seen to offer a great potential for Port of Singapore to further improve its efficiency and increase its market share. Port of Singapore already has a great standing among the world's top ports, in addition to a number of attributes which are very beneficial to the port. By having mega ships, it will enhance the port's reputation of being 'The World's Port of Call'.

6.2 Recommendations for Future Research

This study is limited to assessing the port competitiveness in relation to mega container ships. Due to the diverse nature of port operation, there are still other aspects apart from the port operation side that are open to further investigation. Apart from the port side, it is recommended that further studies should be performed to other aspects of mega container ship operation, for example to liner shipping companies, the economics and routing of the ship, feeder ships transhipment operations, etc.

Finally, the study stands as a modest initiative for further research in the field of port operation and management. It is necessary to conduct further investigation in order to develop and test appropriate models and tools of analysis.

References

Alderton, P., 2005. *Lloyd's Practical Shipping Guides: Port Management and Operations.* 2nd ed. London: Informa.

Alderton, P. M., 2011. *Reeds Sea Transport: Operation and Economics.* 6th ed. London: Adlard Coles Nautical.

Assen, M. V., Berg, G. V. D. & Pietersma, P., 2008. *Key management models : the 60+ models every manager needs to know.* 2nd ed. Harlow: Pearson.

Baird, A. J., 1999. *Container Vessels in the New Millennium: Implications for Seaports.* Halifax, Centre for International Business Studies at Dalhousie University.

Barnard, B., 2012. *G6 Alliance speeds up Asia - Europe service launch.* [Online]
Available at: http://www.joc.com/trade-lanes/g6-alliance-speeds-asia-europe-service-launch
[Accessed 24 June 2012].

Beach, D. P. & Alvager, T. K., 1992. *Handbook for Scientific and Technical Research.* New Jersey: Prentice-Hall.

Bichou, K. & Bell, M. G., 2007. Internationalisation and consolidation of the container port industry: assessment of channel structure and relationships. *Maritime Economics and Logistics,* Volume 9, pp. 35-51.

Chou, C.-C., Liang, G.-S. & Chu, C.-W., 2003. Competitiveness analysis for major ports in Eastern Asia. *Journal of the Eastern Asia Society for Transportation Studies,* Volume 5, pp. 682-697.

Containerisation International, 2012. *Yearbook 2012.* London: Informa UK.

Cork, S. & Holm-Karlsen, T., 2002. *Vessel growth and the impact on terminal planning and development.* Sydney, PIANC.

Department for Communities and Local Government, 2009. *Multi-criteria analysis: a manual.* London: Crown.

Department of Statistics Singapore, 2012. *Statistics Singapore - External Trade.* [Online]
Available at: http://www.singstat.gov.sg/stats/themes/economy/trade.html
[Accessed 17 June 2012].

Donovan, A. & Bonney, J., 2006. *The Box That Changed The World: Fifty years of container shipping - an illustrated history.* New Jersey: Commonwealth Business Media.

Dragovic, B. et al., 2009. *An analyze of relationship between container ships and port development.* Istanbul, Dogus University Publications, pp. 155-160.

Eriksson, P. & Kovalainen, A., 2008. *Qualitative Methods in Business Research.* London: SAGE.

Fung, K.-F., 2001. Competition between the ports of Hong Kong and Singapore: a structural vector error correction model to forecast the demand for container handling serivces. *Maritime Policy and Management,* 28(1), pp. 3-22.

Gadhia, H. K., Kotzab, H. & Prockl, G., 2011. Levels of internationalization in the container shipping industry: an assessment of the port networks of the large container shipping companies. *Journal of Transport Geography,* Volume 19, pp. 1431-1442.

Gelareh, S. & Pisinger, D., 2011. Fleet deployment, network design and hub location of liner shipping companies. *Transportation Research Part E,* Volume 47, pp. 947-964.

Gordon, J. R., Lee, P.-M. & Jr., H. C. L., 2005. A resource-based view of competitive advantage at the Port of Singapore. *Journal of Strategic Information Systems,* Volume 14, pp. 69-86.

Haley, R., 2011. Mega boxships need port design to jump into 'next league'. *Lloyd's List*, 5 December, p. 7.

Imai, A., Nishimura, E., Papadimitriou, S. & Liu, M., 2006. The economic viability of container mega-ships. *Transportation Research Part E: Logistics and Transportation Review,* 42(1), pp. 21-41.

Institute of Chartered Shipbrokers, 2011. *Port and Terminal Management.* Edinburgh: Witherby.

Kleywegt, A., Goh, M. L., Wu, G. & Zhang, H., 2002. *Competition between the ports of Singapore and Malaysia,* s.l.: The Logistics Institute, Georgia Tech, and The Logistics Institute Asia-Pacific, National University of Singapore.

Lam, J. S. L. & Yap, W. Y., 2008. Competition for transhipment containers by major ports in Southeast Asia: slot capacity analysis. *Maritime Policy and Management,* 35(1), pp. 89-101.

Lam, J. S. L. & Yap, W. Y., 2011. Dynamics of liner shipping network and port connectivity in supply chain systems: analysis on East Asia. *Journal of Transport Geography,* Volume 19, pp. 1272-1781.

Leach, P. T., 2012. *Maersk plans other daily Maersk services.* [Online]
Available at: http://www.joc.com/container-lines/maersk-plans-other-daily-maersk-services
[Accessed 1 June 2012].

Leander, T., 2012. *Singapore Sling.* [Online]
Available at: http://www.lloydslist.com/ll/sector/ports-and-logistics/article396455.ece
[Accessed 23 April 2012].
Lim, S.-M., 1998. Economies of scale in container shipping. *Maritime Policy and Management,* 25(4), pp. 361-373.
Lloyd's List, 2012. *Lloyd's List Singapore,* London: Informa.
Maersk Line, 2011. *The world's largest ship is the Maersk Line Triple-E class vessel.* [Online]
Available at: http://www.worldslargestship.com/
[Accessed 24 April 2012].
McCalla, R. J., 2004. From 'Anyport' to 'Superterminal'. In: D. Pinder & B. Slack, eds. *Shipping and Ports in the Twenty-first Century.* London: Routledge, pp. 123-142.
McLellan, R., 1997. Bigger vesels: How big is too big?. *Maritime Policy and Management,* 24(2), pp. 193-211.
Meersman, H., Van de Voorde, E. & Vanelslander, T., 2009. *Future Challenges for the Port and Shipping Sector.* London: Informa.
Panayides, P. M. & Wiedmer, R., 2011. Strategic alliances in container liner shipping. *Research in Transportation Economics,* Volume 32, pp. 25-38.
PSA Singapore, 2010. *About Us: PSA Singapore.* [Online]
Available at: http://www.singaporepsa.com/aboutus.php
[Accessed 25 April 2012].
PSA Singapore, 2010. *Terminals: PSA Singapore.* [Online]
Available at: http://www.singaporepsa.com/terminal.php
[Accessed 25 April 2012].
Sien, C. L., Goh, M. & Tongzon, J., 2003. *Southeast Asian Regional Port Development: A Comparative Analysis.* Singapore: Institute of Southest Asian Studies.
Silverman, D., 2010. *Doing Qualitative Research.* London: Sage.
Sohn, J.-R. & Jung, C.-M., 2009. The size effect of a port on the container handling efficiency level and market share in internation transshipment flow. *Maritime Policy and Management,* 36(2), pp. 117-129.
Stopford, M., 2009. *Maritime Economics.* 3rd ed. Abingdon: Routledge.
Tongzon, J. L., 1995. Determinants of port performance and efficiency. *Transportation Research Part A: Policy and Practice,* 29A(3), pp. 245-252.

Tongzon, J. L., 2011. *The rise of Chinese ports and its impact on the Port of Singapore.* Singapore, s.n.

Tran, N. K., 2011. Studying port selection on liner routes: An approach from logistics perspective. *Research in Transportation Economics,* Volume 32, pp. 39-53.

UNCTAD, 2011. *Review of Maritime Transport 2011.* Geneva: UN Publications.

UNCTAD, 2011. *UNCTADStat - Liner shipping connectivity index, annual, 2004-2011.* [Online]
Available at: http://unctadstat.unctad.org/TableViewer/tableView.aspx?ReportId=92 [Accessed 17 June 2012].

Voorde, E. V. d. & Winkelmans, W., 2002. A general introduction to port competition and management. In: M. Huybrechts, et al. eds. *Port Competitiveness: An economic and legal analysis of the factors determining the competitiveness of seaports.* Antwerp: De Boeck, pp. 1-13.

Warren, K., 1999. The dynamics of rivalry. *Business Strategy Review,* 10(4), pp. 41-54.

Appendix – List of Interviewees

Teh Kong Leong
Programme Director, Maritime Studies
Nanyang Technological University, Singapore

Dr. Jasmine Lam Siu Lee
Director, MSc Maritime Studies programme
Nanyang Technological University, Singapore

Capt. Mark. E.S. Heah
Group HSSE Manager
Jardine Shipping Services Singapore

Desiré Ah-Cham
Head-Liner Commercial / Customer Service
Jardine Shipping Services Singapore