# Chapter 1: Introduction

The size of container ship is growing constantly due to various factors such as shipbuilding cargo handing technology improvement, cargo traffic increase and so on. Whereas the ship size growing, the freight level in the liner shipping market is decreasing constantly. The decrease the freight level can be achieved partly but the realization of economies of scale in ship size, a partly by increased competition among the carriers. The competition among the carriers tends become more severe as the ship size grows. In order to keep and secure the competitive power, shipping companies made great efforts not only on reducing the shipping cost and shrink the shipping time but also on the innovation in shipbuilding and loading/unloading equipments. But the splitting increasing in the size of container ships such as VLCS (VERY LARGE CONTAINER SHIPS) made some people doubt about its competition power and the availability.

VLCS (VERY LARGE CONTAINER SHIPS) indeed reduces the transportation cost per unit for the reason of economics scale. In order to reach the economics scale and for the reason of infrastructure within the port, VLCS (VERY LARGE CONTAINER SHIPS) choose to stop in hub ports. Meanwhile, the demurrage cost when ships stay during the port will also increase.

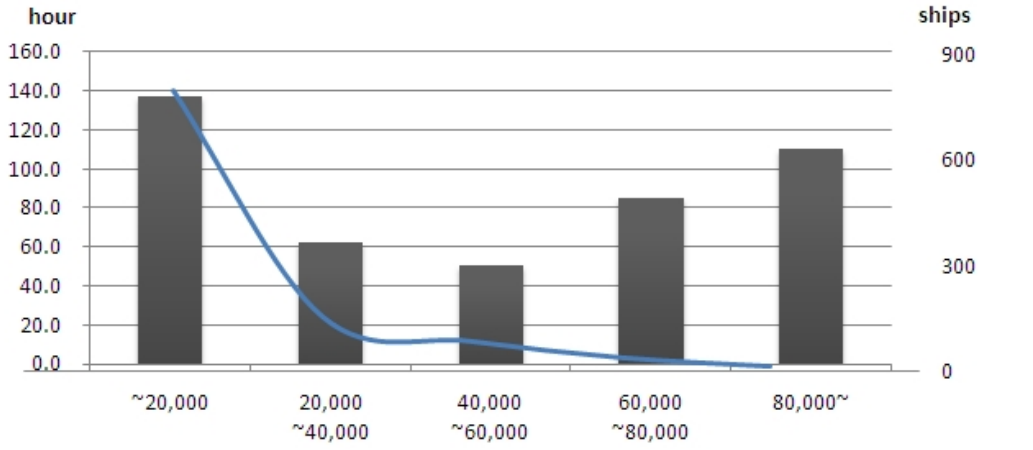
Shipping companies want to run more VLCS (VERY LARGE CONTAINER SHIPS) because of its advantages, so a large quantity orders for VLCS (VERY LARGE CONTAINER SHIPS) are in the schedule. But in order to accept the large ships, the port has to enhance their port facilities and loading/unloading equipments. But they have to consider and balance the investments in the port. And due to the global economic decreasing, the maritime transport market shrinks as well. So a lot of orders for the VLCS (VERY LARGE CONTAINER SHIPS) are being delay.

In order to reach the economics scale by VLCS (VERY LARGE CONTAINER SHIPS), we have to know the quantity of cargos. The economics scale can be reach only when an adequate quantity being reached. But as the reason mentioned before, the decreasing world economics make it is difficult to secure the quantity of cargo. On the other hand, the decreasing maritime transport market stimulates the demand of larger size of ships. If the charges to run a ship decrease, Shipping Company can run a larger ship, so they can benefit from the economics scale. And the competitive shipping charge will gain more market share for the shipping companies.

But in the same time, all the competitive companies have the same strategy which is to make a bigger size ship to benefit from the economics scale. But the haphazard increasing on bigger ships will lead to a great possibility on the overmuch capacity on the container shipping. So nowadays, shipping companies consider the VLCS (VERY LARGE CONTAINER SHIPS) in a broader and higher perspective. This is not only about the benefit from economics scale but also the macroscopically shipping market environment.

**Figure 1 1 Total number of ships and Time in the port**

(Unit: ships, hours)




Source: Pusan Port Authority, 2007

We can know by Figure 1 1. General speaking, the more ship size getting bigger, the more ship stay long-time in port. This study analysis a ripple effect on the demurrage time and demurrage cost which is made by the excessive number of VLCS (VERY LARGE CONTAINER SHIPS). Then we will give suggestions to Pusan port on the development on it facilities and infrastructure and its developing strategy in a long term.

# Chapter 2: Background

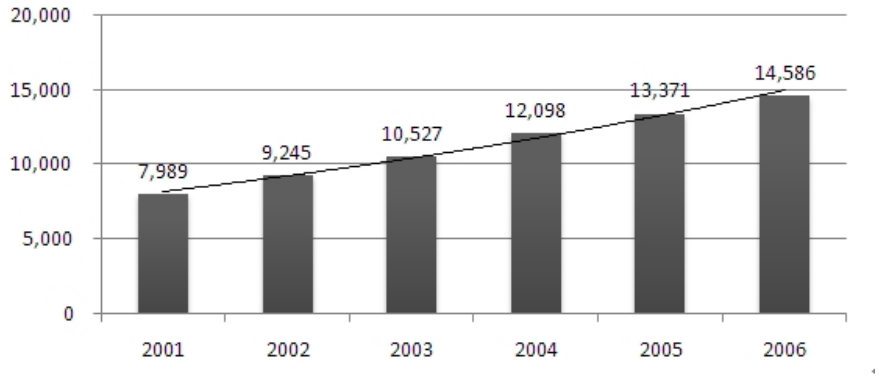
## 2.1 Pusan port environment

### 2.1.1 The position

Figure 2 1 is Handing Volume of Classified World Important Port2001 to 2006. From this table we can see that compare with 2005, the container throughput of the top 10 ports' throughput increased with an average rate 8.3% in 2006 which reached to 14,586 thousand TEUs. The total throughput of the top 10 ports occupies 47% of the total global throughput. Especially the China's ports keep a high growth rate. In the case of Shanghai port, the throughput is 2,171 thousand TEUs in 2006 and ranks the 3rd biggest port in the world just following Singapore and Hong Kong. Compare with 2005, Pusan port grew with an increase rate 9.4% in 2006 and reached to 1,203 million TEUs. The reason why Pusan port didn't increase with high rate is because of the competition with the high growing china's ports.

**Figure 2 1 Total Handing Volume of Classified World Important Port**

(Unit: Thousand TEU)




Source: CI

From Figure 2 1 we know that the total handing volume increased from 7,989 thousand TEU in 2001 to 14,586 thousand TEU in 2006 in world important port. The continuous increasing volume makes us confident with the further increasing in the coming years.

Total handing volumes is increasing every year in world important ports. Handing volumes grows from 7,989 thousand TEUs in 2001 to 10,527 thousand TEUs in 2003, the handing volume reached to 14,586 thousand TEUs in 2006.We can forecast about handing volumes will keep on increasing.

**Table 2 1 Handing Volume of Classified World Important Ports**

(Unit: thousand TEU)

| **Ranking** | Port | 2001 | 2002 | **2003** | **2004** | **2005** | **2006** | **Increase Rate** |
|---|---|---|---|---|---|---|---|---|
| 1 | Singapore | 15,571 | 16,941 | 18,100 | 20,600 | 23,192 | 24,792 | 9.7% |
| 2 | HongKong | 17,826 | 19,144 | 20,449 | 21,984 | 22,427 | 23,230 | 4.4% |
| 3 | Shanghai | 6,334 | 8,620 | 11,283 | 14,557 | 18,084 | 21,710 | 26.4% |
| 4 | Shenzhen | 5,076 | 7,614 | 10,615 | 13,650 | 16,197 | 18,469 | 32.3% |
| 5 | Pusan | 8,073 | 9,453 | 10,408 | 11,442 | 11,843 | 12,030 | 9.4% |
| 6 | Kaohsiung | 7,541 | 8,493 | 8,840 | 9,710 | 9,471 | 9,775 | 5.0% |
| 7 | Rotterdam | 6,096 | 6,506 | 7,107 | 8,281 | 9,300 | 9,600 | 8.2% |
| 8 | Dubai | 3,502 | 4,194 | 5,152 | 6,429 | 7,619 | 8,923 | 20.0% |
| 9 | Hamburg | 4,689 | 5,374 | 6,138 | 7,003 | 8,088 | 8,862 | 13.8% |
| 10 | LA | 5,184 | 6,106 | 7,179 | 7,321 | 7,485 | 8,470 | 8.9% |
| **TOTAL** | | 79,892 | 92,445 | 105,271 | 120,977 | 133,706 | 145,861 | 8.3% |

Source: CI

Pusan port wants to leap its throughput by building a new port. In other to in the competition with China's ports, Pusan port makes great efforts and invests a lot on the

new port project. However, the result of the new port is dissatisfactory. Even though there have some dissatisfactory factors in the development of Pusan port, but the geography location of Pusan port acts as a pivotal point on the sea route between EU and America. The irreplaceable location makes us confident to the future development of Pusan port.

### 2.1.2 Equipment

In table 2 2 is 5 specialized container berths in Pusan port currently. The total length of the 5 berths is 5,147m and the average depth of these berths is 13.3m.

**Table 2 2 Specialized container berth in Pusan port**

| **Classification** | Jasundae | Shinsun | Gamman | Uam | Gamcheon |
|---|---|---|---|---|---|
| Operate date | 09.1978 | 06.1991 | 04.1998 | 07.1996 | 11.1997 |
| Berth length | 1,447m | 1,200m | 1,400m | 500m | 600m |
| Depth of water | -12.5m | -14~-15m | -15m | -11m | -13m |
| Cargo handing ability | 1,000,000 TEU | 1,280,000 TEU | 1,200,000 TEU | 300,000 TEU | 370,000 TEU |
| Berthing ability | 50,000 ton berth×4 10,000ton berth×1 | 50,000ton berth ×1 | 50,000ton berth ×4 | 50,000 ton berth ×2 20,000 ton berth ×1 | 50,000ton berth ×2 |
| Yard | 640,000㎡ | 103 0,000㎡ | 730,000㎡ | 180,000㎡ | 140,000㎡ |
| CY | 390,000㎡ | 67 0,000㎡ | 330,000㎡ | 120,000㎡ | 100,000㎡ |

Source: Korea container dock [container cargo distribution progress & analysis]

The table 2 3 shows that the berthing capacity in Pusan port is 184 ships in 2008. The acreage of warehouse area is 61,000 ㎡ which can stock around 90,000 tons cargoes. The general cargo yard and container yard each occupies 267,000㎡ and 2,067,000㎡ with a capacity of 1,162,000 tons and 257,000 TEUs.

**Table 2 3 Equipment of Pusan port in 2008**

| Equipment | Content | Size | Capacity |
|---|---|---|---|
| Berth | Quay wall | 26,159m | 184ships |
| | Lighter's wharf | 9,604m | |
| Custody | Warehouse | 61,000㎡(11) | 90,000ton |
| | General Yard | 267,000㎡ | 1,162,000 ton |
| | CY | 2,067,000㎡ | 257,000 TEU |

Source: PUSAN PORT AUTHORITY 2008

## 2.2 Container ship environment

### 2.2.1 Bigger of container ship

The global maritime companies want to deal their business with the effect of economics scale. The container ship is getting much bigger than before under the motivation to reduce the cost for the per unit goods.

Table 2 4 shows the development history of containerships. The first generation container ships showed up in 60s with a capacity 700~1500 TEUs. The size of the container ships is getting bigger afterwards. Went through the generation of panamax and post panamax, the super post-panamax and ultra-panamax appeared after 90s.

**Table 2 4 Development of container ship**

| Classification | | Ⅰ | Ⅱ | Ⅲ | Ⅳ | Ⅴ | Ⅵ | Ⅶ | Ⅷ |
|---|---|---|---|---|---|---|---|---|---|
| Development | | Regular | Large /Speed | Save Energy | Huge | | Mega bigger | | |
| Name | | Feeder | Handy | Semi-Panamax | Panamax | Post-Panamax | Superpost-Panamax | | Ultra-Panamax |
| Period | | 60` | 70` | 70`~80` | 80` | 90` | 90` | 90` | 21 |
| Type (TEU) | | 700~1,500 | 1,800~2,300 | 2,000~2,500 | 2,500~4,400 | 4,300~5,400 | 6,000~6,670 | 7,000~8,700 | 10,000~13,000 |
| Vessel | Shipping Company | NYK | MOL | Safmarine | APL | Hapag~Lloyd | Maersk | Maersk | |
| | Year | 1968 | 1973 | 1979 | 1988 | 1991 | 1996 | 1997 | 2005 |
| | Ship nave | Haonemaru | New Jersy | S.A.Waterpark | Levenkusen E. | P. Truman | Regina M. | Souverin M. | Emma |
| Resources | Capacity (TEU) | 752 | 1,887 | 2,464 | 4,340 | 4,626 | 6,418 | 6,600 | 13,000 |
| | LPP (m) | 187 | 263.3 | 247.4 2 | 60.8 | 281.6 | 302.3 | 331.5 | 365 |
| | Los (m) | 200 | 280 | 258.5 | 275.2 | 294 | 318.2 | 247 | 380 |
| | Beam (m) | 26 | 32.2 | 32.2 | 39.4 | 32.25 | 42.8 | 42.8 | 55 |
| | Draft (m) | 15.5 | 19.6 | 24.1 | 23.6 | 21.4 | 24.1 | 24.1 | 30 |
| | Load line (m) | 10.5 | 11.5 | 13.2 | 12.5 | 13.5 | 14 | 14.5 | 15 |
| | Ton (GT) | 16,240 | 37,799 | 52,615 | 50,206 | 53,800 | 81,488 | 91,560 | 150,000 |
| Scale | Hold | 6 | 7~9 | 8 | 8 | 8 | 9 | 9 | 10 |
| | Deck | 2 | 2~3 | 3 | 4 | 5 | 6 | 6 | 7 |
| | Hold transverse | 7 | 9 | 10 | 11 | 12 | 14 | 14 | 18 |
| | Deck transverse | 9 | 12 | 13 | 13 | 16 | 17 | 17 | 22 |

Source: Korea Container Port Authority, 2006

### 2.2.2. Trend of Container ship's bottoms & orderbook

As liner market is under the condition of supply exceeds demand in a long time, so it is hardily to secure the quantity of cargo. And it is costly to operate quantitative ships for a company, so companies try to reduce the cost by running a larger ship instead of quantitative small ships by mean of economics scale. In the same time, liner companies have to consider the other companies in the same maritime market and balance its price to avoid the vicious cycle and cut-throat competition. So a larger size container ship is a very good choice for some companies to increase their competitive power.

**Table 2 5 Bottoms & Orderbook of The World Containership in 2007**

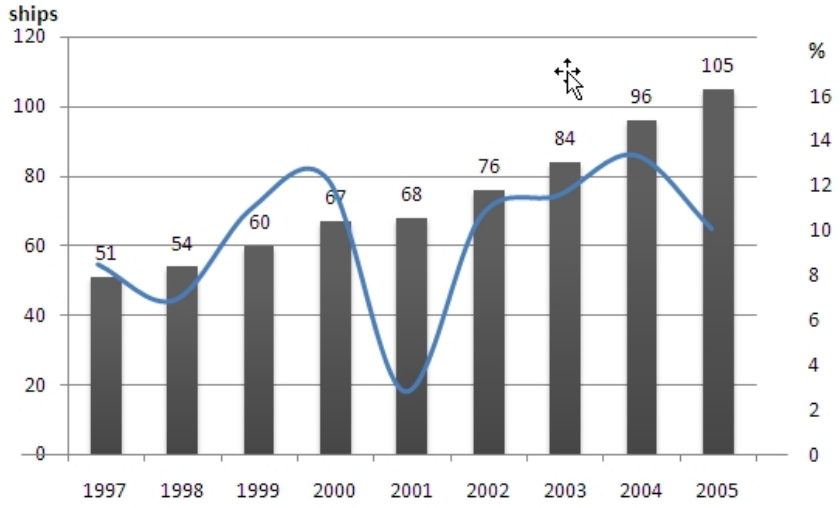
| Size | Bottoms | | Orderbook | | The growing Rate of Order (%) |
|---|---|---|---|---|---|
| | Number | TEU | Ships | TEU | |
| 7500 more | 180 | 1,570,588 | 307 | 3,235,914 | 206.0% |
| 5000~7499 | 397 | 2,316,513 | 169 | 1,033,971 | 44.6% |
| 4000~4999 | 380 | 1,684,270 | 235 | 1,029,593 | 61.1% |
| 3000~3999 | 308 | 1,048,200 | 83 | 285,141 | 27.2% |
| 2500~2999 | 361 | 988,046 | 129 | 342,262 | 34.6% |
| 2000~2499 | 322 | 734,752 | 25 | 53,216 | 7.2% |
| 1500~1999 | 504 | 851,664 | 139 | 242,372 | 28.5% |
| 1000~1499 | 638 | 754,719 | 181 | 220,059 | 29.2% |
| 500~999 | 775 | 568,997 | 173 | 140,172 | 24.6% |
| 250~499 | 265 | 99,846 | 0 | 0 | 0% |
| 100~249 | 107 | 19,314 | 0 | 0 | 0% |
| Total | 4,237 | 10,636,909 | 1,441 | 6,582,700 | 61.9% |

Source: AXS-Alphaliner, Shipping Daily. 01/10/2007

The bottoms area very important element to evaluate the size of container ship. The Table 2 6 shows the Bottoms/Order book of the world container ship. The total bottoms of current world container ships are more than 10,000 thousand TEUs. The total ordered container ship's number are around 6,582 thousand TEUs. The average growing rate is 61.9% among all kinds of container ships in the order. Especially VLCS(VERY LARGE CONTAINER SHIPS) that refers to the ships are more than 7500 TEU, there are 307 ships are in the order book. The total volume of VLCS(VERY LARGE CONTAINER SHIPS) in the order are 3,235 thousand TEU and occupy almost 50% of the total bottoms container ships. From these figures we can see the demand for VLCS(VERY LARGE CONTAINER SHIPS) in maritime market is anxious.

The container ships above 7500 TEU in the order occupy 49.2% of the total ordered container ships' volume. The bottoms of ships among 5000 ~ 7499TEU and 4000 ~ 4999TEU occupy 15.7% and 15.6% of the total ordered container ships. All these three size of container ships which are ships above 4000 TEU occupy 80% of total container ships.

**Figures 2 2 World Container Trade & Annual Growth in 2007**

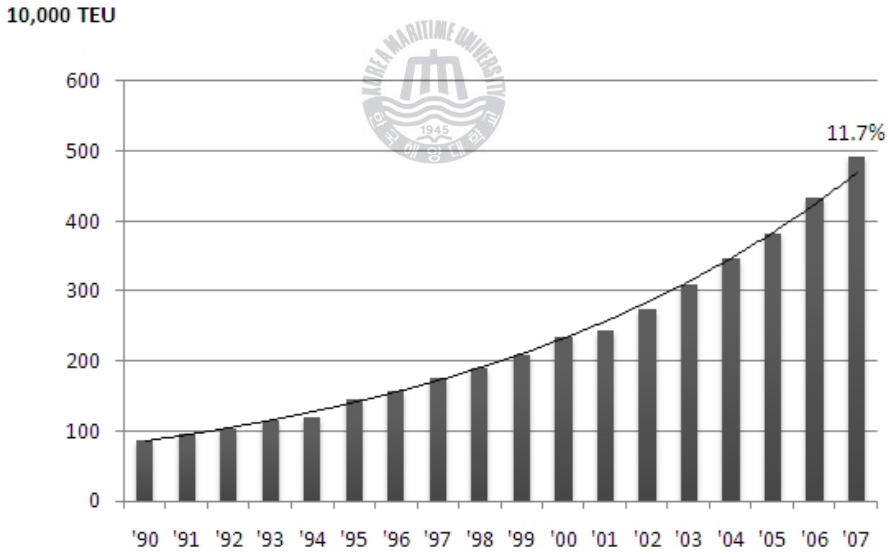


Growth in the liner shipping market has been relatively rapid in comparison with other major shipping sectors such as tankers and bulk carriers. In terms of loaded containers moved from origin to destination, estimated global container trade increased from 508thousand TEU in 1997 to 1,052thousand TEU in 2005. In the last three years demand for container shipping has accelerated strongly, with estimated growth in world container trade reached 11.6% in 2003, 13.4% in 2004 and 10.1% in 2005.

### 2.2.3. A volumes trend of Container ship

Figures 2 3 is about the world container volumes from 1990 to 2007. The average annual growing rate is 10.4% in these years. The container volume in 2007 reached 4,918 thousand TEUs. Compare with 2006, the increasing rate is 11.7%.

**Figures 2 3 The world container volumes in 2008**




Source: OSC, Marketing of container terminals, 2004,
OSC, East Asian Container port Markets to 2020, 2006.

# Chapter 3: A method of study

## 3.1 Precedence of study

The research on the transportations such as railway, motorway etc. on the road have been developed for a long time. The congestion on the road is one of the most serious problems for road transport, so there are a lot of studies on these areas. But there are less researches are being done on Demurrage • Accumulation of Stocks which refer to the stocks caused by the vessels delay in the port. The skimp research on this area is because of the dramatic development of container ships. The problems don't appear immediately, but problems will show up afterwards. In 1977, Goss & Mann announced their research on "vessel time cost calculate methodology" and "vessel time cost result". This is the first study and a methodology on this area. The World Bank made a computer program on shipping cost. The program is based on two ideas from Goss & Mann: The long run opportunity cost and vessel time cost calculate methodology. The World Bank used this computer program to analyze the Demurrage • Accumulation of Stocks cost of a British port in 1970 and the result confirmed the theory of Goss & Mann. On the study of Goss & Mann on Demurrage • Accumulation of Stock cost, they consider both vessel dwell cost and accumulation of stock cost. In the part of vessel dwell cost, they classify the different situations by different vessels: oil tanker, bulk carrier, general cargo bulk, combination carrier, container ship, roll-on/ roll-off, LASH etc. They divide accumulation of stock cost into 4 parts: general cargo, goods, liquid cargo (wet cargo), and container cargo.

Jansson & Shneerson also did the research on Demurrage • Accumulation of Stocks in 1982. They believe that too many uses on facilities in port cannot make it more efficient. Contrary, the vessel service time increase and it will lead to negative effect which refers to the congestion within the port. The waiting cost (Queuing cost), the wage for labor etc. are increasing in Demurrage • Accumulation of Stocks cost. The congestion actually increases the Demurrage • Accumulation of Stocks cost. So the

appropriate number of facilities is an important issue in the research on Demurrage • Accumulation of Stocks.

Young Hyuk-Lee & Se Young-Kim studied on the imports and exports freight in S. Korea in 1991. Their research is based on two problems: vessel traffic jam in Pusan & Inchon port and the impact of Pusan region's traffic jam on the nation economy. They divide and calculate the vessel traffic jam into two parts: vessel cost and cargo time cost. In the part of region's traffic jam, they consider the traffic facilities as two parts: vessel and vehicle's cost and then analysis the time cost of transport cargo. They use the methodologies such like straight line method and declining balance method of calculating the cargo's time cost. The result of their research is that the traffic jams in Pusan & Inchon port made an annual loss of $1,13o ~ 1,530 thousand of nation economy.

Young Tack – Jang & Sung Gi – Kim worked on the Demurrage • Accumulation of Stocks cost in S. Korea in 1993. Their calculation of Demurrage • Accumulation of Stocks cost bases on the presumption of a long-term opportunity cost. In their research, the vessel and cargo refer to general cargo, goods, liquid cargo (wet cargo), and container cargo. The vessel dwell time cost is the waiting cost that base on the presumption of a long-term opportunity cost. The cargo dwell time cost is based on the data of finance market. In their study, the cargo dwell time cost is 'Cargo dwell time cost = (economic value × social discount rate)/365' per ton. In a case of a 10,000 ton vessel with 70% cargo loaded, the waiting cost for one day in 1990 are: container vessel $10,487; general cargo ship $6,511; oil tanker $6,213; bulk carrier 2,893.

Young Tack – Jang & Souk Kyung-Sung did the same research on this area. Their research is based on the data from foreign trade statistics and Maritime affairs & Fisheries statistics. They also got data from national flag carrier ocean-going vessel companies. These data is about 205 vessels and around 47.5% of all vessels in these companies. From their research, the Demurrage Accumulation of stocks cost of oil

tanker and bulk carrier is getting increasing because of the LNGSHIP. As LNGSHIP requires better infrastructure and facilities in the port, in order to accommodate the demand, port has to charge more cost. So the dwell cost for oil tanker and bulk carrier increasing as well.

Above all, there is no study specialized on the dwell time of container vessels before in S. Korea. So this study will focus on container vessels especially the study on the dwell time of VLCS (VERY LARGE CONTAINER SHIPS).

## 3.2 Analysis methodology

### 3.2.1 Demurrage presumption and Accumulation of Stocks cost presumption

#### 3.2.1.1 A definition of Demurrage presumption

Demurrage time is the time that vessel unnecessary dwell in the port. This is because of the factors happened in the port such as waiting for the documents and waiting for the loading/unloading of the other ships etc.

The definition from the Ministry of Maritime Affairs and Fisheries considering the demurrage time only the time that vessel unnecessary waiting for more than 12 hours. They did a research on those demurrage ships which unnecessary waiting for more than 12 hours and their demurrage time. The reason could be the uncertain reasons happening on the sea and the fixed berth number and berth share, also the reason for the service time for the other ships in the port, the waiting time in the port is inevitable for ships.

But from the economical point of view, we believe, the ship unnecessary waiting for more than one minute is ship's demurrage time. Due to the reason of fixed number of berth and the berth share, some people try to solve the problem by build more berth. But sometimes the ship has to waiting for the documents and the process to berth even though the berth is empty. So build more berths is not the ideal way and will lead to

unnecessary economic loss. So in this study we will research on the phenomenon that make vessel waiting for berth. Then we will give suggestions on how to avoid it.

Even though the port environment is getting better in S. Korea, but the waiting time for demurrage vessel doesn't change where we can see from Table 3 1. The demurrage rate of vessel is the numbers of demurrage ships divide the numbers of ships entry into a port.

$$\text{Demurrage rate of vessel} = \frac{\text{The numbers of demurrage ships}}{\text{The numbers of ships entry into a port}}$$

**Table 3 1 Economic loss by Demurrage in Pusan port**

| Year | The number of ships entry into port | Number of Demurrage ships (ships) | Demurrage rate (%) | average Demurrage Time (unit: day) | Loss cost ($) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Total | Direct cost | Indirect cost |
| 2003 | 27,275 | 381 | 1.4 | 1.0 | 72,999 | 3,423 | 69,576 |
| 2004 | 27,855 | 310 | 1.1 | 1.1 | 67,632 | 2,940 | 64,683 |
| 2005 | 27,813 | 267 | 1.0 | 1.2 | 60,805 | 2,476 | 58,329 |
| 2006 | 27,479 | 270 | 1.0 | 1.2 | 63,464 | 2,340 | 61,134 |
| 2007.06 | 14,247 | 221 | 1.6 | 1.2 | 54,152 | 1,866 | 52,286 |

Source : Shipping daily (www.shippingdaily.co.kr)

In 1999, the average demurrage time is 1.14 day. The average demurrage time is 1.0 day in 2003 and by the end of June in 2007, the average demurrage time is 1.2 day. Even though the port's cargo handling ability and operation is getting much more efficiency than before, but the average demurrage time is almost same in the past years. It is because that the development of infrastructure in the port is slower than the development of vessel size.

### 3.2.1.2 Analysis methodology of Demurrage presumption

This study bases on the theory and methodology which have been done by both Goss & Mann(1977) and Young Tack – Jang & Sung Gi – Kim(1992)

Normally there are three different methodologies to calculate the vessel demurrage time cost. First way to calculate is general mathematic calculation: find out the data about the vessel dwell time and calculation the market price. The second way is more empirical, they doing research to those experience vessel managers, to let them choose to bear the demurrage cost or fill in a questionnaire with various options on how to avoid the vessel demurrage cost.

The third way they use the concept of vessel long term opportunity cost which they don't consider the situation that there don't have demurrage in the port. In a short term, if there don't have demurrage in the port so the ship can benefit from it. So whether ship can benefit depends on the maritime market. But this hypothesis is not accurate yet. However it is still popular because this hypothesis used in the area of appraising the society cost in public investment. Accordingly, our study recommends research in this way. Because this hypothesis make economic analysis and concept of port develop strike tally.

This hypothesis is on the assumption that the benefit of shadow price's reduction is influenced by price yield level, and it makes the cash operating cost and capital cost strike tally. In other word, it appears on Long-term Equilibrium Revenue Level by a calculated put NPV (Net Present Value) NPV is an indicator of how much value an investment or project adds to the value of the firm.

and IRR (Internal Rage of Return) The internal rate of return (IRR) is a capital budgeting metric used by firms to decide whether they should make investments. It is an indicator of the efficiency of an investment, as opposed to net present value(NPV), which indicates value or magnitude. Accordingly, the calculation way of vessel dwell

time is by opportunity cost conception and this is what we call "shadow price way". This price doesn't include that receiving any special services from the port. Normally we calculate vessel cost and DWT by the unit of per day. Accordingly, we have to change the numbers of capital cost and operating cost in to the unit of per day. The elements we need in our calculation list as below;

- Wages: Sea-man's salary, Also include Fringe benefit, Appropriation for them after retire.
- Ships store: Vessel operating needs a foundation cost for its resources.
- Insurance: Vessel insurance, P&I insurance, other mutual aid between association & insurance for vessel
- MA intendance cost: The repairing charges
- General cost: General cost, exclusive of shipping cost, cargo cost
- Fuel cost: fuel cost during dwell time

If we know the shipping price, we can know the social opportunity cost as well. And we assume that the supply and demand are without the monopoly phenomenon. Because the shipping cost is no relationship with society cost of resource, so we consider the shipping cost out of general cost list. And the shipping cost is influenced by various reasons. So we except shipping cost from cargo cost and time cost

Capital charge can be the same with investment capital cost which equals constant annuity during vessel's service time. Appropriate capital cost for vessel investment cost is collected and become same to the beginning investment.

$$CC = \frac{C_0}{\frac{1-(1+r)^n}{r}}$$

CC: Annual capital cost (capital charge)

$C_0$ : Beginning investment capital cost

n : Vessel's economic period of depreciation

r : Social discount rate

The good point of this way is that we don't have to calculate cost both The depreciation cost and The interest cost. Besides, it should be appropriate equal capital cost every year during vessel's economic life. Therefore we can calculate the stationary vessel time cost by Vessel's age.

But in this way, the vulnerable point is that we cannot consider the diminution effect by technique development. However, it's clear that technique development makes more efficient in the field of maritime.

On one side, if vessel's dwell time decreases, shipping companies can reduce the number of vessels in the maritime market, for necessary service to customers . And the asset for operating fewer vessels can be used in the other field. On the other side, if dwell time is getting increase, shipping companies have to spend money on demurrage cost which was supposed to be investing in the other field. Accordingly, if we want to know the annuity of capital cost, we need to know the long-term opportunity cost. Its receiving rate of return doesn't reflect in the maritime market. In this kind of view, Shipping Company has to pay a fixed interest on vessel loan when vessel is under construction. So this interest is exclude because it is not reflect social opportunity cost

Generally, vessel's economic life is 25 years. But this economic life gets off Scrap Value. Because Scrap Value not only takes a few position after 25year but also in case of change present value, this result is a negligible quantity.

According to the other researches on discount rate of port development investment's business validity analysis and discount rate of economical effect analysis, the discount rate is around 5.5%. So in our study, we use 5.5% for social discount rate.

The entire price is nothing to inflation. Because this price is calculate at real terms. When cost list different from base year, it be adjust producer price index for change number with base year price. We can solve price fluctuation by the way that divide statistics data by price index increasing rate.

Normally, vessel's working time is 350days per year. So we can see vessel's long-term opportunity cost per day in the below calculation

$$LROC = \frac{CC+OC}{350} + FC$$

$$= \frac{1}{350}\left[W + SP + INS + MNTN + GA + \left(\frac{C_0 \cdot r}{1-(1+r)^{-n}}\right)\right] + [(F_1 \times P_{f1)} + (F_2 \times P_{f2})]$$

LROC : Vessel's Long Run Opportunity Cost per day

CC : Annual Capital charge

OC : Annual operating cost

FC : Fuel cost per day

W : Annual wages

SP : Annual ships store cost(Stores & Provision)

INS : Annual insurance

MNTN : Annual repairing charges

GA : Annual general cost

$C_0$ : Beginning capital cost

r : Social discount rate

n : Number of vessel's economic life year

$F_1$ : The amount of fuel used per day

$P_{f1}$ : Fuel price per ton

$F_2$ : The amount of lubricant oil used per day

$P_{f2}$ : Lubricant oil per ton

In this calculation, we should know the vessel's weight tonnage, purchase year, purchase price, annual wages, ships store cost, insurance, repairing charges, general cost, the amount of fuel used per day, the amount of lubricant oil used per day etc. We change price index and mediate base year price. And then, we analyze vessel' long-term opportunity cost by regression analysis. So we can know the vessel's long term opportunity cost per day of different size's vessel by the formulation below:

$$Y = a \cdot X^b$$

Y : vessel's a long-term opportunity cost per day

X : DWT

**3.2.2 The premise of Demurrage, Accumulation of Stocks cost**

Before, we calculate vessel's with dwell time cost without cargo. This is except accumulation of stocks cost. If ship waiting in port. Of course, both dwell cost of vessel itself and accumulation of stocks cost of manufactured good son the vessel are appear together.

The cargo dwell time cost shows in various results. First, some cargo has to arrive at a specification date. Some companies have very huge project and it require the cargo arrive at the destination on time. So if the cargo is delayed, the companies have to suffer a huge loss. On the other side if we can forecast the delay of the cargo before hand, we can prepare to change the investment plan. If the delay of cargo is a death

blow of the company's business, they can use air transport instead of maritime transport. This kind of adverse criticism is similar to the short run opportunity cost of vessel time. So it is impossible to find out one general methodology to solve all the problems in one time.

Second, if cargo spends a long time on transit, the insurance of cargo will be higher as well. So if the cargo spends less time on the way, the insurance will also getting decrease. But normally, most of damage cargo is damaged during the process of loading/ unloading and it is seldom to be damaged during the waiting time. So it is difficult to gather information from this effect.

Third, the cargo on the transit can be realized to financial resources procurement by working capital from inside and outside environment. So we can pursue a bank load of money include pre-paid interest from outside environment. The pre-paid interest will increase if the dwell time is longer. In the case of inside environment, importer and exporter cannot take interest if except opportunity cost. In some case, opportunity cost appears because of the used capital cost from bank or society cost etc. We don't consider the financial resource relation both outside procurement and inside procurement. So we analyze the cost of manufactured goods for capital of social opportunity rate. Even though consider social discount rate on manufactured goods value.

$$\text{Accumulation of Stocks cost per day} = \frac{\text{cargo value x social discount rate}}{365}$$

$$\text{Accumulation of Stocks cost per time} = \frac{\text{cargo value x social discount rate}}{365 \times 24}$$

We can calculate the cargo value by the way of divide export and import cost by volume rate, which are from the maritime export and import volumes and bank data. The cargo value per weight can be calculated in the way of divide amount of an articles list by volumes.

#### 3.2.2.1 A discount rate

Social discount rate is opportunity cost of resource. So not only we presume benefit from the investment in the other areas but also it appears objective value of time which can be changed by people, society, age etc.

The discount rate conception is applied in investment business. But there have different view on this issue. The government applies the social discount rate on the port development investment business. But generally, the private capitals apply the financial discount rate which is based on the market interest rate on the port development investment business.

Normally we appropriate social discount rate is lower level than market rate of interest. On one side we use social discount rate to appraise business validity. On the other side, we apply market rate of interest to private investment business. Market rate of interest decided by the following factories: borrowed capital procurement cost, opportunity cost about equity capital and business's size, Scale, geographical location

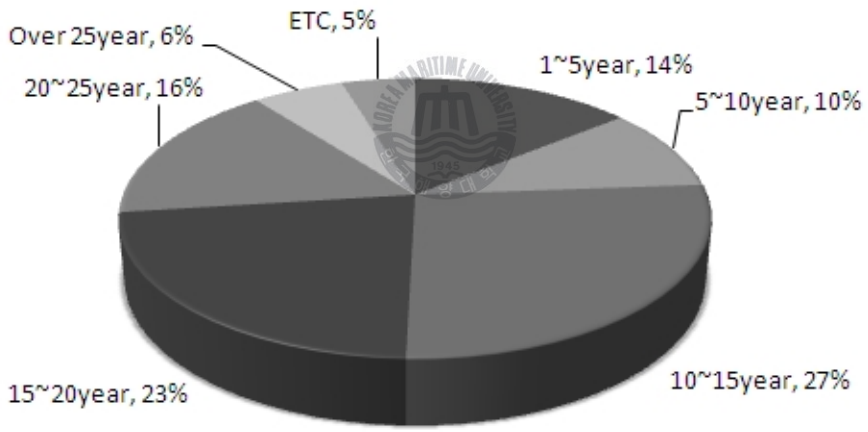
In case of market receiving rate of return, this study applies 9.18% on the in expediency receiving rate of return. We consider private investment business's receiving rate of return level and domestic port private investment business's average investment receiving rate of return. And in case of social discount rate, we use 5.5% Traffic facilities investment business. A discount rate change 7.5% to 5.5%. in social discount rate which is from Korea Development Research Center (2007)

#### 3.2.2.2 Vessel's age

The age of vessel can be checked after vessel is launching because the ship is rust out by the act of the sea water. We categories the vessel launching time below 10 years is

new ship, the ship between10 to 20 years is a second hand vessel, the vessel is more than 20 years is a hulk. Some shipping companies are running some vessels which are more than 30 years. In the case of cargo ship, the average economics age is 25 years. Normally, shipping companies believe that after 25 years running of vessel, they can get the initial cost of the ship built. So in this study, we believe the vessel's life cycle is 25 years. In the case of S. Korea vessels in 2008, the average domestic vessels' age below 10 year occupy 24%; the ships more than 20 years are 22% of total domestic vessels; the ships more than 25 years are only 6%. The vessels between 10 to 20 years are 50%. The reasons why the major part vessels are between10 to 20 years are because we brought a quantity of second hand vessels.

**Figures 3 1 Presentation on Korea Nationality Ocean-Going Vessel's age**




Source: Monthly maritime korea, 02.2008, 44p

# Chapter 4: Result of Analysis

## 4.1 Demurrage

### 4.1.1 Data

This study uses the data from Korea Maritime Institute (2002). We also consider 3parts for vessels' demurrage cost and then we can analyze the result of Vessel capital cost and demurrage operation cost. First, this study change a base finance agreement from pre-existence study's data (2000) by using average changing rate with America dollar and price index in 2007. Second, pre-existence study classifies the vessels into container ship, general cargo ship and bulk carrier. In our study, we consider container ship in the unit of per DWT. Third, Goss & Mann readjust the wages' data from the increase wage rate. In this study, we use the wage data from the vessel companies in S. Korea.

Container ship's annual total operation cost is: $9,259,000 for 4,000TEU ships, $11,822,000 for 6000TEU ships and $14,494,000 for 10,000TEU ships in 2001 which we can see from table 4 1.

**Table 4 1 Annual Shipping cost of Container ships**

unit : Thousand $

| Classification | 4,000TEU | 6,000TEU | 10,000TEU |
|---|---|---|---|
| Labor costs | 850 | 850 | 850 |
| Repair upkeep cost | 900 | 1,025 | 1,150 |
| Insurance | 800 | 1,000 | 1,700 |
| Ships store cost | 250 | 300 | 350 |
| General management cost | 175 | 175 | 175 |
| Fuel cost | 4,284 | 5,722 | 7,269 |
| Shipping cost | 2,000 | 2,700 | 3,000 |
| TOTAL | 9,259 | 11,822 | 14,494 |

Source: Drewry Shipping Consultants, Post-Panamax The Next Generation, 08, 2001

### 4.1.2 Result of demurrage

In our research we get the vessel demurrage time cost from the data of vessel C & shipping ship companies and Drewry Shipping Consultants Company. This study is research on the vessel's dead weight tonnage, production year, purchase year, service life, annual operation cost(wage, insurance, repairing charges, ships store cost, general cost) and fuel cost etc.

The operating cost is the summation of annual wages; ships store cost, insurance, operation upkeep cost, general cost and total annual operating cost. The fuel cost Fuel cost = (fuel cost ÷ per day × fuel price) + (lubrication oil consumption ÷ per day × lubrication oil price)is the summation of that product of number of fuel cost per day multiply fuel price and that product of number of lubrication oil consumption per day multiply the lubrication oil price.

The long term opportunity cost per vessel and day Long term opportunity cost = (annual capital cost + operating cost) ÷ 350 + fuel cost is the summation of the quotient of annual capital cost and operating cost divide 350 plus fuel cost per day.

In the result, we get the weight in DWT for different size of container ships. This study makes the regression equation from correlation of vessel scale (DWT) cost per day. As mentioned above, this study considers a fault type of ships (non-liner) by vessel's economics of scale. The calculate expression can be seen downwards,

$$\mathbf{LROC = a \bullet DWT^{b}}$$

LROC: Vessel's a long-term opportunity cost per day

a, b : computation

We can get the result of regression analysis on time cost of container ship by a logarithmic function. The result shows on the below table 4 2.

**Table 4 2 Regression analysis on time cost of Container ship**

| a | b | $R^2$ |
|---|---|---|
| 8.074(42.87) | 0.834(42.98) | 0.97 |

(): t-value

The type of ship expression for the demurrage cost of container ship for this study base on the study from Goss and Mann (1977)'s a presume expression.

$$\mathbf{In(y) = a + bIn(x)}$$

y : Vessel's a long-term opportunity cost(LROC)

x : Vessel' ton (DWT)

This study uses the expression above to calculate the vessel demurrage time cost per day by divide the vessels into different size. We can see the result from the table below Table 4 3. We can see demurrage cost per day by the expression downward,

$$\mathbf{LN(COST)} = \mathbf{a + bLN(DWT) = LN(e^a) + LN(DWT^b) = LN(e^a \times DWT^b)}$$

$$\therefore \mathbf{COST = e^a \times DWT^b}$$

Because regression expression's result is a = 8.074, b = 0.834. We apply the result's coefficient to the vessel size, so we can see the time cost per vessel. In case of a 5,000DWT vessel, its cost is \$3,735(Cost $=e^{8.074} \times 5000^{0.834}$). The result is dividing the LN Natural logarithm cost by the time (the time here is 24hours).

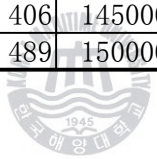
The demurrage cost is increasing when the vessel's size increasing. When the vessel's volume is increasing from 20,000 DWT to 120,000 DWT, the demurrage cost is

increasing from $11,870 to $52,898 per day. A 150,000 DWT container ship's demurrage cost can be $63,719 per day (see table 4.3).

**Table 4 3 Demurrage cost of container vessels**

Unit : US$

| DWT | Cost per day | Cost per hour | DWT | Cost per day | Cost per hour |
|---|---|---|---|---|---|
| 5000 | 3, 735 | 156 | 80000 | 37, 721 | 1, 572 |
| 10000 | 6, 659 | 277 | 85000 | 39, 677 | 1, 653 |
| 15000 | 9, 338 | 389 | 90000 | 41, 614 | 1, 734 |
| 20000 | 11, 870 | 495 | 95000 | 43, 534 | 1, 814 |
| 25000 | 14, 298 | 596 | 100000 | 45, 437 | 1, 893 |
| 30000 | 16, 647 | 694 | 105000 | 47, 324 | 1, 972 |
| 35000 | 18, 930 | 789 | 110000 | 49, 196 | 2, 050 |
| 40000 | 21, 160 | 882 | 115000 | 51, 054 | 2, 127 |
| 45000 | 23, 345 | 973 | 120000 | 52, 898 | 2, 204 |
| 50000 | 25, 489 | 1, 062 | 125000 | 54, 730 | 2, 280 |
| 55000 | 27, 597 | 1, 150 | 130000 | 56, 550 | 2, 356 |
| 60000 | 29, 675 | 1, 236 | 135000 | 58, 358 | 2, 432 |
| 65000 | 31, 723 | 1, 322 | 140000 | 60, 156 | 2, 506 |
| 70000 | 33, 746 | 1, 406 | 145000 | 61, 942 | 2, 581 |
| 75000 | 35, 744 | 1, 489 | 150000 | 63, 719 | 2, 655 |



## 4.2 Accumulation of Stocks cost

### 4.2.1 Data

The calculation for accumulation of stocks cost's data is from the Korea Customs Service Web-site「foreign trade statistics system(2007) 」and Korea Maritime Institute. The volume of export and import from「foreign trade statistics system(2007) 」uses the unit in M/T. But now there is no system can change to R/T R/T: Revenue Ton unit. Accordingly, this study considers the situation mentioned above, so we gather the data on export and import amount from Korea Customs Service Web-site「foreign trade statistics system(2007)」, and the data on the volume of export and import from Korea Maritime Institute data.

And Korea Customs Service Web-site「foreign trade statistics system(2007)」classifies items into 99 different categories on the HS(Harmonized Commodity Description and Coding System). Annual Statistics of Maritime Affairs and Fisheries divide the items of Korea Customs Service into 32 categories. So we will make the annual foreign trade statistics into 99 categories and the annual statistics of maritime affairs and fisheries into 32 categories.

A classified cargo volume item equals to a classified container cargo weight item multiplies a classified cargo volume item. In this calculation, we will change the unit from M/T to R/T.

### 4.2.2 Imports and exports freight about Accumulation of Stocks cost

#### 4.2.2.1 Economic value of Container Cargo

In the next table 4 4, the total Korea's import & export volume is 693,447 thousand ton in 2007. The total export cost is $ 36,997 million with a volume of 181,674 thousand tons. The total cost is import appear $ 35,684million with a volume 511,773 thousand tons. Expect and import per unit value are 2,036 and 697 $/ton. The average volume per ton of container trade in S.Korea in 2007 is 1,048 $/ton.

**Table 4 4 Import and export in cargo tonnage and value**

| Classification | Cost($) | Volumes(ton) | Value per ton($/ton) |
|---|---|---|---|
| Export | 369,976,726,000 | 181,674,634 | 2,036 |
| Import | 356,845,733,000 | 511,773,257 | 697 |
| TOTAL | 726,822,459,000 | 693,447,891 | 1,048 |

source: Korea Customs Service

From table 4 5 the total import& export volume of container ship in 2007 is 16,057699 TEUs, which is 244,010,916 tons totally in Korea.

**Table 4 5 Container trade in Korea in 2007**

| Classification | Import | | Export | | TOTAL | |
|---|---|---|---|---|---|---|
| | TEU | Ton | TEU | Ton | TEU | Ton |
| Full | 6,500,000 | 117,000,000 | 7,056,162 | 127,010,916 | 13,556,162 | 244,010,916 |
| Empty | 2,296,000 | 0 | 205,537 | 0 | 2,501,537 | 0 |
| Total | 8,796,000 | 117,000,000 | 7,261,699 | 127,010,916 | 16,057,699 | 244,010,916 |

Source: Pusan Port Authority, 2007

In table 4 6 the total volume of container cargo is 244,010,916 tons in 2007, and the total cost is $ 340,236,121,827.

**Table 4 6 Container trade by cargo type in tonnage and value in 2007**

unit: US $

| Import | | Export | | TOTAL | |
|---|---|---|---|---|---|
| Ton | Cost | Ton | Cost | Ton | Cost |
| 117,000,000 | 81,580,954,436 | 127,010,916 | 258,655,167,391 | 244,010,916 | 340,236,121,827 |

#### 4.2.2.2 Demurrage cost of freight

Goods' value will decrease following the social discount rate which is coursed by vessel's delay. We use the way of Goss & Mann's accumulation of stocks cost to consider the container cargo.

The accumulations of stocks cost can be calculate by cargo's value per ton multiply the quotient of divide social discount rate (market receiving rate of return) by 365.

**Table 4 7 International cargo trade by major container in 2007 in Korea**

| Ton | COST | Value per ton | Time cost by Container | |
|---|---|---|---|---|
| | | | Cost per day | Cost per hour |
| 244,010,916 | 340,236,121,827 | 1,394 | 0.210 | 0.009 |

Demurrage cost equals to value per ton multiply social rate / 365 and the divide by 24.

### 4.2.3 Container box

First, in order to know the annual capital cost, we apply the service life and social discount rate (5.5%)into the container charter fight purchase price. The Annual opportunity cost is the summation of annual capital cost plus annual maintenance cost. So the container charter fight's dwell time cost per day is the quotient of dividing annual opportunity cost by 365.

**Table 4 8 Purchase price and maintenance cost of container box in 2007**

unit : US$

| Classification | 20feet | 40feet |
|---|---|---|
| Price | 1,452 | 2,322 |
| Service life | 15 | 15 |
| Annual maintenance cost | 128 | 204 |

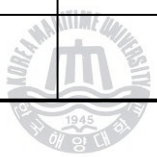
Normally the container service life is 15 years, the annual maintenance cost for a 20feet container box is $128 and $204 for a 40 feet container box.

The table 4 9 shows that the opportunity cost per day for a 20 feet container is 0.747 US$, the opportunity cost per day for a 40 feet container is 1.193 US$.

**Table 4 9 container charter fight dwell time cost in 2007**

unit : US$

| **Classification** | 20feet | 40feet | - |
|---|---|---|---|
| Capital cost | 145 | 231 | annual capital cost 20TEU: 1,452/((1-((1+0.055)^-15))/ 0.055) |
| Operation cost | 128 | 204 | maintenance cost |
| Annual opportunity cost | 273 | 435 | capital cost + upkeep cost |
| Opportunity cost per day | 0.747 | 1.193 | annual cost / 365 |
| Opportunity cost per hour | 0.031 | 0.050 | day cost / 24 |



The table 4 10 shows the container cargo accumulation of stocks cost. The container cargo cost per day is the summation cargo cost per day plus container box cost. So a 20 feet container cargo's accumulation of stocks cost per day is 4.527$ a 40 feet container cargo's accumulation of stocks cost per day is 8.753$.

**Table 4 10 container cargo Accumulation of Stocks cost**

unit : US$

| **Classification** | **20feet** | **40feet** |
|---|---|---|
| Cargo cost per day Time cost by Container per day * 18ton | 3.780 | 7.560 |
| Container box cost | 0.747 | 1.193 |
| Container cargo cost per day | 4.527 | 8.753 |
| Container cargo cost per hour | 0.189 | 0.365 |

1TEU = 18ton

### 4.2.4 Result of Accumulation of Stocks cost

Accordingly, ship dwell time cost is the summation of ship demurrage cost plus accumulation of Stocks cost. But the unit is different from ship demurrage cost and accumulation of Stocks cost. The ship demurrage cost is calculated by DWT and the ship accumulation of stocks cost is calculated by TEU. So we have to change them to the same unit. In our study, we change all their unit into DWT.

- Korea Container ship's bottoms(A) = 3,169,742DWT
- Korea Container ship's bottoms (B) = 219,978TEU
- Change computation(DWT/TEU) = A/B = 14.41

**Table 4 11 Result of Accumulation of stocks cost in 2007**

Unit : $

| DWT | Cost per day | Cost per hour | DWT | Cost per day | Cost per hour |
|---|---|---|---|---|---|
| 5000 | 1,100 | 46 | 80000 | 17,593 | 733 |
| 10000 | 2,199 | 92 | 85000 | 18,692 | 779 |
| 15000 | 3,299 | 137 | 90000 | 19,792 | 825 |
| 20000 | 4,398 | 183 | 95000 | 20,891 | 870 |
| 25000 | 5,498 | 229 | 100000 | 21,991 | 916 |
| 30000 | 6,597 | 275 | 105000 | 23,091 | 962 |
| 35000 | 7,697 | 321 | 110000 | 24,190 | 1,008 |
| 40000 | 8,796 | 367 | 115000 | 25,290 | 1,054 |
| 45000 | 9,896 | 412 | 120000 | 26,389 | 1,100 |
| 50000 | 10,995 | 458 | 125000 | 27,489 | 1,145 |
| 55000 | 12,095 | 504 | 130000 | 28,588 | 1,191 |
| 60000 | 13,195 | 550 | 135000 | 29,688 | 1,237 |
| 65000 | 14,294 | 596 | 140000 | 30,787 | 1,283 |
| 70000 | 15,394 | 641 | 145000 | 31,887 | 1,329 |
| 75000 | 16,493 | 687 | 150000 | 32,986 | 1,374 |

Table 4 11 shows the accumulation of stocks is increasing when the vessel's size increasing. When the vessel's volume is increasing from 20,000 DWT to 120,000 DWT, the accumulation of stocks is increasing from $4,398 to $26,389 per day. A 150,000 DWT container ship's accumulation of stocks can be $32,986 per day

## 4.3 Result of Demurrage and Accumulation of Stocks cost

Table 4 12 shows the Dwell Time Cost of vessel. When the vessel's volume is increasing from 20,000 DWT to 120,000 DWT, the accumulation of stocks is increasing from $16,269 to $79,288 per day. A 150,000 DWT container ship's accumulation of stocks can be $96,705 per day

**Table 4 12 Dwell Time Cost of vessel**

**Unit : US$**

| DWT | Demurrage | *AS cost | TOTAL | DWT | Demurrage | *AS cost | TOTAL |
|---|---|---|---|---|---|---|---|
| 5,000 | 3,735 | 1,100 | 4,835 | 80,000 | 37,721 | 17,593 | 55,314 |
| 10,000 | 6,659 | 2,199 | 8,858 | 85,000 | 39,677 | 18,692 | 58,370 |
| 15,000 | 9,338 | 3,299 | 12,637 | 90,000 | 41,614 | 19,792 | 61,406 |
| 20,000 | 11,870 | 4,398 | 16,269 | 95,000 | 43,534 | 20,891 | 64,425 |
| 25,000 | 14,298 | 5,498 | 19,796 | 100,000 | 45,437 | 21,991 | 67,428 |
| 30,000 | 16,647 | 6,597 | 23,244 | 105,000 | 47,324 | 23,091 | 70,414 |
| 35,000 | 18,930 | 7,697 | 26,627 | 110,000 | 49,196 | 24,190 | 73,386 |
| 40,000 | 21,160 | 8,796 | 29,957 | 115,000 | 51,054 | 25,290 | 76,343 |
| 45,000 | 23,345 | 9,896 | 33,240 | 120,000 | 52,898 | 26,389 | 79,288 |
| 50,000 | 25,489 | 10,995 | 36,484 | 125,000 | 54,730 | 27,489 | 82,219 |
| 55,000 | 27,597 | 12,095 | 39,692 | 130,000 | 56,550 | 28,588 | 85,138 |
| 60,000 | 29,675 | 13,195 | 42,869 | 135,000 | 58,358 | 29,688 | 88,046 |
| 65,000 | 31,723 | 14,294 | 46,017 | 140,000 | 60,156 | 30,787 | 90,943 |
| 70,000 | 33,746 | 15,394 | 49,139 | 145,000 | 61,942 | 31,887 | 93,829 |
| 75,000 | 35,744 | 16,493 | 52,238 | 150,000 | 63,719 | 32,986 | 96,705 |

*AS = Accumulation of Stocks

# Chapter 5: Conclusion

In this study we follow the methodology of Goss & Mann. But this methodology is not perfect.

The global ship market is getting much bigger and the ships number is increasing. If Pusan port doesn't make more berths, container ships have to waiting in Pusan port. If this situation happened, Pusan port will lose the status of hob port in East Asia.

Pusan port opens a new port which is specialized for container ships. So it is possible to accommodate the large ships. The berths capacity is getting big as well.

But the new port also has problem. As this is a new port, there don't have enough cargos in new port; the terminal companies don't invest in new port since there don't have enough cargos. But this problem is temporary. We believe it will getting better soon. Chinese ports develop in a very high speed that is one of the problems which restrict Pusan new port's development.

In a long term, if Pusan port doesn't want to lose container ships, they have to make an efficient waiting time system to reduce the dwell time in the port. So in our study, we give information on how the Demurrage and Accumulation of Stocks cost comes. We wish Pusan port can make a better port system to avoid the dwell time by consider the research we given.

As the limitation of data gathering, if we want more details on this research, we have to use the other methodologies. I believe more studies will be done on ship's Demurrage and Accumulation of Stocks cost in the future.

# Ⅳ. References:


1. Filip Merckx (2005), The impact of dwell times on container terminal capacity

2. Young Tae Chang, Sung Gwi Kim (1993), The Cost of Ship's Time in Port

3. Young Tae Chang (1994), A Study on the Estimation of Ship Arrival and Departure Time Distribution in Major Port of Korea

4. Chang Ho Yang, Chang Gun Kim, Jung Uk Bae (2001), A Study on the Presumed plan of Container Terminal Processing Capacity. KOREA MARITIME INSTITUTE

5. Chang Gun Kim(2002), A Comparison and Analyses Port Waiting system by Queuing theory and Time series data. 韓國海運學會 誌 第35號 (08.2002, 141～160)

6. Chul Hwan Han (2007), Market Concentration and Development Strategies of International Liners and Terminal Operators. The Journal of Shipping and Logistics Vol.55(December, 2007, 1~25)

7. Goss, R.O. and Mann,M.C., The Cost of Ship' Time, Advances in Maritime Economics, Edited by R.O. Goss, UWIST, 1982, pp. 139-177.

8. Tae Won Park, Bong Min Jung(2002), Analysis of A Large Container ship on Economical effect, Korea Maritime Institute