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A Comparative Study on European Container Terminal Operation System

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Abstract : *As the competition in the liner shipping industry is becoming fiercer, the shipping company is trying to find the way to keep the best competitive position by reducing the cost level as low as possible and offering the best quality of service to their customer. In order to achieve this goal, the selection of port and terminal that have the best quality of service and cost effective structure is essential for the shipping line, where they can only have a chance to save the money. In this context, the paper compares three European container terminals in order to understand the factors that have to be considered in the decision making process for the selection of terminal. And its advantages and disadvantages of each type of container terminal operation system were analyzed from the liner shipping company's point of view in terms of cost, time, flexibility, stability, hinterland connection, geographical position and terminal productivity. It is obvious that the cost factors are very important for liner shipping company to select their terminal. However, there might be even more important factors than the cost factors, such as quality of port and terminal service, mutual trust, and possibility of future development.*

Key words : *port competitiveness, conventional terminal, automated terminal, indented berth*

1. Introduction

The competition in the liner shipping industry is becoming fiercer. The phenomenon is mainly resulted from the rapid growth of containerized cargo and upsizing of container vessel. Thus shipping liners are trying to reduce slot cost by offering economies of scale. With the same reason, world container terminals are also confronted with severe competition. Because liner shipping companies keep trying to find the way to reduce cost level as low as possible and terminal handling cost is one of the important expenses that the liner shipping company has to reduce.

In this study, three different container terminals in Netherlands and Belgium will be compared in order to give some idea for liner shipping companies, which may be useful for achieving their ultimate goal.

Three different container terminals have very specific terminal operating system respectively. Such as, Ceres Paragon terminal in Amsterdam equipped with an indented berth where ships can be handled from both sides, making loading and unloading much faster than usual; European Combined Terminal (ECT) in Rotterdam, which is very famous for fully automated container terminal, has Automated Guided Vehicles (AGV) and Automated Stacking Cranes (ASC) for its terminal operation; and Hessenatie Terminal in Antwerp has conventional type of terminal operating system with straddle carriers.

In addition, the more interesting thing is that they have very unique geographical situation, which possibly be represented three nautically different type of terminal all over the world. The ship has to pass the lock in North Sea Canal to berth Ceres Paragon Terminal at Amsterdam, which may require additional time. At Antwerp, river Scheldt is another hindrance of Hessenatie Terminal, which is also consuming a couple of hours to berth. However, ECT has relatively better position that they have very short distance from sea to berth. These three terminals have more or less the same hinterland where they can serve North European by road, rail and inland waterway connection.

The main purpose of this paper is to analyze the important factors that play an important role in shipping companies' terminal selection process through the comparison of three different terminals, These factors are the main determinants of a port's competitiveness. Thus the results of the study can give useful implications for port managers and policy decision makers.

This paper is organized as follows. Section 2 reviews the previous literatures regarding the determinant factors of port competitiveness. The section 3 explains the major factors that might determine the competitive advantage of port and terminal according to theoretical backgrounds, especially from the shipping liner's point of view. The comparison of three European container terminals will be presented in section 4 by using the factors that presented in previous section. Finally, some implications will be suggested in section 5.

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2. Literature Review

There are many literatures in the field of maritime and port management that have analyzed the port competition among ports, located in the same port range and sharing the same hinterland. Goss (1990) and Heaver (1995) have argued that the elements of intensifying port competition are the international harmonization of port policies and reducing the role of central government, local autonomy. Even both Slack (1994) and Fleming (1989) have observed that especially the ports specialized in container trade are now faced with intense competition and Heaver (1995) have emphasized that terminals are the major focus of competitive strategy. Therefore, it seems to be useful to summarize some literatures about port competition in order to have some idea for the determining factors of terminal competition in this section, although this paper will be more concentrated from the carrier's point of view.

Slack (1985) indicated that competing ports must be viewed from the perspectives of the exports and importers. He undertook to ascertain the port selection criteria of decision-makers involved in container shipments between the North American Mid-West and Western Europe. And he found that decision-makers are more affected by the costs and levels of the service of the land and ocean carriers than by considerations of port facilities and other port-related economies. In other words, the results revealed that the choice of port is determined by the tariff and service characteristics of truck and rail companies linking the client with the port and by the frequency of sail ng and marine traffics of the North Atlantic container lines.

UNCTAD (1992) suggested several factors as key elements for port competitiveness; geographical location, hinterland transport connection, port service availability and efficiency, price of port services, socio-economic stability, and telecommunication. To create a port development strategy and to improve port efficiency, it is essential all these factors for all ports, with or without inter-port competition, for these factors are based on a single principle: that is, to serve port users better. According to Hayuth and Fleming (1994), geographic location is the key to explaining a port's competitive success. They explained the concepts of *centrality* and *intermediacy* as a critical factor that determines the traffic of transportation hub. These two locational attributes characterize whether a port can be a hub port or not. Centrality generates what can be called true origin and destination container traffic from and to the local hinterland. Intermediacy generates long-distance in transit and transshipment traffic. For this aim, they analyzed the throughputs of world's top 20 container ports.

McCalla (1994) analyzed throughput of major Canadian

Table 1 Summary of Previous Studies on Port Competitiveness

Author(s)	Research region/ports	Research method	Major factors of port competitiveness
Slacks (1985)	North Atlantic	Interview & questionnaire	- Port price - Quality of port service
Flemming & Hayuth (1989)	World's top 20 container ports	Literature survey	- Strategic location (Centrality& Intermediary)
UNCTAD (1992)	-	Literature survey	- Geographic location - Hinterland connection - Port service - Price - Socio-economic stability - Telecommunication
McCalla (1994)	Canadian container ports	Forecasting	- Port facilities - Inland transportation - Port choice of ocean carrier - Demand for shipping - Changes of container route
Notteboom (1997)	European container ports(36)	Shift analysis	- Regular port call for RTW - Large container traffic - High transshipment share - Positive shift effects
Haezendonck et al (2000)	Port of Antwerp	Field survey	- Superstructure - Flexibility - Productivity of dockworker

container ports and tried to forecast future container traffic in Halifax, Montreal, and Vancouver. He suggested five important factors, which could influence on future traffic and competitiveness of Canadian ports. These five factors are port facilities, inland transportation, port selection of ocean carriers, demands for container shipping, and changes in transport route of containers.

Notteboom (1997) examined the concentration and de-concentration tendencies and load center development in European container port system for the period 1980-1994. Through this study, he suggested some criteria evaluating load center status such as regular port of call for Round-the-World service of shipping lines, container traffic volume (more than 400,000TEU), high transshipment share, and substantial positive shift effects which means consecutive positive shift of container traffic towards a port. Haezendonck *et al.* (2000) aimed to identify the most important location advantages determining the port of Antwerp's competitive position for container and conventional cargo as compared to its main rivals in the Hamburg-Le Havre range. They based on the extended version of Porter's diamond approach for analyzing the competitiveness of seaports. This study suggested that a port's competitiveness depended on both the domestic 'diamond' and the foreign 'diamonds' relevant to the actors operating in the port. They used a field survey as an empirical analysis and found that the port of Antwerp largely benefits from the superstructure used by forwarders, the flexibility and the productivity of its dockworkers and its forwarders.

As other studies on the port competition, Miyajimi and Kwak (1989) have suggested that containerization in one of the most powerful exogenous determinants of the changing rivalry in the port sector. According to Baird (1996), scale enlargement in container shipping and the need for the faster turnaround times of vessel will lead to a serious competitive disadvantage for upstream ports with restricted maritime accessibility, such as port of Antwerp. Notteboom *et al.* (1997), however, have demonstrated that this conclusion is wrong and have suggested that other elements, such as hinterland accessibility, infrastructure quality and productivity, also perform a vital role in strengthening a port's competitive position. Thus, there have been considerable studies on the main determinants of a port's international competitiveness. <Table 1> is summarized previous studies on the determinants of port competitiveness.

3. Major Factors Determining Terminal Competitiveness

3.1 Cost

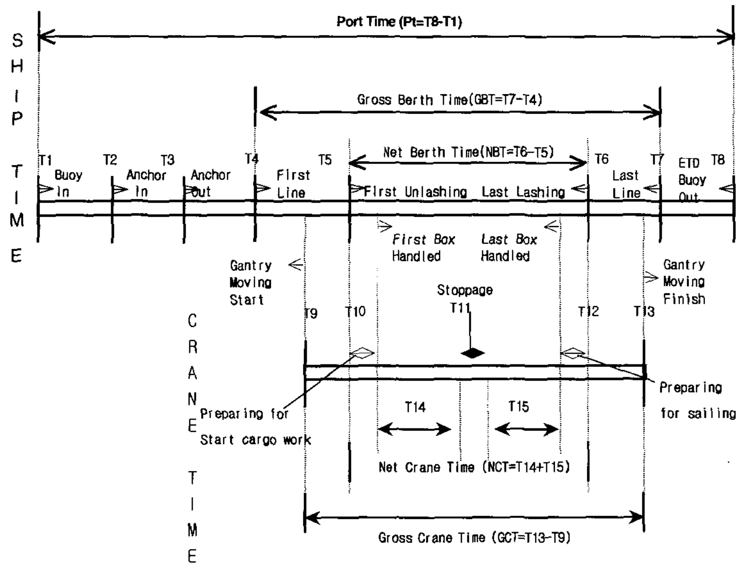
The goal of a liner shipping company is to become the operator with the lowest unit cost by deploying bigger vessel and reducing port and terminal cost. As vessel only can make profit when she is on sailing, staying in port costs money. Therefore, shipping company always tries to reduce the cost in port. The cost in port can be divided into port cost and terminal cost from the shipping company's point of view. Port cost consists of port due, pilot charge, tugboat charge and other nautical service charges. And terminal cost consists of equipment cost, labor cost, operating cost and infrastructure cost. Each of these costs plays an important role in the decision-making process of whether a port will be chosen or not.

Nowadays, it is a common for a liner shipping company to negotiate with the terminal as a group in order to enjoy the benefit of economies of scale through the cooperation with other liner shipping company as an alliance. Generally, we can expect that if the terminal has the more cost effective structure, it has more chance to attract shipping lines.

3.2 Time

The shorter time vessel stay in port, the more cost vessel can save. Therefore, the speed of container handling and consequent vessel turnaround time in port is crucial point in port competition. It is, however, partly influenced by geographical location of port or terminal itself. Even if the terminal productivity is relatively higher than rival port, the port that needs more access and departure time due to geographical hindrances such as lock, river channel and tidal restriction has significant competitive disadvantage. In this case, the port should maintain well-organized port control system in order to compensate geographically inherent handicap. Therefore, turnaround time in port does not mean only for berth time at terminal that mostly influenced by terminal productivity but also total port stay time including the vessel maneuvering time from pilot station or port entrance buoy to berth in harbor and vice versa.

For the definition of each time in port, it is useful to quote time definition in port as illustrated in <Figure-1>. It could be generally divided into two terms; ship time and crane time. Ship time is defined as the time a vessel spends in port. It includes port time, gross berth time and net berth time. And crane time, which takes when cargo is loaded and discharged at berth, includes gross crane time and net crane time.



Source: Jung, S. H. (1999).

Fig. 1 Time Definitions in Port

3.3 Flexibility

Flexibility is a very important factor in terminal competitiveness and can be divided by three aspects; flexibility in terminal operation, terminal capacity and modal split. First, flexibility in terminal operation is crucial factor for shipping liner's port selection. Fully automated terminal system is very difficult to be flexible in operation because every sequence of operation is early fixed by computer system, which hardly can be changeable later on. However, the conventional terminal, mainly operated by straddle carrier system, is relatively easy to increase the productivity by putting simply additional yard equipments such as straddle carrier or yard tractor. Thus this type of terminal gains a great advantage in flexibility over fully automated terminal. Second, terminal capacity is one of major determinants of terminal flexibility that may absorb handling volume at high peak. In practice, 80% utilization of theoretical capacity is an optimal operational capacity of terminal. It has to be considered whether the terminal has enough space to extend quay length and yard space when it reaches its maximum capacity. Third, flexibility in modal split is also a important factor in terminal operation. Flexibility in modal split is defined as the ability of a transport mode at port and terminal such as truck, train and inland barge to meet varying customer demands in time, place and quantity. The terminal that has a variety of modality will have more competitive advantage towards other terminal that has limited possibility. Recently, European government encourages using inland waterway for hinterland connection because of environmental reason.

3.4 Stability

As far as stability in port operation is concerned, we considered three different level; social stabilty, labor stability, and terminal stability. First, social stability implies the events such as civil war, safety problems, unstable service standards and charges etc. Especially, if the port has unreliability of port services such as pilot service, tug boat assistance and line handling service, it is a major disadvantage for the port and terminal. Second, the labor stability is also one of the key elements in the performance of port and terminal. If the port has unstable labor force, because of lack of skill, strikes, boycotts, high damage level and theft, the port user will try to avoid the port and use a neighboring port. Third, terminal stability means the reliability in terminal operation. It includes stability of terminal operating system, yard equipments supply during cargo operation and the failure rate of yard facilities.

3.5 Hinterland Connection

There might be several ways to understand the connectivity of the port. In Asian region, the connectivity of port means more ship-to-ship and ship-shore-ship transfers as transshipment in port. In Europe, however, the landside connectivity is more crucial because Hamburg-Le Havre port range has the same hinterland, North and East Europe. Therefore, in this paper, the scope of the term will be narrowed as the connectivity of hinterland. The quality of the hinterland transport connections is measured in terms of speed, reliability and cost. Nowadays, terminal is not simply loading and discharging point but huge distribution platforms and the new concept of Value Added Logistics (VAL) would be applied, where an order-operated distribution system is more emphasized than a stock-operated distribution system. Therefore, road, rail, and inland waterway connection have to be developed and maintained properly to accomplish a smooth distribution of both import and export containers.

3.6 Geographical Location

Geographical position is the prime factor in a port's competitiveness. Although we cannot change the geographical position of terminal and port, the terminal and port can hardly be expected to obtain a strong competitiveness without such good natural conditions.

Table 2 Summary of Major Factors Determining Terminal Competitiveness

Major Factors	Details	Remark
Cost	Port Cost Terminal Cost	Direct cost
Time	Port Time (Turnaround Time) Gross Berth Time Net Berth Time Gross Crane Time Net Crane Time	Indirect cost
Flexibility	Flexibility in Terminal Productivity Flexibility in Terminal Capacity Flexibility in Modal Split	Adoption capability
Stability	Social Stability Labor Stability Terminal Stability	Firmness of conditions
Hinterland Connection	Road / Rail / Inland Waterway	Strength of total logistic chain
Geographical Position	Favorable Position Less Favorable Position	Inheritance

4. Comparison of Three European Container Terminals

In this section, the comparison of these three terminals will be carried out with the same sequence of factors that have been explained in previous section in order to see the differences of each terminal and how port selection is proceeded by shipping lines.

4.1 Cost

There are many elements consisting of port cost such as port dues, pilot charge, tug boat charge and line handling charge etc and it have to be compared every elements exactly in order to verify for the most cost efficient port. However, as three terminals are all located in the same areas of European Monetary Union (EMU), we assume that the other cost factors such as terminal equipment cost, labor cost and operating cost are the same. Thus port dues and terminal tariff at each port will be compared in this paper.

<Table 3> shows the port due of each port that is based on 5,000 TEU class container vessel. It shows that the port due at Antwerp is cheaper than Rotterdam and Amsterdam. However, it takes 4~5 hours more from pilot station to the berth at Antwerp than the time at Rotterdam. If we assume that the hire base of this type of container ship is roughly USD 34,000 per day, 8~10 hours port in and out time means that a shipping company calling the port is loosing USD 11,300~14,200 more costs than other ports. For Amsterdam, it costs about USD 7,100 due to the time for the passage of Sea Lock and North Sea Canal, which is 5 hours more than that of Rotterdam. Therefore, the total cost that the shipping line has to bear will be up to USD 35,200 at Antwerp and USD 29,100 at Amsterdam respectively.[1)] With respect to this point, it seems that Rotterdam is the most favorable port for shipping lines.

Table 3 Comparison of port due in three container terminals(Unit : Euro)

	Amsterdam	Rotterdam	Antwerp
Port due	22,000	27,000	21,000
Additional Cost considering port time	7,100	-	11,300~14,200
Total cost	29,100	27,000	32,300~35,200

Note : 1) 5,000 class TEU base.

As port dues are considerably lower than terminal handling cost in most ports, the terminal handling costs are more significant cost factors for liner shipping company as a direct expenditure.[2)] Thus terminal cost is another significant cost factor for liner shipping company. Terminal handling costs of three terminals are presented on the <Table 4>.

As the terminal handling cost at Hessenatie is the lowest one, it looks like Hessenatie terminal is more favorable than the other two terminals for shipping lines. However, longer

1) We assume the exchange rate of Euro/USD is 1:1.

2) In the very rough calculation, the port costs would be about Euro 0.5 to Euro1.0 per ton and the terminal handling costs would be about Euro 5.0 to Euro7.0 per ton for containerized cargo.

passage of river channel means the longer exposure on danger during the passage of river channel, which is uncountable as a cost at most of the case. It makes, therefore, not easy for liner shipping company to choose this terminal as a calling terminal although it has lower terminal handling cost structure. Furthermore, shipping line transfer terminal tariffs to the final customer by means of Terminal Handling Charges (THC). It means that although it depends on the market position of shipping line and the relationship with their customer, the shipping line may compensate this cost, even part of it. Therefore, terminal cost might not play a significant role in terminal selection process in some situation.

Table 4 Comparison of terminal tariff in three container terminals(Unit : Euro)

	Amsterdam	Rotterdam	Antwerp
Terminal tariff	60	72	53

Note : According to the Ceres Paragon Terminal, terminal tariff will be still depend on the negotiation between terminal and shipping line. But the range will be between ECT and Hessenatie tariff.

4.2 Time

We assume that the call size, handling moves per calling, would be 2,500 moves because the average size of container ship in Europe/Asia route is the range of 4,000~7,000 TEU and the call size of this ship would be 2,500 moves.[3] As we can see on the <Table 5>, the total vessel turnaround time of Ceres Paragon at Amsterdam is 25.4 hours while ECT at Rotterdam is 33.3 hours. Port time of Hessenatie at Antwerp is 37.0 hours., which is mainly because of long transit time of River Scheldt although they can perform relatively high productivity at terminal.

In very rough calculation, 2,500 boxes of containers mean 4,000 TEU of containers loading and discharging at one port. This number is calculated by multiplying 2,500 boxes with TEU factor of Asia/Europe trade(1.6) and if we assume that the equal number of containers are loaded and discharged with normally three calling ports in Europe, the size of ship will be reached to 6,000 TEU.

Fully automated terminal does not mean high productivity because of the slower moving speed of equipment and lower stacking height as well as teething trouble which may occur during the implementation of new technology or advanced program, such as DynaCore System at ECT so far.

Table 5 Comparison of port time in three container terminals

	Ceres Paragon	ECT	Hessenatie
Handling moves	2,500 moves	2,500 moves	2,500 moves
Gross berth productivity	136 moves/hour	80 moves/hour	100 moves/hour
Gross berth time	18.4 hours	31.3 hours	25.0 hours
Berth in/out	7.0 hours	2.0 hours	12.0 hours
Port time	25.4 hours	33.3 hours	37.0 hours

Note : 1) Gross berth time = handling moves /GBP
2) Port time = gross berth time + berth in/out

4.3 Flexibility

For liner shipping company, it is very important to keep high level of schedule punctuality of their vessels in order to satisfy their customers requirement. The main reason of schedule failure for shipping line is severe weather condition during the sea voyage, but this is uncontrollable.[4] The most favorable and efficient way to recover the delayed schedule is to minimize port time by increasing the terminal productivity.

With respect to terminal productivity, Hessenatie terminal has more flexible terminal operation structure than ECT and Ceres Paragon(<Table 5>). Because the productivity in this kind of conventional type of terminal highly depends on the number of quay cranes and straddle carriers that they can provide for the vessel operation. However, for the automated terminal, such as ECT, shipping liner couldn't expect the same level of flexibility because every quayside and yard operation sequences are programmed in advance. For Ceres Paragon terminal, as the terminal have been planned based on high productivity concept already, the additional productivity to increase flexibility could not be expected easily.

Another aspect that could be considered to presume the flexibility in terminal is the capability of expansion of quay length and yard space. For ECT Delta terminal, they have enough space and quay wall that can be extended at Delta area, if they need. Apart from that, Port of Rotterdam have new port development and expansion project such as

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4) According to the internal data of one of liner shipping company, it is indicated that the delay percentage due to severe weather condition is even up to 39%~41% among all other reason of schedule failure, which is considerable amount.

Euromax terminal and Maasvlakte II. Ceres Paragon terminal, as newly opened terminal, has also enough space to extend as they have 60 hectares of expansion area for container terminal. In case of Antwerp, they have decided to develop new container terminal at Flushing in Netherlands recently together with Rotterdam Port Authority as they acknowledged the limitation of developing container terminal space in their homeport.

In addition, the flexibility in terminal will be explained by the adaptability of different modality in terminal such as feeder, inland barge, rail operation in terminal. For ECT Delta terminal at Rotterdam, they can accommodate a part of barge operation at the same quay wall where the main line vessels are usually working although they have separated barge terminal nearby. This gives a great opportunity to increase the flexibility in terminal operation. Meanwhile, there is separated and dedicated barge terminal where they even allocate separated barge cranes in Ceres Paragon terminal at Amsterdam in order to increase the productivity in barge operation as well. But this is in question whether this kind of terminal structure may increase the flexibility or not. In case of Hessenatie terminal, they have also separated barge terminal inside lock at the same yard area, which is more convenient for barge that navigate only along the inland waterway. However, it does not mean that this kind of terminal structure may help to increase terminal flexibility. If the handling volume of inland barge operation is increased, they might suffer from congestion at barge terminal, as they couldn't use main quay wall at the same time that is separated by a lock. As we explained above, there are many aspects that have to be considered together in order to measure the flexibility of terminal and it can be hardly quantified. Therefore, it absolutely depends on the preference and business structure of individual shipping line to qualify the flexibility of these three terminals.

4.4 Stability

There might be not a big difference on social economic and labor situation in these three terminals because they are all in the same region. With respect to stability of terminal system, Ceres Paragon and Hessenatie terminal have basically similar terminal operation system as conventional type, although Ceres Paragon terminal has different concept of gate complex and the advanced yard equipments. However, ECT Delta terminal has fully automated terminal operation system that has AGV and ASC in yard operation. As ECT is so dependent on computer system, they need to stabilize the computer system in order to have the similar stability level of other terminal. Therefore, it might be graded medium level of stability for Ceres Paragon and ECT, and high grade for Hessenatie terminal. However, as it is very difficult to quantify, similar to the measurement of flexibility in terminal, the stability of these three terminals, it may be differently measured by shipping lines depend on their preferences.

4.5 Hinterland Connection

It is noticed that Hessenatie terminal is more dependable on road transportation as the way of hinterland connection than other modality, while ECT is using more barge and feeder connection than road connection. The percentage of using trucks for hinterland connection is reached up to 59 % at Antwerp. As it is located about 60 sea miles of inside land from coastal line, which means that it is closer to the hinterland area, it could be more favorable to use trucks for cargo transportation than the other modalities. In case of ECT Delta terminal, it might be more favorable to use inland waterway connection because it is situated near to the sea. The share of barge transportation is reached up to 42.5% in ECT while the percentage of inland shipping of Port of Rotterdam in total is 26%.

4.6 Geographical Location

The geographical location of Rotterdam is more favorable than that of other two ports, Amsterdam and Antwerp for shipping line's point of view. As it is very near to the sea, it takes only one hour from pilot station to the berth in Delta terminal. And there is no tidal and draft restriction, which is even suitable for the future type of Mega ship.

On the contrary, the ship has to pass the Sea Locks in North Sea Canal at Amsterdam, which will increase the turnaround time in port by about 5.0 hours, port in and out time. This might be the main hindrance of shipping line to choose Ceres Paragon terminal as a calling terminal. The maximum available draft(13.7 m) also will be restricted due to the depth of Sea Locks and North Sea Canal. For the Port of Antwerp, located in River Scheldt, it causes additional about 10.0 hours of turnaround time in port compare to Rotterdam, which might be one of the most obstacles of Hessenatie terminal. It is obvious that the geographical location of Rotterdam is the most favorable for shipping line. However, Amsterdam and Antwerp also may have another advantages such high terminal productivity that may be trade-off with the other weak points of those ports.

4.7 Terminal Productivity

As we may assume that the more cost efficient terminal has the more chance to lower the terminal tariff, this kind of terminal is also favorable to the liner shipping company. For this aim, we can compare crane year performance in TEU that presents annual handling volume per crane on <Table 6>.[5)]

Table 6 Crane productivity at each terminal(Unit : TEU)

	Ceres Paragon	ECT	Hessenatie
Throughput	712,000	2,500,000	1,178,093
No. of quay crane	9	25	8
Crane productivity	79,170	100,000	147,260

From the result, Hessenatie terminal has the best productivity of quay crane as they have performed 147,260 TEU per quay crane. Ceres Paragon terminal might be performed 79,170 TEU per quay crane and ECT performed 100,000 TEU per crane based on the throughput performance in 2001.

Table 7 Quay productivity at each terminal(Unit : TEU)

	Ceres Paragon	ECT	Hessenatie
Throughput	712,000	2,500,000	1,178,093
Quay length	1,050m	3,400m	1,180m
Quay productivity	679	735	998

To understand the quay productivity, we can compare the throughput per one meter quay wall as presented on <Table 7>. In general, the conventional type of terminal has the more throughputs per quay length.[6)] In this case, we can hardly say that Ceres Paragon terminal is an efficient terminal with respect to the quay productivity although they might be able to handle containers faster than other two terminals because of indented berth structure. According to <Table 7>, Hessenatie has the most efficient handling performance per quay length as they have handled almost 1,000 TEU per one meter quay length while Ceres Paragon has the lowest performance with 633 TEU.

Another way of measuring terminal productivity is calculating area productivity that can be obtained through annual throughput is divided by the total space of terminal. As seen on the <Table 8>, Hessenatie has the highest area productivity while ECT has the lowest area productivity.

Table 8 Area Productivity at each terminal(Unit: TEU)

	Ceres Paragon	ECT	Hessenatie
Throughput	712,000	2,500,000	1,178,093
Terminal Area	63.0ha	280.0ha	66.5ha
Area Productivity	11,309	8,928	17,715

It shows that fully automated terminal needs more space than conventional terminal because the terminal equipment, AGV, normally needs more space to make turn and yard stacking height is also more restricted than that of conventional type of terminal.

And terminal productivity can be compared the handling capacity per labor, labor productivity(<Table 9>).

Table 9 Labor Productivity at each terminal(Unit: TEU)

	Ceres Paragon	ECT	Hessenatie
Throughput	712,000	2,500,000	1,178,093
Employment	350	1,200	400
Labor Productivity	2,036	2,083	2,945

Note : Hessenatie and Noordnatie have been merged recently, thus the number of employee at Europa terminal is estimated figure.

The more handling capacity per person is the more favorable to the terminal. The higher handling capacity per person means the lower labor cost per move. If the terminal has the lower labor cost level per move, it is the more attractive to the liner shipping company as well. It is interesting to know that contrary to what one may expect, the handling capacity per person is not higher for the automated ECT terminal. On the contrary, the labor productivity for the conventional Hessenatie terminal is significantly higher, about 40% higher than ECT.

4.8 Summary

As a consequence, we summarize the advantages and disadvantages of these three terminals in <Table 10>. The most important advantage of Ceres Paragon terminal would be the high productivity of container handling in terminal.

5) As there is no actual performance available for Ceres Paragon terminal yet, we assume that the annual handling performance of Ceres Paragon terminal would be 75% of annual terminal capacity, which could be applied to average container terminal in order to have optimal terminal handling performance.

6) In case of Ceres Paragon terminal, the length of quay wall at indented berth has been only counted the length of one side in this calculation. If we calculated two times of quay length, the throughput per one meter quay length would be even less, 491 TEU per meter.

The advantages of ECT Delta terminal are mainly from geographical location such as short port in/out time, enough depth and near to Distriparks. In case of Hessenatie terminal, the main advantage would be the flexibility in terminal operation. On the other hand, the major disadvantages of Ceres Paragon terminal would come from the geographical reason such as passage of Sea Locks and restriction of draft. For ECT Delta terminal, the major disadvantages are come from inflexible terminal operation system and yard stack inefficiency. The major disadvantages of Hessenatie terminal are also geographical conditions such as passage of river channel and draft/tide restriction.

Table 10 Advantages and disadvantages of each terminal

Terminal	Advantages	Disadvantages
Ceres Paragon	-Fast operation -Passionate as new starter Benefit low tariff (for a start) -Well treated	-Passage of sea lock -Draft restriction -Inflexible ship stowage -Teething problem as a start
ECT	-Near to sea -Deep draft -Stable productivity -Barge operation on the same berth -Relatively easy expansion Near to Distriparks	-Inflexible terminal productivity -Possible waiting time for barge -Yard stack inefficiency -Teething problem due to upgraded yard program
Hesse natie	-High productivity -Flexibility in operation	-Tide restriction -Draft restriction -Passage of river channel

5. Conclusion

The main purpose of this paper was to recognize the important factors that play an important role in terminal selection process through the comparison of three different terminals, being Ceres Paragon, ECT Delta and Hessenatie terminal in Netherlands and Belgium. The results of comparison for major factors are summarized on the <Table 11>.

Additionally, we tried to compare the three terminals with the other factors in this paper that may determine the productivity of terminal, such as crane productivity, quay productivity, area productivity and labor productivity. Although these factors are not directly influencing the terminal tariff, it might be good indication for liner shipping company to choose a terminal as we may assume that the terminal that has the more cost efficient structure has the more chance to lower the terminal tariff. The results of comparison for terminal productivity are summarized on the <Table 12>.

Table 11 Comparison results of major factors at three terminals

Factors		Ceres Paragon	ECT	Hessenatie
Cost	port cost	Medium	High	Low
	terminal cost	Medium	High	Low
Time		Short	Medium	Long
Flexibility		Medium	Low	High
Stability		Medium	Medium	High
Hinterland Connection		N. A	More barge	More truck
Geographical location		Northsea canal Sea locks	Near to sea Deep draft	River Scheldt Tidal restriction

Table 12 Comparison results of terminal efficiency at three terminals

Factors	Ceres Paragon	ECT	Hessenatie
Quay productivity	Low	Medium	High
Crane productivity	Low	Medium	High
Area productivity	Medium	Low	High
Labor productivity	Low	Medium	High

The results of the study indicate that the Hessenatie terminal at Antwerp has the most efficient terminal structure and the excellent terminal performance. It has the lowest terminal handling and port costs among these three terminals. However, the tidal restriction and the passage of River Scheldt would be the most obstacles of Hessenatie terminal, where it can hardly accommodate the future size of container vessel. As the increasing size of container ship is a main trend in liner shipping industry, the capability of adaptation for the future type of container ship is getting more important for the terminal competitiveness. In case of Ceres Paragon terminal at Amsterdam, although it seems that it has relatively lower efficient terminal structure, the other factors are more or less comparable to ECT Delta terminal at Rotterdam. Ceres terminal tried to recover its weak point, North Sea Canal and Sea Locks, by high productivity. However, the draft limitation at Sea Locks and North Sea Canal would be the major hindrance of this terminal to adopt future size of container ship, so called Megaship. As there is no draft restriction at ECT Delta terminal at Rotterdam, it is suitable for the future type of container ship. However, it has relatively higher cost structure and the terminal efficiency is only comparable to Ceres Paragon terminal although it has a state of the art terminal operation system.

This study suggests some implications for port managers and policy decision makers. First of all, there are many factors that the liner shipping company has to consider in their terminal selection process, which might be trade-off between them in most cases. It is obvious that the cost factor is a very important for liner shipping companies to select their terminals. However, there might be even more important factors than the cost factor, such as quality of port and terminal service, mutual trust, and possibility of future development. Second, although Ceres Paragon and Hessenatie, located in Amsterdam and Antwerp respectively, have locational disadvantage, they have certain competitive advantage by developing their own resources and capabilities. Ceres Paragon tries to get high terminal productivity using indented berth system and Hessenatie has recorded one of the most efficient terminal in Hamburg-Le Havre port range through itsr own unique conventional terminal operation. In Korea, Incheon port is also operated by a lock system like Amsterdam. Thus successful story of Amsterdam can be a good benchmark for Incheon to establish it's future development strategy. Third, this study suggests that an automated terminal is not a panacea. ECT is a fully automated terminal, but lack of flexibility is a main drawback. The productivity of ECT is lower than Hessenatie. At this moment, Korean government has also planned a automated container terminal in Gwangyang Ⅲ phase, thus we should consider what kind of terminal operation system is the most suitable to our port.

In this paper, we examined the major factors that determining the port and terminal competitiveness and tried to evaluate them from the liner shipping company's point of view. However, the relative importance of these factors can be different depending on a shipping company's situation or shipping market situation. Therefore, the further study is needed as the market situation is changed in near future. In addition, as the Ceres Paragon terminal is not in operation yet, this study is carried out based on the estimated performance of Ceres Paragon terminal. Therefore, once the practical performance information is available, it is useful for further study based on the practical data.

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