韓國港灣學會 第11卷 第1號, pp.1～15. 1997.

論 文

Integrated Approaches to Berth Productivity Improvements in Port Development and Operation and Logistics : A Conceptual Perspective

J. G. Gim[*] · *J. I. Lee*[**]

항만개발 · 운영과 로지스틱스에 있어서 부두생산성 향상에 대한 종합적 접근법: 개념적 관점

김 진 구 · 이 종 인

Key Word: Berth Productivity(선석/부두 생산성), Port Development(항만개발), Port Operation(항만운영), Conceptual Perspective(개념적 관점), Despatch Money (조출료), Traffic Forecast(물동량 예측), Queueing Theory(대기행열이론), Logistics(종합물류), Congestion of Vessels(선박폭주), Sub-system(부차시스템), Intrinsic capacity(연수용능력), LDCs(Less-developed Countries ; 개발도상국), Performance Indicator(성과지표), Berth Occupancy(선석점유기간), Strategic Planning(전략적 기획), Statements of Fact(사실진술서)

Abstract

The improvements of berth productivity is closely related to berth/port systems and its relationship extends to the overall pattern of port development/logistics, transport and trade. Since ports in general and berths in specific function as a bridge transferring seaborne cargoes from seaside to landside and vice versa, berth productivity improvements should be considered in terms of the total system in which the cargoes are transported from origin to destination via berths/ports. In that respect, the objective of this study is to improve berth productivity which is a vital factor in the strategic planning

---

* 정회원, 한국해양대학교 박사과정(로지스틱스어학 연구소장)

** 정회원, 한국해양대학교 교수

*** This is a revised version of a paper presented at a seminar on "Ports for Ships and Ships for Ports: Port Development Planning and Operations" held at the LSE, London in March 1993.

in port development and operation and logistics. According to a literature survey on the subject, the contents of the studies have been limited to either a macro-perspective or a micro-perspective which is only a partial solution to the problem. Hence, this limitation requires an integrated approach to find an ultimate solution, which should be considered not separately, but as a whole.

The contents and scope of this study cover the improvements of berth productivity in conjunction with strategic planning in port development, efficient operation and logistics from two different viewpoints, macro- and micro-perspective. After that, a combination of these two perspectives is applied to the integrated approach due to lacking a comprehensive perspective from either macro-approach or micro-approach. In reality, a port itself is a complex and dynamic organization. Therefore, a comprehensive insight needs an integrated approach for the long-term national economic development. In this approach, the utmost importance is how to find the bottlenecks and to solve the problems effectively from the beginning stage in port development.

In conclusion, derived from the macro- and micro-perspective, the attempt to establish an integrated approach is the merit of this study, which is required as a comprehensive measure since none of the two can be a solution independently. In terms of reinforcing this study, it needs further empirical research due to the restriction of the theoretical method of this paper.

Consequently, the reinforced research will be able to enhance the integrated approach on the basis of the conceptual perspective.

1. Introduction

Higher berth productivity is closely related to berth/port systems and its relationship extends to the overall pattern of port development /logistics, transport and trade. Since ports in general and berths in specific function as a bridge transferring seaborne cargoes from seaside to landside and vice versa, berth productivity improve-ments should be considered in terms of the total system in which the cargoes are transported from origin to destination via berths/ports. Since the cargo volume itself cannot be considerably changed at different links and nodes in transit, the initial berth productivity is a clearly vital factor in the strategic planning in port development /operations and logistics.[1]

However, in reality, a port itself is a complex organization and the cargo-handling involves sophisticated and multiple procedures, extending to a comprehensively interlocking port and inland transport system. Hence, to identify bottlenecks in the total system is a priority in strategic port planning/operations and logistics. If a bottleneck exists there, since that very limiting point determines the maximum cargo

1) Strategic planning minimizes risks in rapidly changing environments. Thus, the strategic development planning and efficient operations, along with continued evaluation and modification, are essential to long-term profitable business in port logistics and transportation. For further details, see J.R. Stock and D.M. Lambert, "Strategic Logistics Plan," Strategic Logistics Management 2nd ed. (Homewood, Illinois: Irwin, 1987), pp. 689-690.

traffic, the bottleneck point must be broken so as to expand the capacity of the system up to the desirable level as a whole at falling costs per unit of capacity.

This paper discusses the improvements of berth productivity in conjunction with strategic planning in port development, efficient operations and logistics from two different viewpoints, namely, macro- and micro-perspective. After that, the combination of these two perspectives is applied to an integrated approach due to lacking a comprehensive perspective. According to a relevant literature survey, such examples in macro approaches include "Port Efficiency and Capacity-Identifying the Bottlenecks" by D. Hilling and "Container Terminal Productivity: A Perspective" by T.J. Dowd and T.M. Leschine[2]; micro approaches are "Optimal Handling Capacity at a Berth" by J.D. Griffths and "The Economics of Port Pricing" by K.J. Button.[3]

2. Macro-Approaches to Berth Productivity Improvements

2.1 Factors Depressing Throughput Level

In macro-perspective, the most importantfactors depressing the level of throughput are any inadequate port development plans, which result in failures to meet the target set by national economic planning programmes. If ports are unable to meet the demands imposed upon them, such a situation often manifests itself in the long vessel queues currently prevalent in ports such as Pusan and Incheon in Korea. The congestion and waiting of vessels in ports of Pusan and Incheon appeared to have peaked at 5.0% / 28.6% in 1994, and further to 8.9% / 31.2% in 1995, and slightly declined to 8.3% in Pusan port but further to 36.7% in Incheon port in the period of Jan.-June 1996, respectively as shown in [Table 1]. Because of such delays and ship waiting, the direct and indirect economic losses per annum is estimated to 620 billion Won in 1995. During the period of 1990-95, the relevant losses were 2.6 trillion Won, which exceeds the amount of total port investments over the same period.[4]

---

2) D. Hilling, "Port Efficiency and Capacity-Identifying the Bottlenecks," Asian Port Management Conference, (Djakarta: PORTEC, 1985); T.J. Dowd and T.M. Leschine, "Container Terminal Productivity: A Perspective," Maritime Policy and Management, Vol. 17, No. 2, 1990, pp.107-112. Further examples are R. Robinson, "Modelling the Port as an Operational System: A Perspective for Research," Economic Geography, 52(1976), 71-86; J.J. Evans and P.B. Marlow, Quantitative Method in Maritime Economics, Fairplay Publication, Norwich, Norfolk, 1986; P. Saarto, op. cit., pp.259-268; M. Stopford, Maritime Economics, Unwin Hyman Ltd., 1988; I.S. Jun and Gim J.G., "A Study on the Establishment of Sea Route between North Korea and South Korea," A Study on Laws, Systems and Practical Problems of North-South Korea Exchange Cooperation, Korea Unification Board, 1993.

3) J.D. Griffths, "Optimal Handling Capacity at a Berth," Maritime Studies and Management, Vol. 3, pp.163-167; K.J. Button, "The Economics of Port Pricing," Maritime Policy and Management, Vol. 6, No. 3, 1979, pp.201-207. Further micro approaches include S.R.C. Wanhill, "A Study in Port Planning: the Example of Mina Zayed," Maritime Studies and Management, Vol. 2, 1974, pp.48-55; J.O. Jansson and D. Sheerson, "Port Economics," MIT Press series in Transportation Studies, No. 8, Cambridge, Mass., 1982; J. Imakita, A Techno-Economic Analysis of the Port Transport System, (reprinted 1986, first published 1978 by Saxon House, Teakfield), Gower Publishing Co., Aldershot, 1986; E.G. Frankel, Port Planning and Development, John Wiley and Sons, New York, N.Y., 1987.

4) I.S. Jun, "The Estimation of Congestion Cost in Korean Ports and Airports," whose paper was presented at a seminar on Congestion Cost Conference held at the Sam Sung Economic Research Institute, Seoul, May 1996.

Table 1. Status of Congestion and Waiting of Vessels in Ports of Pusan and Incheon

(Unit : Vessel, %)

	1994 : A	B	B/A	1995 : A	B	B/A	1996* A	B	B/A
Pusan Port	16,859	840	5.0	18,264	1,601	8.9	9,572	791	8.3
Incheon Port	4,965	1,421	28.6	2,666	833	31.2	2,922	1,072	36.7

* A = the number of vessels entered ports; B = the number of vessels awaited ports.
Source : The Ministry of Maritime Affairs and Fisheries, "Congestion and Waiting of Vessels in Korean Ports, in 1994, 1995 and Jan.-June 1996."

To avoid such port congestion, any country has to determine as early as possible the right level of capacity it requires, and how much to invest in the sector concerned.

Difficulties in strategic port planning are noteworthy in that not only does the traffic flow vary in volume over time, but also the pattern of flow shows a marked change. This change depends on domestic economy shifts from an early stage to a more mature stage, where strategic port planning/operation create and contribute to higher place/time utility. A berth or port is a gateway for imports or exports of commodities, and not the final point of production or consumption. It is a mere connection to the sea on one side and to inland transport facilities on the other.

Thus, the improvements of the berth/port systems, only considered as an intermediary system, without a commensurate consideration of the joint system, will result in the superficial improvement of the total system. Since a port is to make a smooth flow of cargoes between sea and land transport, its two foremost problems are noticeable: ① an individual port is only one of many links in the overall transport chain; ② a port itself is a component in the integrated complex transport system. These complex problems in port development and logistics denote that the optimal coordination of the entire interrelated transport system is a task which must have first priority.

2.2 Different Levels of Port Systems and Their Major Influences

Next, different levels of port systems account for the system scale for port analysis in the total system and each characteristic of the sub-systems is followed by a brief explanation:[5] ① intra-port system happens within the port infrastructure which is controlled by the port system itself. This is called a port authority system. The physical limits of the port show the system boundaries and shipping/cargo inputs are considered as given; ② for port-hinterland system, port hinterland and thus the port demand can be affected by changes in regional development, reallocation of traffic to neighbouring ports, i.e., coal industry in Cardiff, Wales in the U.K.; ③ two-element port system needs a new port frontier. One port relates to the other port, i.e., Masan Port(40 miles off from Pusan Port) has been used as a feeder service port to relieve the Pusan Port congestion. This system comprises the shipping network linking the two ports, together with the land-based linkages; ④

5) Robinson, op. cit., pp. 72-74. For further information on modelling techniques related to port system analysis, see S.H. Moon, "Port Planning and Analysis by Modelling Techniques," Journal of Korean Association of Shipping Studies, 18(August 1994), pp.337-65.

in regional port system, port competition occurs. For example, in South Wales ports compete with each other as do the ports of London and Rotterdam. Interport shipping linkages may suggest interdependence within the port system; ⑤ N-port system represents a total global system, viz. a global maritime system. This contains a total interactive port system in which all linkages such as land and sea exist. All these different levels of port system indicate the complexity and variety of port organization in conjunction with the total system.

Major influences on port systems are worthwhile examining on both maritime and land sides. In the seaward side, important variables include navigation aids, channel approaches, vessel design, cargo operation technology, and shipping lines' port selection procedures. On the landward side, influencing factors cover transport networks, land vehicles, customs clearance procedures, maritime-related industries, urban development, and regional/government policies.

Since all these items are interactive and complex components of the total system, strategic port planning and operations for higher berth productivity must be evaluated in a broader context. In the broadest possible strategic planning framework, a vast number of different parties(shippers, shipowners, freight forwarders, stevedoring companies, port/maritime authorities, and the relevant governmental / non-governmental agencies) are involved. Strategic planners in port development / operations and logistics / transport must consider the harmony between them with regard to balancing the supply of and demand for the capacity of all functions in the sub-systems.

2.3 Strategies for Port Development and Logistics

The third macro-perspective stresses that for efficient berth productivity and its sustained effectiveness, a comprehensive strategy for port development planning/operations and logistics must be considered. Its formation consists of deciding such issues as whether the need should be met, and how, where, and when it should be met. The answers to these issues depend on the port development objectives, on resource availability, and government policy, aiming at an optimal share of the nation's economic resources to be devoted to transportation as a whole.[6] Within the broad national port strategy, each individual port development and logistics must be coherently planned. At the beginning stage of the port planning, it is convenient for the planners concerned to use the port planning chart. It can be a simple and practical tool to estimate berth requirements and ship costs for port development planning.[7]

Moreover, port development comprises a combination of long-term and medium-term planning of new facilities plus (in the case of an existing port) short-term planning to improve the port operations and logistics management. In relation to these long, medium and short term investment policies, the following phases must

---

6) Frankel, p. 244; M.L. Fair and E. W. Williams, Jr., Economics of Transportation and Logistics (Dallas, Texas: Business Publications, 1975), p. 518; Imakita, pp. 6-13.

7) UNCTAD, Port Development: A handbook for Planners in Developing Countries (New York: UN Publication, 1985), pp. 7 and 126-129. For estimating berth requirements and ship costs, refer to the related port planning charts IA and IIA for examples of use of the planning chart I and II for break-bulk general cargo terminals, respectively.

8) Ibid., pp. 7 and 126-127.

be considered:[8] a planning phase to end in a recommendation on which course of action the port should follow, a decision phase to be substa due to the securing of funds, a design phase to turn the chosen plan into detailed engineering designs, and a construction phase to be regarded as its implementation.

In general, the planning phase is a most important stage in obtaining the information necessary for producing preliminary cost estimated and final ones mainly depend on the engineering difficulty and magnitude of the project. The emphasis on each phase and time involved varies with specific project.

2.4 Different Time Phase in Port Development Planning

Finally, it is worth noting key abstracts from each different time phase in line with strategic port development and logistics. The short-term planning considerations include maximizing capacity of existing facilities which should always be first priority. This priority can go ahead independently of the medium-and long-term plans. They also need data base and berth productivity statistics to identify both bottlenecks and the potentially increasing capacity, which requires further action to improve management and productivity/efficiency of existing facilities.

The medium-term planning factors are detailed requirements, clearly defined projects, and consistency with the master plan. Moreover, they require feasibility study for each proposal and justifying investment, preparation of detailed traffic forecasts and cost estimates, including broad project definition and analyses of alternatives.

The master/long - term plan must provide the framework for medium-term planning. The long - term planning considerations include ① defining the role of port - to serve the trade of the hinterland, to assist in generating trade, and to transit for distant hinterlands such as land-locked states; ② defining responsibilities of port-seaward responsibilities such as conservancy, engineering, and dredging with landward responsibilities such as storage and transport links; ③ land use policy for port - freedom to acquire, control, and determine land use within port boundaries and in adjacent land; ④ financial responsibility of port - commercial, self-supporting, freedom to set tariffs, degree of commercial accountability, governmental control, regulations and targets.[9]

3. Micro-approaches to Berth Productivity Improvements

3.1 Berth Throughput Increase

The first micro-perspective contends that, in light of berth productivity, one way of reducing port costs per unit is to increase the berth productivity through the increase of the tonnage handled at each berth. Since there are a variety of characteristics in each different port, and the operation of a berth tends to be a complex process, a careful study is needed to develop methods of analysing berth operations, depending on local conditions at each individual port. This aims at identifying the bottlenecks to higher throughput and assessing the benefits of eliminating such bottlenecks.

In case of Kiire oil storage base in the southern end of Japan(one of the largest in the

9) Ibid., p. 8.

world), the areas where cargo oil is discharged from a super oil tanker to the shore oil storage tanks, or to the storage base via the shore tanks through oil pipe lines, can be considered as a particular example of the berth system before the delivery system.[10] Since the objective of the base is to keep oil in the storage tanks, which are located within cargo transferring areas by cargo oil pipes, the Kiire base is regarded as a cargo destination for which oil is pumped from the vessel to the storage tank by means of the pumping and piping system.

The relationships between port costs and vessel working time at berth is applicable to the aforementioned case that, one way of saving port costs is to improve berth productivity by means of reducing cargo discharging hours by using shore booster pumps, plus saving ballasting/deballasting hours by using gravity in the vessel's tanks during cargo operation. Likewise, reduction in port costs resulting from saving in cargo working time by efficient port development and cargo operation may obtain the despatch money which is converted into the demurrage to be occurred by port congestion. Dr. D. Hilling argued that ports obtain income from ships sitting on berths and thus they may not be so keen to see ships turned round too quickly. But this study considers/premises that the point is applied to the case of port congestion costs exceeding the port development expenses to relieve the aforementioned congestion.

3.2 Traffic Forecast

The second consideration is the traffic forecast, which covers traffic forecasting principles / procedures / markets and trends, and evaluation of forecasts.[11] For traffic forecasting principles, since berth productivity is of fundamental significance in port development / operation and logistics, first, it is essential to examine traffic forecasting in light of what kinds / tonnages of cargoes to transfer via the berth system, how to pack / handle as maritime cargoes, and what ship types / tonnages / cargo equipments / frequency of use to employ. It is noted that traffic forecasting is subject to a high degree of uncertainty and risk-taking. Therefore, all forecasts must be handled with caution.

Regarding traffic forecasting procedures, once the principles of traffic forecasting have been taken into account, a systematic procedure for executing a detailed forecasting is required. Its objective should cover determinants of the potential market for the commodity trade, the evaluation of the actual commercial prospects of servicing the trade, and the use of the information to estimate actual sales.[12] The forecasting procedure must be examined to analyse past traffic and review market influences on traffic trends, to estimate systematic traffic growth rates and investigate traffic influencing factors, to combine all information into alternative growth and technology scenarios, and to tabulate annual forecasts in each traffic

10) For reasons of Japanese energy saving for emergency and security importance, the access to Kiire base for oil storage was prohibited strictly except for key members for safety inspection and logistics management in the mid 1970's when I worked there as a merchant marine/logistics officer. The application of the berth system to the Kiire base is on the basis of my working experience on the spot.

11) UNCTAD (1985), pp. 40-52.

12) Frankel, p. 167.

13) UNCTAD (1985), pp. 41-43.

class(i.e., tonnages, numbers/sizes of ships, and seasonal effects) for each scenario.[13] It is notable that if the cargo operations belonging to different traffic classes take place at the same berth, it is desirable to work with the average performance figures for mixed traffic.

With reference to market forecasting trends, the market forecast must be considered as an essential part of realistic traffic forecasting, which is to identify the potential users and means of transport to be used for the various commodities. It is noteworthy how the market forecasting activity gives rise to the improvements of berth productivity. In view of the rapid pace of change in ship and cargo-handling technology, each stage in the analysis in conjunction with the market forecasting has to ascertain what types of vessels are being constructed for services which affect the types/sizes of the berth and what methods of cargo handling will be adopted.

Before projecting any past trend, the factors affecting this trend and the likelihood of its persistence must be considered. Key factors in most cases in the developing countries include direct dependence of traffic on the GNP, deliberate development/running down of traffic in a specific commodity/product such as national self-sufficiency in a major foodstuff or development of a new industry, a gradual shift in regional centers of production/consumption, in port development and logistics technology or routing from break-bulk shipment to containers or from maritime to overland transport.[14]

In order to find a traffic trend in a series of annual figures, simple methods are desirable to calculate an annual percentage growth rate, or to plot quarterly figures and draw in the trend by eye. When the trend is likely to persist, a more accurate and standard method such as a "least square fit" procedure is desirable to ascertain the form of the trend. When a detailed traffic record such as monthly figures maintained for several years is investigated, a regular and cyclic pattern is to be noted.[15] Such analyses are likely to be simpler and more useful if traffic is classified into main commodities, and seasonal commodities, each being kept separate.

Finally, evaluation of forecasts often requires outside consultants to prepare the forecast in cases where very sophisticated and critical situations are involved. Then, it is advisable to ascertain that the consultants have fully understood the local needs and circumstances. In order to check how they have been derived, if mathematical figures are involved, the following key items are required to test the relevant forecast:[16] ① what is likely to happen, what is the desirable achievement has been considered, and that which is desirable can be obtained from the berth system, contributing to national economic targets; ② for each projection of a past trend, how the past trend has been interpreted and why the future continuation of each has been questioned; ③ whether past records have been analysed for seasonal variations and their causes identified; ④ in each industry and for each principal cargo, whether a search has been made for traffic-influencing events in the future.

It is noteworthy that if any forecast trends are linked to national economic indexes beyond the berth system in the local circumstances, these

14) Moon (August 1994), p. 337.
15) UNCTAD (1985), pp. 47-48.
16) Ibid., pp. 51-52.

must be adjusted for local variation from the national average.

3.3 Berth Productivity Measurement

The third factor in the micro-perspective of efficient berth productivity is how to measure accurately the flow of cargo that transfers the berth system. A series of methods of analysing performance include a basic method, a simulation method, optimization and queuing theory approaches.

First, a simple and basic method represents one of a number of possible routes along which import cargo flow: discharging stage, transferring stage, storaging stage, and delivery stage.[17] By increasing the capacity of the narrowest part of a transfer system, say 50 tons, the capacity of the whole system can be improved. The capacity can continue to be improved by increasing the capacity of the bottleneck until it equals that of delivery stage, say 70 tons. The tonnage is to be translated into the number of berths needed to answer the question of why the berth productivity figure is important. This implies that further improvements in the total capacity will require an increase in the capacities of both transfer stage and delivery stage together. This basic method leads to how the intrinsic capacities of the various parts of a berth can be measured.

A more detailed method of analysis is the computer simulation method. This method requires the careful collection and analysis of large quantities of data, such as the basic method plus an understanding of the logic of the management decisions influencing the way of port development/operation and logistics/transport. The decisions can include a priority system used in allocating ships to berths, the conditions under which overtime or additional gangs and work force can be permitted to speed up the cargo operations at an increased cost.

However, the application of simulation method is not a lightly undertaken task. The data requirements and technical expertise for a realistic simulation model are beneficial in replacing this method for the basic method, which is more likely to prove the practical tool. In reality, the berth system is unlikely to be a single homogeneous unit and hence it is more likely to comprise several interacting parts as in the parts of the berth system.[18]

Once cargo has been discharged from the ship, the cargo follows one of three possible routes: ① the indirect route - cargo is passed through the transfer system, storage (shed or open storage) system, and delivery system(rail/road/barge); ② the semi-direct route - cargo is put down on the berth apron(or into barge/rail wagon) temporarily due to the immediate unavailability of the rail/road /barge system; ③ the direct route - cargo is directly discharged into rail/ road/barge.

The connected inland transport systems have an important bearing on the berth operations but are not usually under general control. For effective berth productivity, all parts of the berth systems should be matched to the demands placed on them individually, i.e., hourly / daily / weekly, according to the nature of the system part. Compared to the simulation method, the essence of the basic method is to locate the slack and find out

17) UNCTAD, Berth Throughput: Systematic Methods for Improving General Cargo Operations (New York: UN Publication, 1973), p. xv. See (Figure 1): Diagrammatic Representation of Flow of Import Cargo.

18) G. De Monie, "Analysing Berth Throughput," in UNCTAD, Manual on Port Management: Port Operation (New York: UN Publication, March 1976), p. 95. See (Figure 20): The Parts of the Berth System.

19) For relevant modelling approaches, see Imakita, 185-90; Moon (August 1994), pp. 337-65; Monie, pp. 96-99.

the causes of its existence.[19] Slack is due to demand not fully taxing resources or interruptions from other parts of the system. The higher berth throughput and thus berth productivity can be increased by improving operational methods or investing in new facilities.

The third method is optimizing the approach in which the criterion to optimize the cargo-handling rate at the berth is the criterion to minimize the total cost of operation of the berth. This optimizing model indicates how to decide the optimal cargo-handling capacity for the single berth available.[20] This cost can be denoted by the sum of all costs to provide the berthside facilities. In many situations, a ship's arrival follows a Poisson distribution.[21]

However, if the ship's arrivals do not follow the Poisson distribution but are scheduled to follow constant intervals of time or some other distribution such as an Erlang distribution related to the berth service time, the analysis afore-mentioned will still be valid provided that the appropriate queuing formula is employed.[22]

Since different sized vessels have different waiting costs per unit time, it is necessary to find not the mean overall queue lengths but the mean number of ships present in each size of categories within which handling performances of cargo and waiting costs are constant, and then to find the mean overall queue length. Alternatively, the whole operation can also be simulated. However, a disadvantage in using simulation is that it is often difficult to see the precise effects of any changes made in the parameters of the problem.

4. Integrated Approaches to Berth Productivity Improvements

4.1 The Application of Queuing Theory

The queuing theory is applicable to the relationships of berth capacity, cargo handling rates, ship waiting time, port congestion/costs, performance assessment and followed by suggested operational management of productivity improvements. Its result may overestimate the average ship waiting time, especially, at the higher values of berth occupancy. The reason for this is that a certain port can have several ways of coping with the peak demands placed on it so as to avoid the extremely long queues which may otherwise occur. In view of the relative benefits from the cost minimization, below are two methods to be noted:[23] ① a temporary increase in the berth capacity using moorings and ② a temporary increase in cargo-handling rate using more gangs or overtime working. These

20) Griffiths, pp. 163-67.

21) Ship's arrival pattern is followed by Poisson distribution: Formula, p(x)=(mxe-m/x!), where e is a constant, about 2.71828 and x is any possible value that X can take on. The formula has been applied to ship's arrival pattern in time T, as follows: p(n)=(mT)ne-mT/n!, n=0,1,2,3, ... ; where m is the mean arrival rate and m=np. Source: Lincoln L. Chao, Statistics: Methods and Analysis, 2nd ed. (Tokyo: McGraw-Hill, 1974), pp. 168-71.

22) Griffiths, p. 164-66. For the general method of analysis of ship's arrival patterns as per the Poisson distribution, see two cases of ① the time spent in cargo work being negative-exponentially distributed, and ② service time being constant.

23) UNCTAD (1976), p. 77; for determining optimal hatch pattern, see Imakita, pp. 79-89.

24) For the solution of problems on the cargo handling rates and the restrictions of hold capacity, see UNCTAD (1976), p. 81. An empirical data indicates that a certain amount of percentage increase in the effective productivity leads to a better resultant compared to the same amount of percentage increase in the number of berths.

imply certain additional costs, but such costs are likely to be less than the congestion costs which may otherwise build up.

A practical statistics[24] shows that an increase in the effective berth productivity of this amount can cope with the increase in traffic better than the same amount increase in the number of berths. This indicates that an increase in the effective berth productivity of this amount could be achieved simply by reducing the relevant idle time. During periods of heavy traffic, when ship's waiting time for berth can be longer than cargo working time, the effect of reducing cargo operation time tends to be drastic as shown in the aforementioned [Table 1]. The case of this congestion denotes that the additional costs of more intensive working are to be smaller than the high costs of the immobilization of vessels in Korea and other LDCs facing similar situations.

4.2 Performance Indicators and Practical Measurement

In order to assess accurate performance and thus reliable berth productivity, ports need to collect detailed information on key indicators such as vessel turn-round time, berth occupancy /throughput, and labour costs in port development and logistics/ transport. Since such information is a smaller set of primary indicators, it allows a broad judgment to be made and points of serious deviation to be noted. Since the linkage of cargo operation and transport system is needed so that their points can be examined at a greater detail to find the causes of deviation. Such statistics can be further aggregated at the level of the port amounted from individual berth operations within a port. When considering capacity, individual berth information is more desirable than that relating to a whole port because each is effectively different from all items. So the considerations on individual berth indicators are significant due to the great variety in their physical attributes, equipment, organization and thus performance and capacity. This performance evaluation can be made in terms of productivity related to cost per ton at individual berth concerned, outputs of the berth, gang, or individual vessel. It can be assessed regarding the service quantity of vessel turn-round time, or time in port, and utilization of berth occupancy, berth working time or equipment.

For practical measurement of berth productivity, performance indicators have to be able to show how productively berth facilities are used so that port planners can plan when additional ones are needed. They must also be able to show the quality of service given to the shipowners/ shippers. To obtain collective statistics data, full cooperation of all different parties involved is required. Since each port has a different character, as does each group of berths within the port, careful selection is crucial to distinguish different indicators from the set and to place their own special significance on each.

Likewise, the emphasis on the berth group is vital for effective port development/operation and transport logistics. It is noteworthy that different berth groups are important to a certain degree of independence, meanwhile they do affect each other, especially, in the case of vessel waiting time. Where it may be useful to watch any indicator in solution to see if it changes, no general conclusions can be drawn from any one indicator in isolation. Since the weakest link in the berth/port system determines the level of productivity in the total system and provides the greatest potential for improved performance, systematic investigation is required to determine the actual and intrinsic capacities of the sub-system. In order to identify the constraints imposed by the effects of imbalance between the systems and thus to assess reliable performance, it is a precondition for the port development planners and operators of the sub-systems concerned.

In terms of the efficient operational management of ports/berths, to isolate their development planning and daily operations from dynamic maritime environment is unrealistic and impractical. Hence, such development and operational management must be analysed and assessed in a broader context and in the broadest possible planning framework. This request for more effective strategic planning measures enables the planners/operators to do the detailed examination of operational management, cargo handling technologies and the productivity of the individual components combining the total operational systems.[25]

In practice, it is important to undertake on-the-job training(OJT) on the spot in the port/berth in question rather than in other places where circumstances and environments are completely different. Field studies such as Maritime Science experiments in Millport and European ports study tour in Maritime Transport of the LSE Sea Use Programme are good examples. In many cases, the operational management through the higher throughput can be greatly increased and the delay reduced by giving attention to the identifiable bottlenecks. Since the total operation of the port/berth comprises many activities, each one must be analyzed carefully and the relative effect determined.

4.3 Working Procedures for Operational Improvements

Operational improvements can be achieved through effective working procedures. Cargo throughput can be increased and unit cost reduced by changes in work methods or procedures. Such measures cover the notification of a ship's arrival and cargo manifests to the port/stevedore well in advance to permit effective planning of vessel and cargo operation, the cargo work planned so that the work can be finished simultaneously in all holds, and sufficient space provided at the apron alongside the vessel with enough space in the shed to accommodate discharged cargo. The operational efficiency can be increased through mechanization of cargo operations requiring only a minor investment as compared to an investment in port facilities.

It is noted that the relative factor endowments have to be considered, especially in some ports of developing countries where layout productivity is high and wages are low. The use of manual versus mechanical measures is advantageous. Such examples are the sweeping of soybean oil and edible oil at the final stripping stage, by shore workmen on product oil tankers, when the use of stripping pumps/equipments is inefficient in the port of Karachi, Pakistan. Other examples can also be seen at the trimming stage of rice loading in bulk in the ports of Rangoon and Bangkok. Since items of equipment can often differ by type, age, state of maintenance, and efficiency, a technical and economical study has to be carried out periodically to judge the relevant conditions and replace existing equipment with more efficient and compatible equipment. It is crucial that effective operation and timely maintenance procedures serve to protect the large investments made and prevent the problems of cargo handling equipment which cause costly

25) Hilling (1985), PORTEC II,

delays in port operation.

Finally, the Statements of Fact show all information on time spent in port/ berth. Since the Statements of Fact enable the port planners /operators to analyze the performance of capacity of existing facilities, these can be utilized as a tool for better operational management or the planning of new facilities. In order to carry out new strategic development/operational planning, such prior information or knowledge of the performance data of existing facilities is a requirement. Hence, any improvements in berth productivity must be considered in the future in port development planning, efficient operation and logistics manage-ment.

5. Conclusion

In conclusion, berth productivity is a vital and critical factor of port development, operations and logistics/transport. Since berth is a key factor in port production function, the improve-ment of berth production is bound to lead to an improvement of port production. The matter is to identify bottlenecks in the total system well in advance so that port planners and operators with prior information on the relevant performance data can execute strategic planning and efficient management in port development/operation and logistics. Such initiative is to enhance the relevant berth productivity.

In the macro-perspective, the scope of the title goes beyond berth systems and a preliminary investigation of the total transport system is undertaken to identify the inter-relationships and constraints in the total system. In the macro perspective factors, the efficiency must be considered in conjunction with the overall transport system that aims at enhancing a national economic planning programme.

In the micro-perspective, the contending scope is restricted to the berth system and its related parts. In the dominant part of the berth system, all cargoes have to pass through the vessel cargo handling system that covers the discharge of cargo from and the loading of cargo onto vessels. If other parts of the system (fed by the vessel cargo handling system) have capacities lower than the demands in question by the ship operation, they are subject to restraining the vessel operation and thus limiting the capacity of the whole berth system.

Of the two approaches, the utmost importance is how to find the bottlenecks and to solve the problems effectively. Derived from the macro- and micro-perspective, the attempt to establish an integrated approach is the merit of this study, which is required as a comprehensive measure since none of the two can be a solution independently.

In terms of reinforcing this study, it needs further empirical research due to the restriction of the theoretical nature of this paper. Consequently, the reinforced research will be able to enhance the integrated approach on the basis of the conceptual perspective.

요 약

선석/부두생산성 향상은 항만시스템에 밀접한 관계가 있고, 이러한 관계는 항만물류 · 수송 및 해운무역 전체의 영역에 까지 확대된다. 포괄적인 항만과 특정한 선석은 해상물동량을 육상측으로, 육상화물을 해상으로 환적하는 교량의 기능을 담당하고 있기 때문에 항만개발 · 운영자 및 물류관련자는 화물이 원산지/선적지에서 항만/선석을 경유하여 최종목적지까지 수송되는 전체적 시스템과 관련하여 그 생산성 향상을 고려하여야 한다. 이와 관련하여 본 연구는 선석/부두생산성의 향상에 목적을 두고, 먼저 거시적 접근과 미시적 접근을 시

도하였다. 그러나, 문헌조사에 따른 지금까지의 관련논문들은 미시적접근이 아니면 거시적접근으로 전체를 조명해 보기에는 한계가 있었다.

연구의 방법과 범위는 부두생산성 향상을 위해서 직접/간접적으로 관련이 있는 항만개발기획과 운영 및 항만물류 · 수송에 연계된 미시.거시적 접근과 양자통합의 종합적 접근이다. 실제적으로, 항만은 그 자체의 활동만으로도 복잡하고 역동적이어서, 항만 기획단계에서부터 총체적 접근으로, 병목구간과 같은 애로의 문제점들을 효과적으로 해결함으로서, 궁극적으로는 국가경제에 이바지 할 수 있는 안목의 종합적 접근이 필요하다.

결론적으로, 그 최종목적달성의 근간이 될 부두생산성에 대한 거시 또는 미시적 접근의 단편적인 안목을 탈피하여 양자를 통합한 전체적 관점에서 필요한 연구문제의 제기와 그 해결의 실마리를 제안 했다는 중요성은 지대하다고 하겠다. 본 연구의 한계는 개념적 접근으로 향후 이 논문을 바탕으로 한 보강차원의 실증적 연구가 더 필요하다.

REFERENCES

1) Button, K.J. "The Economics of Port Pricing." Maritime Policy and Management, 6, No. 3(1979), 201-07.
2) Chao, Lincoln L. Statistics: Methods and Analysis. 2nd ed. Tokyo: McGraw -Hill, 1974.
3) Dowd, T.J. and T.M. Leschine. "Container Terminal Productivity: A Perspective." Maritime Policy and Management, 17, No. 2 (1990), 107-12.
4) Evans, J.J. and P.B. Marlow. Quantitative Method in Maritime Economics, Fairplay Publication, Norwich, Norfolk, 1986.
5) Fair, M.L. and E.W. Williams, Jr. Economics of Transportation and Logistics. Dallas, Texas: Business Publications, 1975.
6) Frankel, Ernest. G. Port Planning and Development. New York: John Wiley and Son, 1987.
7) Griffiths, J.D. "Optimal Handling Capacity at a Berth." Maritime Study and Management, 3 (1976), 163-67.
8) Hilling, D. "Port Efficiency and Capacity-Identifying the Bottlenecks." Asian Port Management Conference, Djakarta: PORTEC, 1985.
9) Imakita, J. A Techno Economic Analysis of the Port Transport System. Hants, England : Saxon House, 1987, 6-13.
10) Jansson, J.O. and D. Sheerson. "Port Economics." MIT Press series in Transportation Studies, No. 8, Cambridge, Mass., 1982.
11) Jun, I.S. "The Estimation of Congestion Cost in Korean Ports and Airports." CongestionCost Conference, Seoul: Sam Sung Economic Research Institute, May 1996.
12) I.S. Jun and Gim J.G. "A Study on the Establishment of Sea Route between North Korea and South Korea" (in Korean) A Study on Laws, Systems and Practical Problems of North-South Korea Exchange Cooperation. Seoul: Korea Unification Board, Dec. 1993.
13) Monie, G. De. "Analysing Berth Throughput." in UNCTAD. Manual on Port Management: Port Operation. New York: UN Publications, March 1976.
14) Moon, S.H. "Port Planning and Analysis." (in Korean) Journal of Korean Association of Shipping Studies, 18 (Aug. 1994), 337-65.
15) Robinson, Ross. "Modelling the Port as an Operational System: A Perspective for Research." Economic Geography, 52 (1976), 72-74.
16) Saarto, P. Quantitative Method in Maritime Economics, pp. 259-68.
17) Stock, J.R. and D.M. Lambert. Strategic

Logistics Management. 2nd. Homewood. Illinois: Irwin, 1987.

18) Stopford, M. Maritime Economics. 1988; rpt. Routledge, London, 1992.

19) UNCTAD. Berth Throughput: Systematic Methods for Improving General Cargo Operations. New York: UN Publications, 1973.

20) --------. Manual on Port Management: Port Operations. New York: UN Publications, 1976.

21) --------. Port Development: A Handbook for Planners in Developing Countries. New York: UN Publications, 1985.

22) Wanhill, S.R.C. "A Study in Port Planning: the Example of Mina Zayed." Maritime Studies and Management, 2 (1974), 48-50.

23) Yi, C.Y. and S.H. Moon. "An Analysis of the Port Transportation System." (in Korean) Journal of Korean Association of Shipping Studies, 1 (1983).