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A Study on the Relationship between Arrival Time Interval and Waiting Ratio of Ships at Ports

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Abstract. This study analyzed the relationship between arrival time interval and waiting ratio of ships at ports using the computer simulation. The simulations were based on the actual arrival records of 1,437 ships at three ports in Korea for three years. The results of the analysis showed that the relationship between waiting ratio and arrival time interval changes by following the pattern similar to logo of Nike. In other words, instead of uniform arrival time, arrival times with 15~20% standard deviation showed lowest waiting ratio. Therefore, the actual waiting ratio in three years was about 4.5~5.0% but results of 15~20% of standard deviation applied on the equidistant interval time showed about 1.5% of ratio which is much lower.

Keywords: Port Simulation, Ship's Waiting Ratio, Standard Deviation, Service Level, Nike theory

1 Introduction

The ship waiting ratio in port is treated as important service level inicator. Therefore, the ship waiting ratio is very important element between shipping company and stakeholders in the perspective of competitiveness except some situations when the shipping company has to use certain port.

So, construction of excess port infrastructure for improvement of service level without understanding of the ship waiting ratio of the relevant pier in the perspective of service provider may result in decline in cost competitiveness due to future burdens of expenses. On the other hand, paying no attention to the construction of port infrastructure may result in lowered service quality leading the shipping companies and shippers to move the port of call into different ports or near countries. This will create vicious cycle of reduction of berth occupancy rate and occurrence of loss on the perspective of terminal operation companies (TOC) and countries.

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2 Literature review

United Nations Conference on Trade and Development (UNCTAD) (1973) classified loading & unloading capabilities of ports into intrinsic capability and optimal capability. The intrinsic capability is the capability calculated under the assumption that the port system operates without stopping which means that the capability per hour is operated 24 hours and 365 days [1].

Goss and Mann (1994) calculated the port waiting cost using the long-run opportunity cost concept, the time cost of ships and cargos were estimated based on the 1970, and the results of the study developed further into core theory and methodology for the calculation of the time cost of ships and cargos [2]. Jansson and Shneerson (1982) calculated the port related costs as congestion costs and queuing costs without classification [3]. Yeong Tae Jang and Sook Kyong Seong (2002) calculated the time cost of ships and cargo per day based on the 50,000 Dead Weight Tonnage (DWT) according to the research method of Gross and Mann [4].

B. Dragovic, N. K. Park, Z. Radmilovic and V. Maras (2005) applied simulation techniques to the logistic ability related with ship arrival, berthing, service, and ship departure in the container port [5]. Michael Maloni and Jomon Aliyas Paul (2013) conducted simulation of calculating advantages and cost of various options of port networks in the West Coast of US in order to utilize the treatment capacity of the present ports. The results proved that simulation is effective method of reducing the future port congestion degree [6].

E. Page (1972) suggested the average waiting time ratio depending on the number of berth under E2/E2/n in the form of figure [7].

3 Model Design

3.1 Assumptions for model

The ports with piers satisfying the following conditions were selected in order to analyze the relationship between ship arrival time interval and ship's waiting ratio. First, one pier must berth one ship at a time. For example this study excluded the situation where the length of pier is long enough to berth small ship while one ship is already berthed. Second, the unloading piers dealing same items were selected as subjects. Third, the selection of piers was restricted into the piers with more than 300 ships berthed and at least 1 million ton of throughput handling record in past three years. Lastly, only those piers which are able to deal 10,000 DWT to 30,000 DWT were selected. The reason of these restrictions is to obtain statistical significance in a level in which the results of this experiment can generally be applicable to other piers.

3.2 Input and output variables of the model

After statistically analyzing the actually treated record data and the input values were drawn to apply input variables to the simulation model. Output variables are then obtained after conducting the simulation by applying input variable values. The input variables and output variables applied to the simulations are shown in Table 1 [9].

Table 1. Input Variables and Output Variables of the Simulation Model

Variables	Name	Meaning
Input	Ship arrival distribution	Normal or Exponantial Distribution
	Throughput by TPC	Trial or Exponantial Distribution
	Throughput per hour by TPC	Unit : Minute
	Number of berths	Units
	Number of annual service days	Days
	Service time per day	Hours
Output	Number of ships	Units
	Berth occupancy rate	%
	Ship's waiting ratio	%
	Quay wall throughput	Unit : ton(DWT)

3.3 Experimental subject ports

Three ports were selected as subject port for this experiment. They are Yeompo pier and Mipo pier in Ulsan port and Hyundai HYSCO pier in Gwangyang port. The berthing record data from 2009 to 2011 were used as basis for the simulation [9].

Based on the berthing record data for three years, the input data values which were applied to the simulation were statistically analyzed and summarized.

4 Research Results and Analysis

As a process of simulation, the standard deviation of arrival time was increased by 5% until it reaches 100%, creating total 21 intervals, based on the same interval. Also, the simulation was conducted 10 times for each interval to generate average values.

The results are summarized into the Table 2. Yeompo pier in Ulsan showed lowest waiting ratio of 0.0116(1.16%) at 20% standard deviation. The Hyundai HYSCO pier in Gwangyang showed minimum waiting ratio of 0.0141(1.41%) at 15% standard deviation. On the other hands, Mipo pier in Ulsan showed lowest waiting ratio of 0.0149(1.49%) at 20% standard deviation.

Table 2. Waiting Ratio per Std. Dev. of Three Target Berths

No	Std. Dev. Rate	Waiting Ratio		
		Ulsan Yeompo	Kwangyang HYSCO	Ulsan Mipo
1	0%	0.0168	0.0198	0.0215
2	5%	0.0180	0.0200	0.0198
3	10%	0.0154	0.0160	0.0194
4	15%	0.0134	**0.0141**	0.0165
5	20%	**0.0116**	0.0150	**0.0149**
6	25%	0.0132	0.0167	0.0152
7	30%	0.0155	0.0184	0.0179
8	35%	0.0181	0.0211	0.0195
9	40%	0.0212	0.0242	0.0222
10	45%	0.0236	0.0274	0.0257
11	50%	0.0281	0.0305	0.0285
12	55%	0.0305	0.0328	0.0308
13	60%	0.0318	0.0362	0.0358
14	65%	0.0371	0.0397	0.0379
15	70%	0.0396	0.0419	0.0394
16	75%	0.0396	0.0450	0.0422
17	80%	0.0434	0.0447	0.0439
18	85%	0.0454	0.0474	0.0452
19	90%	0.0456	0.0510	0.0478
20	95%	0.0515	0.0503	0.0485
21	100%	0.0534	0.0502	0.0515

5 Conclusion

The ship waiting ratio is important service level indicator in the management of ports [10]. The ship waiting ratio must be maintained under certain level in the perspectives of competition. Then, TOC must decide their investment on manpower, construction of new piers, and facilities in order to lower the ship waiting ratio until certain level.

The purpose of this study was to analyze the correlation between ship waiting ratio and standard deviations of arrival time with same interval.

The results of the study showed that minimum 1.5% of ship waiting ratio was shown when the standard deviation were at 15~20%. This phenomenon is a results 3.0 ~ 3.5 times smaller than the actual ship waiting ratio of 4.5~5.0%. TOC will have innovative solution if this is achievable in the real world. Also, the trend of change in ship waiting ratio depending on the changes in standard deviation was shown to follow the shape of logo pattern of NIKE which the author named as "NIKE theory".

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