한국항만학회 '98 추계학술대회논문집, pp. 263~269

論 文
B2-3

A study on the forecasting of container cargo volumes in northeast ports by development of competitive model

K. T. Yeo[1] · C. Y. Lee[2]

컨테이너 항만간의 경쟁 상황을 고려한 물동량예측에 관한 연구

여 기 태 · 이 철 영

Key Words : Container Cargo Volume, SD method, HFP method, Unit Port Model , Competitive Port Model, Structure Model, Port Components, Sub System, Feedback Loop, Dynamic characteristics

Abstract

The forecasting of container cargo volumes should be estimated correctly because it has a key roles on the establishment of port development planning, and the decision of port operating system. Container cargo volumes have a dynamic characteristics which was changed by effect of competitive ports. Accordingly forecasting was needed overall approach about competitive port's development, alternation and information. But, until now, traffic forecasting was not executed according to competitive situation, and that was accomplished at the point of unit port.

Generally, considering the competition situation , simulation method was desirable at forecasting because system's scale was increased, and the influence power was intensified.

In this paper, considering this situation, the objectives can be outlined as follows.

1) Structural model constructs by System dynamics method.

2) Structural simulation model develops according to modelling of competitive situation by expended SD method which included HFP(Hierarchical Fuzzy Process)

And actually, effectiveness was verified according to proposed model to major port in northeast asia.

1) A regular member, Yangsan College, Full -Time Lecturer
2) A regular member, Korea maritime university, professor

1. Introduction

Container cargo volumes should estimate correctly because it has a key roles on port expansion, port development, establishment of long term plan, and decision of system's detail components. But generally, the conventional methods of container forecasting is done through regression methods based on GNP growth trends and by other forecasting methods proposed by several authors. However conventional methods proves to be inaccurate because no comprehensive analysis on the relationships among several port components were done which are significant to the fluctuation of freight flow generated among inter-competitive ports. Stiff competition among neighbouring ports also warrants the approach towards port planning and development to be scrutinized. Accordingly forecasting was needed overall approach about competitive port's situation. The objectives of this paper can be outlined as follows.

1) To establish Competitive Port Model by Expansion Method of System Dynamic method.
2) By using developed model, container cargo volumes under competitive situation can be forecasted.
3) To analyse sensitivity by alternation of parameter, and to propose a port development strategy.

And, Competitive Ports Model includes five ports - Pusan, Kobe, Yokohama, Kaoshiung, Keelung, - which adjacents to each other by geographically and has a competition relation.

2. Methodology & Flow of study

In order to develop an Competitive port model, two methods have utilized.

1) SD Method (System Dynamic) :

If a system has a large boundary and complexity, forecast's accuracy will be very low when consider the system's substance as black box. Thus, it is necessary that analysis by structure model. To examine competition in Northeast Asia Ports, it has assumed that the form of structure model, for which the System Dynamics method is adapted in this paper.

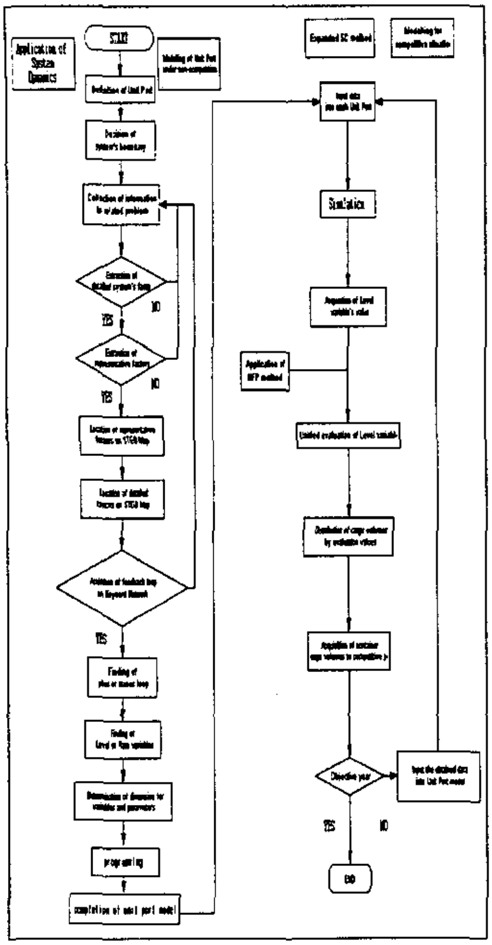
2) HFP Method (Hierarchical Fuzzy Process)

The Competitive Ports Model has several sub-systems which consists of each Unit Port models. And, each Unit Port model found by quantitive, qualititive factors and their feedback loops. All effects which components of one port have influence to components of the rest ports must be surveyed in order to construct Competitive Ports Model, but it may be impossible currently. In this paper, model was simplified by HFP-Hierarchical Fuzzy Process Method -adapted to integration of level variables of unit port model. Container cargo volumes in Competitive Ports Model is distributed by results of HFP method. And, distributed container cargo volumes effected to unit port model.

3. Development of Unit Port Model

3.1 A concept of Unit Port Model

In this section, we defined that Unit Port point out port system itself as subjects of competition. And we describe modelling methodology about to Unit Port. Components of port system have a reciprocal action. For example, if number of liner which was called one port was increased under



<Fig. 2-1> is flowchart of study.

the conditions that facility was not increased, then waiting number of liner in one port was increased.

And if waiting vessel was increased, each vessel's port charge to the calling port was increased. These increased port charge decreased potential calling vessels and calling companies. After all, export and import cargo volumes which was handled each port was decreased. As shown these cases, quantitive and qualititive components of port's system not only effect to port independently but also have complicate reciprocal action. It is possible that Unit Port system is regarded as huge and complexity. Also, Huge and complexity system can be forecasted by structural model. Structural model is very effective to analysis of system. These model have long since adapted to physical system. Transportation network, electricity network and telecommunication network is example for physical system. And recently these method applied to social system. World future is forecasted by structural model which used components - population, food, environment, industrialization.

In this paper, because Unit Port system have many components which have reciprocal relation, structural model was applied to this system. And, structural model constructed by System Dynamic method.

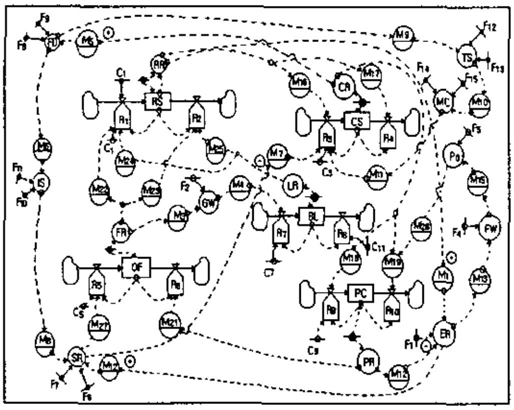
3.2 Development of Unit Port model by SD method

In this sub section, extraction of factors which was consisted of Unit Port accomplished by consultation of experts like research worker-professor, research fellows related to harbor, expert group. Five factor groups-Location, Facility, Service, Cargo volumes, Port charge-was obtained by results of consulting.

Method of factor extraction was KJ. Reason of adaption this method was different former study which was compared all factors by one to one, it was very effective to extract factor which has contents and meaning as a whole in parallel with very short time.

System's structure which has feedback loop was found easily by location of representative and detailed factors on keyword network of STGB map. Using these keyword network, feedback loop was found. <Fig. 3-1>'s detail flow diagram of

Unit Port model is developed by finding of variables and parameters.



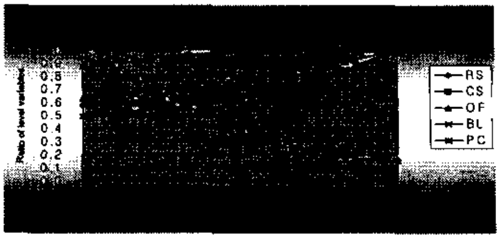
<Fig. 3-1> Detail flow diagram of Unit Port model

3.3 Application of the model

Real and estimated data of each port were used for system simulation. Simulation's result of Pusan port is as follows in <Table 3-1>, <Fig. 3-2>

<Table 3-1> Basic behavior of the container terminal of Pusan port

Level variable \ year	1998	1999	2000	2002	2003
Number of Liners ships/year	852	883	940	1,193	1,449
Congested ships ships/year	61	43	29	13	11
Container cargo volumes TEU/year	5,154,526	5,539,037	5,973,804	7,021,476	7,735,482
Berth length (m)	2,454	2,84	2,997	3,900	4,729
Port charge (₩)	122,794	128,665	132,937	133,955	131,256



<Fig. 3-2> Graph for basic behavior

In 2003 year, results of simulation was acquired that liner's number increased from 829 ships to 1,450 ships and container cargo volumes increased from 4.56 million TEU to 7.74 million TEU.

According to the simulation, because of increased liners and container cargo volumes, length of berth should expand from 2,162m to 4,729m. Result of berth expansion, congested ship's number decreased from 97 ships to 11 ships. Also, we can find that port's charge has a fluctuation.

<Table 3-2> Fluctuation of components among competitive ports in northeast asia

port \ Level variables		rs	cs	of	bl	pc
Kobe	97	766	149	1368780	10276	113526
	98	793	147	1394440	10385	116312
	99	830	143	1428011	10531	119982
	2000	879	137	1468555	10718	124542
	2001	943	127	1514830	10946	129869
	2002	1025	113	1565175	11218	135685
	2003	1128	95	1617620	11537	141485
Yoko hama	97	851	9	2859190	5206	125868
	98	894	9	3020795	5275	128955
	99	953	9	3245712	5370	133014
	2000	1028	8	3542178	5490	138012
	2001	1119	8	3921202	5639	143732
	2002	1225	6	4396692	5818	149734
	2003	1344	5	4986413	6031	155295
Kao shiun g	97	711	19	5264382	5727	95605
	98	753	18	5503264	5873	98909
	99	809	17	5828162	6073	102408
	2000	879	15	6246099	6333	106117
	2001	962	13	6766625	6660	109239
	2002	1052	10	7405573	7063	110575
	2003	1141	7	8192166	7557	108709
Kee lung	97	765	8	2038876	3287	94884
	98	818	7	2130236	3384	97793
	99	885	5	2254617	3519	99849
	2000	963	4	2416363	3693	10050
	2001	1043	3	2623058	3913	99089
	2002	1114	2	2887504	4184	95314
	2003	1158	1	3229808	4516	89313

Simulation for Kobe, Yokohama, Kaoshiung, Keelung in northeast asia by real data is resulted as <Table 3-2>.

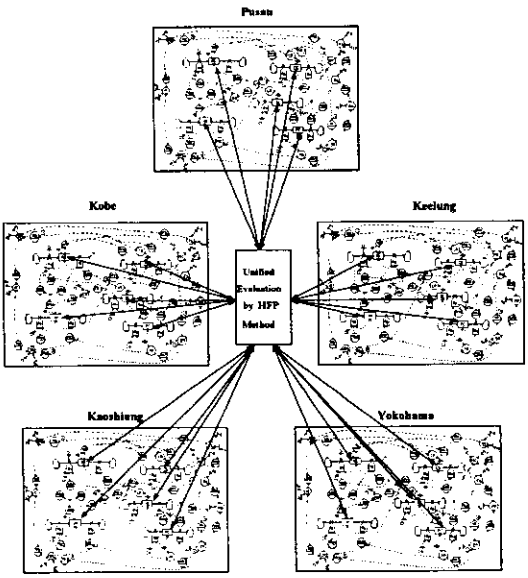
4. Development of model for competitive ports

Establishment of competitive port model was accomplished by unification of Unit Port model. <Fig. 4-1> is flowchart of study.

Distribution values of container cargo volumes at each port was acquired by fuzzy integral value.

<Table 4-1> Distribution values of container cargo volumes

	Pusan	Kobe	Yoko hama	Kao shiung	Keelung
97	5,144,025	1,644,494	3,435,118	5,283,036	2,449,568
98	5,330,683	1,696,016	3,674,101	5,634,301	2,590,942
99	5,488,376	1,732,855	4,149,002	6,004,287	2,735,920
2000	5,770,688	1,794,571	4,328,534	6,530,510	2,952,790
2001	6,001,327	1,826,597	4,728,225	7,014,239	3,162,909
2002	6,223,604	1,848,608	5,192,878	7,509,121	3,410,394
2003	6,563,581	1,904,682	5,871,299	7,592,208	3,802,968



<Fig. 4-1> Unification concept of each Unit Port models by expanded SD model

Comparison of results of simulation with estimated cargo of KMI was appeared as <Table 4-2>

<Table 4-2> Comparison of estimated cargo volumes (unit : TEU)

	1999	2000	2001	2002	2003
Forecasted results of KMI	6,020,945	6,446,577	6,872,209	7,297,841	7,723,473
Results of simulation	5,488,376	5,770,688	6,001,327	6,223,604	6,563,581

In Pusan port, container cargo volumes under competitive situation was forecasted small than non-competitive situation, that is Pusan port is rack of competitive power to other port.

4.3 Sensitivity analyses

4.3.1 Change of each port by increasing of port charge in Pusan

In this sub section, parameter c_9 which was increasing ratio of port's charge increasing ratio in Pusan port increase to 15% at real increasing ratio than other port adapted real data. As result of alternation, Pusan port's container cargo volumes translates to other ports.

<Table 4-3> Result of simulation for each ports

	Pusan	Kobe	Yokohama	Kaoshiung	Keelung
1997	4,388,975	1,741,407	3,637,557	5,594,377	2,593,926
1998	3,879,516	1,877,048	4,066,275	6,235,706	2,867,499
1999	3,212,406	2,002,579	4,794,806	6,938,872	3,161,774
2000	2,572,045	2,162,381	5,215,698	7,868,985	3,557,985
2001	4,603,569	1,979,188	5,123,212	7,,600,196	3,427,133
2002	3,887,217	2,089,077	5,868,372	8,485,915	3,854,022
2003	4,232,518	2,099,839	6,472,880	8,736,872	4,192,625

Because of port charge's increase in Pusan, Pusan's container cargo volumes have fluctuation in decreasing manner. And other ports which was received Pusan's cargo have increasing tendency. Namely, developed model can estimate change of container cargo volumes in competitive relation by alternation of simple parameter, and reflects dynamic characteristics which are included in model.

4.3.2 Alternation of congested ship ratio

<Table 4-4> is results of container cargo volumes in each ports that congested ship ratio increase to 20% at real increasing ratio. In this results, it is shown that Pusan's cargo volumes was decreased because of increasing congested ship. But, container cargo volumes which flowed out from Pusan move to other port.

<Table 4-4> Result of simulation by alternation of congested ship ratio in Pusan port

	Pusan	Kobe	Yokohama	Kaoshiung	Keelung
1997	5,058,683	1,655,448	3,457,999	5,318,227	2,465,884
1998	4,887,266	1,751,332	3,793,934	5,818,065	2,675,446
1999	4,504,162	1,849,494	4,428,272	6,408,437	2,920,076
2000	4,035,433	1,994,107	4,809,818	7,256,629	3,281,107
2001	3,368,835	2,113,982	5,472,131	8,117,810	3,660,540
2002	5,116,371	1,962,568	5,513,000	7,972,031	3,620,633
2003	4,359,560	2,087,432	6,434,637	8,685,253	4,167,854

5. Conclusion

Many study precedent for modelling of port competitive situation was proceeded. But, theoretical frame, analysis and method was very weak.

In this study, new algorithm for observation of port's system was presented. And, using this new algorithm-method of expanded SD, port's system in northeast asia was simulated

Algorithm for embodiment of port's competition was developed through two steps. The first step used System Dynamic method for establishment of Unit Port model. In second step, HFP(Hierarchical Fuzzy Process) method for expansion of prior SD method was introduced. This expended algorithm applied to embodiment of port's competition. Model's boundary included five ports-Pusan, Kobe, Yokohama, Kaoshiung, Keelung- which adjacent to each other by geographically, and used data is real values in each ports. Sensitivity analyses was carried out by alternation of each port's parameters. Result of adaptation, container cargo volumes of several ports in northeast asia was forecasted. Proposed model in this study, can estimate change of container cargo volumes in competitive relation by alternation of simple parameter. And, these are very helpful for port's mangers who plans development of port.

〈요 약〉

컨테이너 물동량의 예측은 항만개발계획의 수립, 항만운영시스템의 결정 등에 매우 중요한 역할을 한다. 그러나 컨테이너 물동량은 그 특성상 경쟁하는 항만간에 서로 영향을 받아서 변하는 특성을 지니고 있으므로 경쟁항만의 개발 및 변화 등의 정보를 종합적으로 고려하여 예측할 필요가 있다. 하지만 지금까지는 물동량 예측은 이러한 경쟁상황을 고려하지 않고 단위 항만을 기준으로 수행되어 왔다. 일반적으로 경쟁상황을 고려할 경우, 시스템의 규모가 크고 상호 작용하는 영향력이 강해지므로 시뮬레이션에 의해 예측하는 것이 바람직하다. 본 연구에서는 이러한 상황을 고려하여

1) System Dynamics를 도입한 구조모델을 구축하고

2) 항만간의 경쟁상황은 HFP-Hierarchical Fuzzy Process-에 의해 모델화하는 구조형 시뮬레이션 모델을 개발하는 것을 목적으로 한다.

그리고, 실제로 동북아의 주요항만을 대상으로 제안된 모델을 적용하여 유효성을 검증한다.

〈Bibliography〉

1. J. W. Forrester, *World Dynamics*, The MIT Press, 1971.
2. Lee, C.Y., "A concept of system engineering", 1997, pp. 121-175.
3. Lee, C.Y., "A concept of port logistics", 1994, pp. 137-150.
4. Yeo, K.T., Roh, H.S., Lee, C.Y. "On the Evaluation Algorithm of Hierarchical Process using λ-Fuzzy Integral-Applying for estimation of safety in ship berthing ", Journal of the Society of Maritime Safety, Vol.2. No.3, pp 97~106, 1996.1.
5. Yeo, K.T., , C.Y. Lee, "A strategic consideration for optimization of physical distribution in container terminal", The korean institute of port research, 1997, vol.11 No.2
6. Yeo, K.T., , C.Y. Lee, "On the competitive model among northeast asia port by System Dynamics method", The korean institute of port research, 1998, vol.12 No.1