IDENTIFICATION OF MEASUREMENT ITEMS OF PERFORMANCE DIMENSIONS IN CONTAINER PORT TERMINALS

T. Hari Krishna[1] **N. Vijaya Sai**[2]

M. Ashok Chakravarthy[2] **V. Sudheer Kumar**[2]

[1]Department of Mechanical Engg, V.R. Siddhartha College of Engineering, Vijayawada, India.

[2]Department of Mechanical Engg, V.R. Siddhartha College of Engineering, Vijayawada

Abstract— **Globalization and expansion in international trade generated more competitive markets for container terminal industry. Increased customer demands have taken substantial effect on the formation of strategies for container terminal operations and in turn became important for performance evaluation of container terminals. This study suggested a model with sixteen items under four performance dimensions to evaluate the performance of container terminals through confirmatory factor analysis. Four performance dimensions namely: 1) Throughput measures 2) Productivity Measures 3) Utilization Measures and 4) Service Measures are considered. The result produces a validated model that can help in diagnosing performance of container terminals.**

Key Words: Container terminals; Performance Dimensions; Throughput measures; Productivity Measures; Utilization Measures; Service quality Measures.

I. INTRODUCTION

In Today's complex and competitive environment, container terminals need to measure, monitor, control and improve the performance of the container terminals in order to sustain and increase competitiveness. Performance measurement of container terminals is considered as multi-criteria decision making problem as the performance of container terminals depends on multiple criteria.

Dong-Wook Song and Kevin Cullinane (1999) considered TEU throughput to determine the industry's efficiency and performance using stochastic frontier models.

Kisi et al. (1999) considered performance indicators of container terminals in four levels namely: labour, cargo, ship and berth. Thomas and Monie (2000) categorized performance dimensions of container terminals into production, productivity, utilization and service.

Junn-Yuan Teng et al (2004) evaluated competitiveness of East Asian region ports using gray relation analysis with 31 factors. In the study, thirteen criteria (labor quality, financial liberalization, political, social, and economical stability, hinterland productivity, ship mean service- time in port, loading and discharging ratio, terminal movement capability, operation cost of carriers, port service charge, impact of customs service and inbound/outbound ratio) are arrived as critical criteria for competitiveness of the ports. Wiegmans et al. (2004) presented an operational approach for the measurement of the quality of container terminal services to identify the critical performance conditions in terms of quality for container terminals. Soner Esmer (2008) has covered a wide range of performance dimensions (production, productivity, utilization and service Measures) using the container terminals that reviewed in existing literature. Jing Lu et al. (2010) evaluated container terminal service attributes through statistical methods such as Internal-Consistency Reliability, Factor Analysis and cluster analysis. The study identified five most important container terminal service attributes (Custom declaration efficiency, Loading and discharging efficiency Reliability of the agreed vessel sailing time, Berth availability and Port tariff). Dong-jin KIM (2012) evaluated port efficiencies with four productivity criteria (TEUs/year/crane, TEUs/year/length, TEUs/year/area and TEUs/year/hour) and ranked nineteen European container ports using PROMETHEE methodology. Longjia et al. (2013) performed regression analysis with throughput (TEU) as independent variable and ten dependent variables (Total berth length, Port draft, total terminal area, total container yard area, total number of quay cranes, total number of yard cranes, total number

ISSN: 2278 – 1323

of straddle carriers, total number of prime mover tractors, total number of trailers and total number of lifters/stackers) using data on the forty ports in East and Southeast Asia. Venkata Subbaiah et al. (2014) developed hybrid methodology to evaluate container terminals using four categories (Throughput, productivity, utilization and service of performance measures.

Various categories of performance dimensions of container terminals are reported in the literature. These performance dimensions require observable measuring items to evaluate the performance of container terminals. Confirmatory factor analysis is useful statistical technique to identify the measurement items of the observable variable or latent variable.

Chang et al. (2008) performed exploratory factor and confirmatory factor analysis and identified five port choice categories, i.e. port charge; physical/operational ability of port; advancement/convenience of port; marketability; operational condition of shipping lines; affecting the choice of port by the shipping companies. Yeo et al. (2008) identifies the components influencing their competitiveness and presents a structure for evaluating them using factor analysis. Ines Kolanović (2008) determined port service quality attributes using exploratory factor analysis was used and the convergent and discriminatory validity of the factors have been additionally tested by using the confirmatory factor analysis.Hwang and Chiang (2010) explored causal relationships between types of port, influential factors and port competitiveness.Chiang and Hwang (2010) explored causal relationships between influential factors, types of port cooperation, integration of ports and the overall competitiveness of ports in a region using factor analysis and structure equation modeling.Ines Kolanović et al. (2011) proposed a model defined by five factors for a customer-based port service quality using factor analysis. Caschili and Medda (2013) determined the Port Attractiveness Index for 41 container ports of 23 African countries for the period 2006-2010 by employing structural equation modeling approach.

Various methods for measurement of performance of container terminals has been proposed and recognized in previous literatures. But there is little investigation has identified the reliability and validity of items of performance dimensions particularly in respect of container terminals. This study examines and determines items for measuring the performance of container terminals of specific regions through confirmatory factor analysis.

II. THE CONCEPTUAL MODEL

The proposed model is based on four performance dimensions (Throughput, Productivity, Utilization and Service quality). In this study, in order to determine the domain that encompasses container performance dimensions an exhaustive theoretical, empirical and practitioner literature were reviewed. A conceptual frame work is developed by incorporating ideas, theories and studies from literature. In this context, the following hypotheses are introduced and the conceptual frame work is shown in the Fig. 1.

H1: Items relating to the throughput measure constitute performance dimension of container terminals.
H2: Items relating to the Productivity measure constitute performance dimension of container terminals.
H3: Items relating to the utility measure constitute performance dimension of container terminals.
H4: Items relating to the service measure constitute performance dimension of container terminals.

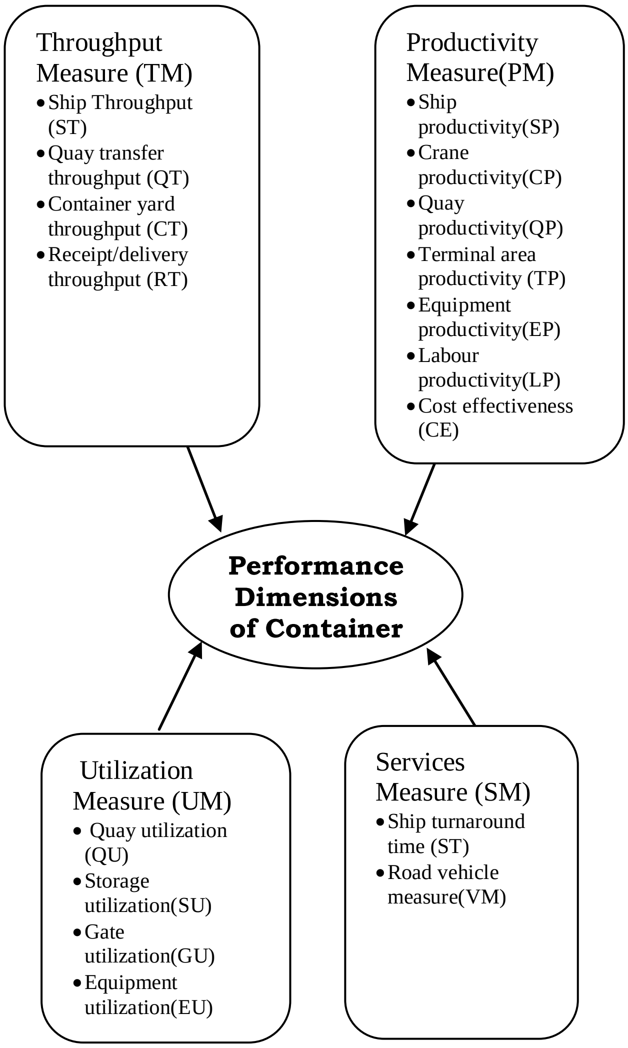

Figure 1 : Conceptual Model of Performance dimensions of Container Terminals

ISSN: 2278 – 1323

III. Scale Development

A list of 17 performance measurement items of container terminals are considered based on the literature related performance measurement of container terminals and interview with experts in the marine industry. Each item was rated on a five-point Likert scale (1- Strongly disagrees; 2- Disagree; 3- Undecided; 4- Agree; 5-Strongly agree) according to the following question: "please assess the degree to which the performance measurement items of container terminals need to be adopted or implemented.

IV. Data Collection

The data was collected by delivering the questionnaire, by email/ in person, to prospective respondents in the marine logistics. Typically they were the person responsible for making decisions about container terminal functions and were the most knowledgeable informants about the organizations functional activities. A total of 200 questionnaires were distributed, and only 110 completed surveys were returned, of which only 3 surveys were unusable. The overall response rate was 53.5%.Descriptive analysis of the data is shown in table 1.

Table 1: Mean and Standard Deviation of items of performance dimensions

Performance dimension	Item	Mean	Standard Deviation
Throughput Measure (TM)	ST	3.29	1.41
	QT	3.36	1.39
	CT	3.33	1.49
	RT	3.28	1.4
Productivity Measure (PM)	SP	2.97	1.33
	CP	3.52	1.36
	QP	3.66	1.28
	TP	3.62	1.22
	EP	3.61	1.14
	LP	3.47	1.23
	CE	3.7	1.24
Utilization Measure(UM)	QU	3.1	1.56
	SU	3.42	1.51
	GU	3.56	1.5
	EU	3.57	1.44
Service Measure(SM)	ST	3.49	1.46
	VM	3.31	1.45

5. RESULTS AND DISCUSSION

A confirmatory factor analysis (CFA) using LISREL 8.0 was used to test the measurement model. Also, to evaluate the fit of CFA, several goodness-of-fit indicators were used.

RELIABILITY ASSESSMENT

Establishing construct reliability involves testing each of the multiple indicators of a construct. The traditional measure of reliability is Cronbach's Alpha. Since the data for this research was generated using scaled responses, it was deemed necessary to test for reliability. Cronbach's Alpha tests were performed on the four constructs. Based on the coefficient values, the items tested were deemed reliable as they were greater than 0.70.

The study tested the measurement properties of the performance dimensions of container terminals through confirmatory factor analysis using the data collected from the survey questionnaire shown in Appendix-A. CFA was used to evaluate how well the measurement items reflect performance dimensions in the hypothesized structure.

Average Variance Extracted (AVE) of Squared Multiple Correlation (SMC), Composite Reliability (CR) of latent variables is presented in Table 2.Composite Reliability (CR) and Average Variance Extracted (AVE) was more than 0.6 and 0.5 respectively indicating good construct reliability and adequate convergent validity. Also, standardized factor loadings (>0.7) showed that all the items in the model are well loaded on respective performance dimension.

Table 2: Reliability Analysis of the measurement model

Performance dimension	Item	Cronbach's Alpha	Standardized Factor Loadings	SMC	Composite Reliability (CR)	AVE
Throughput Measure (TM)	ST	0.985	0.99	0.98		
	QT	0.9852	0.95	0.91		
	CT	0.9847	0.96	0.93		
	RT	0.9855	0.99	0.98	0.98	0.95
Productivity Measure (PM)	SP	0.9849	0.92	0.85		
	CP	0.9857	0.93	0.87		
	QP	0.9864	0.8	0.64		
	TP	0.9859	0.9	0.81	0.97	0.56

ISSN: 2278 – 1323

	EP	0.9863	0.89	0.79		
	LP	0.9852	0.97	0.95		
	CE	0.9862	0.87	0.76		
Utilization Measure(UM)	QU	0.9848	0.97	0.95		
	SU	0.9849	0.97	0.95		
	GU	0.986	0.87	0.76		
	EU	0.9864	0.82	0.67	0.95	0.83
Service Measure(SM)	ST	0.9862	0.85	0.72		
	VM	0.9849	0.98	0.95	0.95	0.86

To evaluate the goodness of fit of CFA model, various goodness-of-fit indicators were determined and shown in table 3. From the fit indices it is observed that the conceptual model was satisfactorily fit the data.

Table 3: Fit indices of structure model

Indicators	Propriety Indicators	Cutoff Value	Research Findings
Absolute Propriety Indicators	χ^2/d.f	3	2.97
	GFI	>=0.9	0.73
	AGFI	>=0.9	0.63
	SRMR	<=0.08	0.07
	RMSEA	<=0.15	0.14
Relative Propriety Indicators	NNFI	>=0.95	0.96
	NFI	>=0.95	0.96
	CFI	>=0.95	0.97

The value of χ^2/d.f is 2.97 indicates the good fit of the model. As to propriety of the model, values of GFI is 0.73, AGFI is 0.63, CFI is 0.97 indicates close fit of the model. Hence, therefore enough evidences to accept the entire hypothesis are supported. It is also an established fact that RMSEA and SRMR are 0.14 and 0.070 respectively obtained in the study indicates the satisfactory fitness of the measurement model.
Throughput measures (Ship throughput, Quay transfer throughput, Container yard throughput and Receipt/delivery throughput) which indicate the effort involved in moving that cargo, in terms of tonnes handled or containers movements per unit of time.

Productivity measures (Ship productivity, Crane productivity, Quay productivity, Terminal area productivity, Equipment productivity, Labour productivity and Cost effectiveness) are particularly important to the terminal operator as they are directly related to the cost of operating the terminal.

Utilization measures (Quay utilization, Storage utilization, Gate utilization and Equipment utilization) allow management to determine how intensively the production resources are used.

Service measures (Ship turnaround time, Road vehicle turnaround time and Rail service measures) indicate the satisfaction of the customers with the services offered to them in terms of reliability, regularity and rapidity.

6. CONCLUSIONS

The role of sea ports has been gained importance in logistics for efficient transportation of goods. Production capabilities, utilization capabilities, and service capabilities of container terminals need to be improved to maintain competitive edge over the other ports. This study has validated a wide range of performance dimensions that reviewed in existing literature in respect of the container terminals. In this paper, measured variables that affect the performance of container terminals are identified. These items are useful to determine the performance of container terminals. Prioritization of these items needs to be considered for further research for outranking of container terminals to make the results more useful.

REFERENCES

1. Caschili Simone and Francesca Medda (2013), "The Port Attractiveness Index: Application on African Ports", *IAME Conference 2013*, *Marseille*, pp.49-82
2. Chang .Young-Tae, Sang-Yoon Lee, Jose L. Tongzon (2008), "Port selection factors by shipping lines: Different perspectives between trunk liners and feeder service providers", *Marine Policy*, Vol. 32, pp. 877–885
3. Cherng-Chwan Hwang and Chao-Hung Chiang (2010), "Cooperation and Competitiveness of Intra-Regional Container Ports", *Journal of the Eastern Asia Society for Transportation Studies*, Vol.8, pp.1-16
4. Chiang Chao-Hung and Cherng-Chwan Hwang (2010), "Competitiveness of Container Ports in a Region with Cooperation and Integration", *Journal of Society for Transportation and Traffic Studies*, Vol.1, pp.77-92
5. Dong-Jin Kim (2012), "A comparison of Efficiency with Productivity criteria for European Container

ISSN: 2278 – 1323

ports", *The Asian Journal of Shipping and Logistics*, Vol.28, No.2, pp.183-202

6. Dong-Wook Song and Kevin Cullinane (1999), "Efficiency Measurement of Container Terminal Operations: An Analytical Framework", *Journal of the Eastern Asia Society for Transportation Studies*, Vol.3, No.2, pp.139-154
7. Ines Kolanović, Čedomir Dundović, and Alen Jugović (2011), " Customer-Based Port Service Quality Model", *Promet – Traffic & Transportation*, Vol. 23, No. 6, pp. 495-502
8. Ines Kolanović, Julije Skenderović and Zdenka Zenzerović (2008), "Defining The Port Service Quality Model By Using The Factor Analysis", *Pomorstvo*,Vol. 22, No. 2 , pp. 283-297
9. Jing Lu, Xiaoxing Gong and Lei Wang (2011), "An Empirical Study of Container Terminal's Service Attributes", *Journal of Service Science and Management*, Vol. 4, pp. 97-109
10. Junn-Yuan Teng , Wen-Chih Huang and Miin-Jye Huang (2004), "Multi-criteria Evaluation For Port Competitiveness of Eight East Asian Container Ports", *Journal of Marine Science and Technology*, Vol. 12, No. 4, pp. 256-264
11. Kişi, H., Zorba, Y., & Kalkan, M. (1999), "Assessment of Port Performance: Application on Port of Izmir, Strategic Approaches for Maritime Industries in Poland and Turkey, eds: Mustafa
12. Longjia Chu, T. F. Fwa and H. Nishijima (2013), "Container Port Operational Performance Assessment – A Rational Approach based on Internet Website Port Data", *Proceedings of the Eastern Asia Society for Transportation Studies*, Vol.9, pp.1-13
13. Soner Esmer(2008), "Performance Measurements of Container Terminal operations", *Sosyal Bilimler Enstitüsü Dergisi*, Vol.10, No.1, pp.238-255
14. Venkata subbaiah.K., K.Narayana rao and M.Malleswara rao (2014), "Evaluation of Performance of Container Terminals Through DEMATEL-AHP", *International Journal of Quality research*, Vol.8, No.4, pp.533-542
15. Wiegmans. Bart W., Piet Rietveld and Peter Nijkamp (2004), "Container terminal handling quality", *European Transport* , No. 25-26, pp. 61-80
16. Yeo .Gi-Tae, Michael Roe , and John Dinwoodie (2008), "Evaluating the competitiveness of container ports in Korea and China", *Transportation Research Part A*, Vol. 42, pp. 910–921

Authors

T. Harikrishna

Assistant Professor, Mechanical Engineering, V.R.Siddhartha Engineering College, Vijayawada, India.

Dr. N. Vijaya Sai

Head of the Department, Mechanical Engineering, V.R.Siddhartha Engineering College, Vijayawada, India.

1. N. Vijaya Sai, M. Komaraiah & A.V. Sita Rama Raju, "Powder metallurgy Fabrication and Characterisation of copper−fly ash composites", Journal of Manufacturing Technology Today, Vol:10, Jan-2011,

2. N Vijaya Kumar, M.M.M. Sarcar, N. Vijaya sai, "Investigation of Mechanical Properties of Industrial Waste (Granite & Silicate Fume) Reinforced Polypropylene Particulate Composites", International Journal of Composite Materials and Manufacturing, Vol.2, No.02 Jul-12, pp.1-5.

3. N. Vijaya Sai, "Fabrication and Characterization of Copper-Red Mud Particulate Composites Prepared by Powder Metallurgy Technique", Jordan Journal of Mechanical and Industrial Engineering, Vol. 8 (5), Oct-2014, pp. 313 – 321, ISSN 1995-6665.

4. N. Vijaya Sai, P. Nanda Kishore, Ch. Prem Kumar, "Investigation on Dynamic Behaviour of

ISSN: 2278 – 1323

Hybrid Sisal/Bagasse Fiber Reinforced Epoxy Composites", Int. Journal of Innovative Research in Advanced Engineering, Vol.1, Issue 6, jul-2014, pp 357, ISSN: 2349-2163

M. Ashok Chakravarthy
Assistant Professor, Mechanical Engineering, V.R.Siddhartha Engineering College, Vijayawada, India.

V.Sudheer Kumar
Assistant Professor, Mechanical Engineering, V.R.Siddhartha Engineering College, Vijayawada, India.

1. S. Bhagya Lakshmi, Sudheer Kumar V., Ch. Nagaraju, “Dynamic Analysis of Honda Engine Crank Shaft”, International Journal of Engineering and Innovative Technology (IJEIT), ISSN: 2277-3754, Vol. 2, Issue 1, pp. 174-178, July-2012.

2. V.Sudheer Kumar, CH. Hari Krihna, Ch. Karthik Sai,Ch. Naga Raju, "Dynamic Analysis of a cracked Rotor - An Experimental and Finite Element Investigation", 4Th international conference on Materials processing and characterization (ICMPC 2015), organised by department of mechanical engineering gokaraju rangaraju institute of engineering and technology on 13th -14th March 2015, Science Direct, Elsevier

3. V.Sudheer Kumar, Ch. Naga Raju, V.Uma Sai Vara Prasad,U. Koteswara Rao, "Analytical Asesment of Iron Aluminide Alloys as Bearing Material or Rotor Dynamics", International Journal of Engineering Research and Technology(IJERT),Vol.4, Issue 4,April 2015, ISSN: 278-0181

ISSN: 2278 – 1323