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Using an Algorithm to Optimize the Utility of Container Inventory through Virtual Container Yard (VCY)

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***Abstract*—The virtual container yard is an innovative tool that reduces the cost of empty reposition cost of container shipping lines. This concept is underpinning the container interchange between carriers. This paper evaluates the feasibility of introducing an algorithm to optimize the virtual container yard. A combination of qualitative, quantitative approach has been applied and dimension reduction factor analysis was used to analyze data. The container shipping lines may reduce the cost of container reposition by 15-20 percent. Through the virtual container yard. This study reveals key factors relevant to software application that may directly influence the new container management tool namely, virtual container yard as the concept needs a computer platform to operate it in the commercial context.**

Keywords—Virtual container yard, inventory, management

I. Introduction

One of the most striking developments in the global economy since World War II has been the tremendous growth in international trade [1]. Shipping is a business that grew up with the world economy, exploring and exploiting the ebb and flow of trade [2]. From 1981 to 2009, global transport of containerized cargo increased approximately 3.3 times faster than the world's GDP [3]. World's very first all-container ship "Gateway city" was found in 1950 [4] and containerization was commercially implemented in the US in the mid-1950s [1] and is the driver of the twentieth century economic globalization and world container port throughput increased by an estimated 3.8 per cent to 601.8 million 20-foot equivalent units (TEUs) in 2012 [5]. Containerization was not just about ships but a new way of organizing transport [2] has made a significant change globally in the system of freight transport. However, container fleet size and the complexity of the container shipping network [6] have increased dramatically bringing more challenges to the operation of the container shipping system. Cross-border transportation is an engine to promote the foreign trade [7]. The system, that proved its potential as an increasingly efficient and swift method of transport, led to greatly reduced transport costs, and supported a vast increase in international trade.

Container inventory imbalance causes a substantial cost to carriers amounting to twenty two percent in the overall cost structure of containers. The most popular mechanism to overcome this problem is the repositioning of empty containers from the idle location to other locations where they are in demand. Also, there is no commonly accepted standard system to minimize the idle time of empty containers at storage. The virtual container yard (VCY) is a novel strategy underpinning the container interchange between carriers that could substantially reduce this ever-increasing container empty repositioning cost. And it ensures maintaining a balanced container inventory in a port through interchange between carriers. The VCY became a popular topic in the literature in the current decade as the alternative methods such as foldable containers did not prove expected results. This paper considers the operationalization of the VCY through the context of computing and information communication technology (ICT).

Although bigger Container Ships (CS) were built to derive benefits of the scale of economies carriers found it always did not benefit given the derived demand factor inherent in the shipping industry. Economies of scale are pushing towards the largest container possible as it implies for inland carriers little additional costs [8]. Operators have not reaped the benefits of savings on slot costs [9]. In the past CSL operated weekly services independently; each CSL had their own ships plying between identical ports but they only load/discharge containers owned by them (except those who carried SOC[4]). However, economies of scale cannot be a panacea per se. Carriers must find some way to return to profitability [9]. In order to obtain the economies of scale advantage CSL later used to form consortia and share the ship space[5] adopting collaborative approach. Cooperation between the carriers is highly desirable [9]. Unlike the old liner system which focused on individual routes, today competition is global and companies develop alliances [2] and have sought extensive cooperation with others through formation of strategic shipping alliances [10]. Accordingly, CSL presently share ships space with competitors. In addition to sharing of vessel space, these alliances gradually extended the collaboration to other areas such as, service rationalization, operating expense sharing, equipment6 interchange, and joint service contracts.

Although container interchange is not yet a popular mechanism, shipping lines used to interchange their ship space (slots) since last three decades. When CSL realized that they should collaborate to fill their ships they formed strategic alliances, but it took considerable time to form shipping alliances and exchange slots. Slot exchange became a buzz word in the container shipping industry years later after the economic benefits it offered were realized and understood. However, according to industry sources CSL do not pool their containers and interchange even if the contract agreements provide provision for same. The researcher learned some rare instances of exchange of containers between CSL when their exporters erroneously stuffed cargo in partners' containers. But such interchanges were done as a corrective measure for that particular situation only. There is no regular practice of interchanging containers between carriers to reduce empty repositioning requirements. Ultimate result is that they never opt to strike a balance between the container inventories even within the active consortiums (alliances). Therefore, it is quite obvious that the behavioral patterns of CSL with respect to these two phenomenon (i.e. sharing ship space; and pooling containers) are not the same. The primary objective of Collaboration is to work with each other to do a task and to achieve shared goals. Inter-competitor cooperation is different from other types of inter-firm cooperation. [11]. Liner shipping competitors are companies with similar products and customers. Therefore, it is difficult for competitors to cooperate especially from the marketing perspectives and find the right balance between sharing knowledge and resources. Inter-firm cooperation is a source of competitive advantage. [12]. Obviously, they will be more cautious about the resultant visibility that generate through collaboration and any threats on preserving competitive advantage. There is often a general suspiciousness related to inter- competitor cooperation. It took sometimes to form alliances in sharing ship space too but it became a reality having realized it economic benefits. [13] in their study "Empty container repositioning in liner shipping" proposed external container sharing as a strategic option. It refers to pooling container fleets among different ocean carriers.

However, since the container exchange is perceived as a complicated mechanism the decision to exchange containers needs a serious evaluation of its pros and cons in every individual case. This obviously involves many decision parameters. Therefore, the authors believe that ICT could bridge this industry gap and facilitate most effective and economical decision to exchange containers. Accordingly, his paper discusses the possibility of deriving a VCY solution through an algorithm.

II. Literature Survey

The increased attention by the researchers in the recent past shows the ever-increasing impact of container imbalance to the world. For example, only 14 publications were evident during 1972-2005 (33 years) compared to 50 publications during 2006-2011 (5 years) as revealed by [14]. Although the issue of empty container repositioning first attracted attention in the mid 90's, interest in this problem seems to have grown even further in the last five years. Considering the last five years as the

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[4] SOC – Shipper Owned Containers

[5] The "Product" component in container shipping comprises 'ship space' and 'containers'

[6] The words equipments and Containers are used interchangeably

pre- and post-global crisis period, the repositioning issue has gained even greater importance as various problems have been encountered in supplying empty containers. The literature review has revealed that 62 of the studies since 1972 have dealt with repositioning empty containers. 31 of such studies have appeared in journals, 22 of them seem to have published in conference proceedings, but the sources of 7 of them have not been reached.

In the modelling-oriented analyses of the 62 studies published in various journals and conference and/or congress proceedings, two distinct methods approaches have been adopted. The studies analysed have been categorized either as mathematical modelling or heuristic products. 50 of those studies analysing the problem through mathematical modelling seem to have used such modelling technics as numerical experiments, mathematical programming, genetic algorithms, regression analysis, simulation, integer programming, dynamic programming, statistics, linear programming, optimization programming, game theory and deterministic modelling. In the 12 heuristic studies, the methods used have been case study and literature review, and 1 of such studies seems to have preferred to use reverse logistics theory [14].

The research papers referred in [14] has been further analysed in order to ascertain the core issue that has been focused in those studies and summarised under five catagories. It is noted from table: 2.6 that majority of work (18 studies) is been done with respect to Empty Container Repositioning. This study, in contrast, focuses on minimizing of Empty Container Repositioning. It attempts to avoid as much as possible the necessity of repositioning. Only 9 papers were written on Empty Container Allocation while 05 on Empty Container Distribution. 12 papers have covered various aspects of Empty Container Management which is somewhat relevant to this study. There are 4 researches done on Empty Container Reuse which reflects the similar approach of this study because the researcher accepts the fact that it is rather unrealistic to totally eliminate the imbalance therefore "reuse" will directly reduce the need for repositioning. There is only one paper concerning Foldable Containers referred in [14] which again represent a way of reducing the cost of repositioning but not reducing the need for trepositioning.

The concepts being developed for collapsible or foldable containers might represent a potential solution to minimizing both regional and international movements. The potential cost savings of operating collapsible containers extends beyond the lowering of marine and surface transport costs: since several empty containers can be folded and handled in one package, incremental break-down and assembly costs can be off-set with the efficient use of space (at terminals and aboard ships) and reduced trucking, handling, and storage costs. [15] . Use of foldable containers is another solution to reduce the repositioning cost as it occupies lesser space. However it does not make any impact on reducing the number of units that needs repositioning, except the fact that number of slots that occupy the same number of units have been reduced. [16]. To fold a container a three-person team with a forklift is required. This process takes approximately 15 minutes and handling productivity is from four to six containers per hour. The Fallpac is a 20 ft container which combines dismountable and collapsible features. To fold and unfold the container, two people and a forklift are required. According to the Swedish manufacturer, the box can be folded within 10 minutes. There have been many improvements in design features of Fallpac containers, including a prototype of a fully automated version (Hanh, 2003). Purchasing cost and the transportation cost affect the use of foldable containers [16] . Flexible destination ports policy is another application in practice. It only specifies the direction of the MTY flows, whereas ports of destinations are not determined in advance and MTYs are unloaded from vessels as needed [17]. The effectiveness of this method is only limited to the respectives line's service routes, container inventory and fleet size. In contrast collaboration between CSL may directly reduce the number of containers that needs repositioning. Therefore, it would significantly impove the effectiveness of other solutions too thus may be supplimentary to each other through its synery effect.

III. RESEARCH MEHODOLOGY

This study is an extension to the previous research "Selection of an Algorithm to Operationalize the Virtual Container Yard conducted by same authors [18]. The survey was conducted in Sri Lanka. Sixteen out of "Top 20" CSL that carry approximately 75 percent of global container capacity [19] have their representation in Sri Lanka. Therefore, the sample is expected to be reflective of the general view of the global shipping industry. Both qualitative and quantitative methods have been used to collect data. The questionnaire of the opinion survey was distributed to one hundred and twenty shipping companies registered under the Ceylon Association of Ships' Agents (CASA) that comprises a membership 135 and the Sri Lanka Association of Vessel Operators with 14 members. According to industry experts, the major decisions with respect to containers are usually taken in consultation with chief executive, operation manager, and container controller (three strata). Every agent usually has one employee from each stratum. It was learnt that each stratum influences the decision with respect to empty containers (MTY) differently. Edirisinghe, et al. (2015) recommends the suitable sample stratum for CSL that comprises chief executives, operations managers, and container controllers could be 0.20, 0.50, and 0.30 respectively. Therefore, weights were allocated to each job category as follows and a weighted random sample was drawn from each job category.

TABLE I. RESPONDENT DEMOGRAPHY

Job category	Percentage	Sample drawn
Chief Executives	20	40
Operations Managers	50	100
Container controllers	30	60
Total	100	200

In this paper, a questionnaire with five-point rating scale was designed to measure the carriers' perception. The questionnaire was created as follows. The demography section consists four questions based on container stock position and its impact namely, (i) frequency of container inventory monitoring, (ii) empty container Volume of the respondent in TEUs, (iii) type of imbalance that is faced by carrier, (iv) cost of empty container as a percentage of total freight earnings has an impact of container exchange. Psychometric scales are used widely in the social science and educational research. There were fourteen questions designed in the Likert scale as it was considered Likert scale questions are more suitable to measure human attitude. In this study, a questionnaire was distributed to shipping liner agents in Sri Lanka. By using the survey instrument, the shipping personnel could express their opinions and views concerning their perception about e-based applications to reduce their costs incurred on empty container reposition. Questionnaire was sent by email and by post to 200 sample respondents.

TABLE II. DETAILS OF CONSTRUCTS AND VARIABLES

Construct/ Variable	Dimensions/Variables	Items	Code
Purchase Motivation	End user (QAE)	User Qualities	QAE1
		Software Requirements	QAE2
		Scalability	QAE3
		Compatibility	QAE4
		Unrecognized Needs	QAE5
	Software product (QAS)	System Qualities	QAS1
		Run-Time Qualities	QAS2
		Design Qualities	QAS3
		Security Elements	QAS4
		Agility	QAS5
		Exit Strategy	QAS6
		Credibility	QAS7
Performance	PN	Features	PN1
		Fit	PN2
		Futures	PN3
		Flexibility	PN4
		Functionality	PN5
		User Friendliness	PN6
		Ease of Use	PN7
Investment cost	IC	Funds availability	IC1
		Price of software	IC2
		Associated Expenses	IC3

IV. DATA ANALYSIS AND DISCUSSIONS

The data was collected from eighty-eight respondents in the manner illustrated in Fig. 02. Researchers were unable to collect data from forty-eight respondents. However, the respondents' demography of each job category of this study shows a similarity to the recommendation of previous literature.

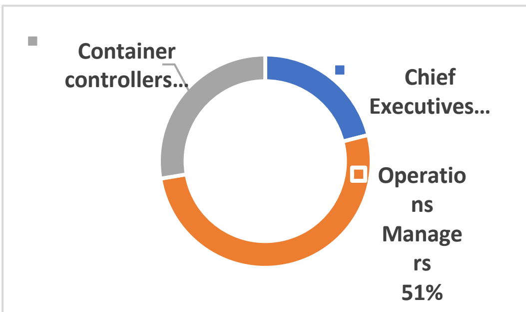

Fig. 02: Analysis of respondents

Since container inventory management plays a key role in liner shipping operation a cross section of senior management involved in the decision-making process is included. Therefore, interviews have been conducted with two chief executives, four operations managers and two container controllers.

Well planned, accurately forecasted, realistically allocated, and effectively managed container flows ensure that material and goods are globally supplied on time, in a cost-efficient way [20]. Therefore, CSL closely monitor their container movements. However, most of shipping agents do not wish to reveal container data with third parties. It is believed that principals (the shipping line's head office) are responsible for these analyses and they consider such information when determine freight rates for each location. Apart from this reason the shipping agents are generally not allowed to discuss any finance related matters with external parties according to the service agreements.

A. Reliability test

The internal consistency of the variables can be determined through reliability test. Since the survey questionnaire consisted Likert-type scale-based questions, a reliability test was conducted to determine each factor among categorized variables. If the internal consistency is high, those items can be used to create the variables. Based on the value, decisions are taken about the acceptability of the variables, if Cronbach's alpha less than 0.5 it is unacceptable.

TABLE III. CRONBACH'S ALPHA

	Cronbach's Alpha	N of Items
QAS	0.51	7
QAE	0.42	5
IC	0.81	3
PN	0.85	7

The Cronbach's alpha value recorded in this research for QAS; IC; and PN were considered acceptable to proceed with the model. However, QAE and QAS reflect poor values 0.42 and 0.51 respectively. However, since these factors are important as per industry sources it was decided to retain the variables.

B. Sampling adiquacy

Then the KMO and Bartlett's Test was conducted for the data obtained. The KMO measures the sampling adequacy which should be greater than 0.5 for a satisfactory factor analysis to proceed. Accordingly, the KMO and Bartlett's test was exercised.

TABLE IV. SAMPLING ADEQUACY

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.909
Bartlett's Test of Sphericity	Approx. Chi-Square	2092.682
	df	253
	Sig.	.000

In this research, the value of KMO measure of sampling adequacy recorded at 0.91, confirming to the recommended value standards. Previous research "Selection of an Algorithm to Operationalize the Virtual Container Yard" identified conducted by same authors [18].

TABLE V. VARIABLE CODES AND LABELS

Variable	Code	Label
Software Requirements	QAE2	Qualifiers
Unrecognized Needs	QAE5	
System Qualities	QAS1	
Design Qualities	QAS3	
Security Elements	QAS4	
Features	PN1	
Futures	PN3	
Flexibility	PN4	
Functionality	PN5	
User Friendliness	PN6	
Ease of Use	PN7	
Price of software	IC2	
Associated Expenses	IC3	
Agility	QAS5	Access
Credibility	QAS7	
Fit	PN2	
Funds availability	IC1	
Exit Strategy	QAS6	Utility
Scalability	QAE3	
Run-Time Qualities	QAS2	Quality

C. Model summary interpritation

TABLE VI. MODEL SUMMARY

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.657[a]	.432	.417	.39190	
2	.655[b]	.429	.417	.39177	
3	.651[c]	.423	.416	.39232	
4	.644[d]	.415	.411	.39390	1.937

a. Predictors: (Constant), QAS2, Access, Utility, qualifiers

b. Predictors: (Constant), Access, Utility, qualifiers

c. Predictors: (Constant), Utility, qualifiers

d. Predictors: (Constant), qualifiers

e. Dependent Variable: Accept

Adjusted R-square is 41.1%, it can be concluded that 41.1% of the acceptance is covered by the model.
Durbin-Watson test statistic value is 1.937, data is not autocorrelated.

TABLE VII. ANNOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17.186	4	4.296	27.974	.000[b]
	Residual	22.577	147	.154		
	Total	39.763	151			
2	Regression	17.047	3	5.682	37.023	.000[c]
	Residual	22.716	148	.153		
	Total	39.763	151			
3	Regression	16.830	2	8.415	54.675	.000[d]
	Residual	22.933	149	.154		
	Total	39.763	151			
4 n	Regression	16.489	1	16.489	106.273	.000[e]
	Residual	23.274	150	.155		
	Total	39.763	151			

a. Dependent Variable: Accept
b. Predictors: (Constant), QAS2, Access, Utility, qualifiers
c. Predictors: (Constant), Access, Utility, qualifiers
d. Predictors: (Constant), Utility, qualifiers
e. Predictors: (Constant), qualifiers

This study reiterates findings of previous literature that factors relevant to software requirements, availability of specific hardware or operating system requires that need to run the software and is flexible regarding operating systems, underlying databases, and hardware platforms play important role in developing an algorithm for VCY. There is a risk in a software due to the problems arising from failure to consider some important aspect of the architecture necessary for successful system construction and it is real concern in this software too given the complex nature of shipping business. The consistency and coherence of the overall design, the ability of the system to undergo changes with a degree of ease, and the capability for components and subsystems to be suitable for use in other applications and in other scenarios play a major role in selection. Given the trend that container market is going the user needs to consider whether this product going to give necessary visibility towards future. It is a concern that whether this product will provide the flexibility that the changes my company foresee doing in future, and different needs or working practices. Functionality is another key issue. The service provider needs take the time to outline end user's needs and consider all the options are covered in the functionality. The investment in this software or even subscription should follow thereafter. A pilot program should be ideal. User Friendliness was considered a key factor.

V. CONCLUSIONS

In model diagnostic test it has been revealed that error terms are not normally distributed with zero mean. That is a violation of regression assumptions. This has been identified in the reliability analysis of the questionnaire. Also, the existence of pertaining literature on this subject was poor making further limitations in this study.
Authors suggest qualitative further research o identify the factors influencing acceptability of a software in VCY.

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