The Sustainable Logistics Strategies for Intermodal Transport Systems of Container Ports in Taiwan

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***Abstract*—**The concept of hinterland is becoming obsolete through the use of containers providing intermodality and reducing the sphere of influence of ports. The competition for intermodal links in container ports is sometimes a short-term objective towards the longer-term vision of establishing a intermodal transport systems and a global logistics center. This paper discusses the success strategies for container ports towards the intermodal transport systems, taking into account both the interior and exterior environment of intermodal transportation development. The Analytic Hierarchy Process (AHP) technique of Multi-Criteria Decision Making (MCDM) is used to evaluate the decision support system for strategic planning of container port logistics systems, and based on the views elicited from a structured survey of container carriers, port operators and academic experts. The sustainable logistics strategies for intermodal transport systems of container ports in real-world decision problems were examined and had obtained a good understanding of the data acquired from participants' perceptions were analysed. The statistical technique of factor analysis was implied in order to utilize the analysing of the relationship between the service purchase behaviour and the degree of satisfaction.

***Keywords*—**Container Ports; Factor Analysis; Global Logistics Center; Intermodalality; Intermodal Transport Systems; Strategic Planning; Sustainable Logistics Strategies.

***Abbreviations*—**Analytic Hierarchy Process (AHP); Multi-Criteria Decision Making (MCDM).

I. INTRODUCTION

CONTAINERS as the transport cargo units have improved intermodality so that it becomes common for different ports to share the same hinterland, and they are pushed into port competition. The rise of intermodal transport has resulted in dramatic changes in the pattern of freight transport and port competition in worldwide shipping. The intermodal system affords exporters and importers impressive opportunities for saving money, expanding markets, and increasing the value added related to distribution, but by far the greatest benefit they afford is the minimization of intermodal transfers. There will be a renewed focus on intermodal freight transportation driven by the changing requirement of global supply chains. Extension of worldwide transportation needs to avoid the high cost of non-movement, even briefly at the point of interchange between modes. To achieve optimum transportation returns, goods in transit should move forward in a continuous manner. Industry and government are concerned about the capacity of ports to handle steadily increasing volumes of intermodal containerized traffic, and the ability of ports to develop an intermodal freight transport system. Some actors in the supply chain have responded by providing value-added services in an integrated logistics package, transforming some container shipping lines into logistics management organizations. The fact that a growing number of ocean carriers expand their role by controlling the total logistics chain including inland transport, storage and distribution implies that criteria for port selection are related to the entire transportation journey and thus no longer restricted to maritime transport alone. Consequently, if a seaport does not succeed in attracting carriers, it will be exposed to the risk of substantial losses of container traffic. These developments force ports to make every effort to be competitive in terms of cost and quality of services and to develop the port area into a logistics park and distribution service centre. As major connecting nodes in national and international transport systems, ports play a very important role in the trade development of a regional economy. Container ports were the important nodal points in the entire global logistic chains of containerised freight transportation. Global trends in containerisation inevitably affect container ports both directly and through changing the environment in which they operate. The new trends affecting the container freight industry are explored mainly by reviewing the recent literature on

containerization [Slack et al., 1996; van Klink & van den Berg, 1998; Alix et al., 1999; McCalla, 1999; Cullinane & Khanna, 2000; Cullinane et al., 2012], and container port development in different parts of the world [Slack, 1990; Todd, 1990; Heaver, 1993; Comtois, 1994; Notteboom, 1997; Rimmer, 1998; Wang, 1998; Jauernig & Roe, 2000; Woodburn, 2001; Barros & Athanassiou, 2004; Hess & Rodrigue, 2004; Song & Yeo, 2004; Notteboom & Rodrigue, 2005; Baird, 2006; Notteboom & Rodrigue, 2008; Rodrigue et al., 2013]. The port, being an interface of land and sea transport, has been conceptualised as the first and most fundamental anchorage point for colonial powers to control the developing world. It was only at later stages that lateral interconnections and inland nodes were developed.

Planning for global logistics management centres implies a demand for good quality logistics services. Major enterprises assume the greatest competitive advantage when they are appropriately supported through key value-added logistics activities. Short-term challenges to intermodal links in container ports need to be overcome to approach the long-term vision of establishing port intermodal transport systems and appropriate management. Many countries seek to have a global logistics management centre, since it is assumed to boost trading activities with other countries. Poor logistics support is one of the major reasons for the failure to attract foreign investors. Many actors in the supply chain have responded by providing value-added services in an integrated logistics package, and many container lines have transformed themselves into logistics management organizations. Logistics has the potential to become the next governing element of strategy as an inventive way of creating value for customers, a source of savings, and an important discipline in providing production flexibility. The fact that a growing number of ocean carriers expand their role by controlling the total logistics chain including inland transport, storage and distribution implies that the criteria for port selection are related to the entire transportation journey and thus no longer restricted to maritime transport alone. Under these circumstances, carriers choose a network in which the port is merely one node, though an important one. Consequently, if a seaport does not succeed in attracting some of the carriers, it will be exposed to high risk of substantial loss of container traffic. There are two distribution strategies in a priority hierarchical process during which strategic operating alternatives are evaluated to determine the most cost-effective way of providing the required service level. They are optimal size and the number of transportation facilities. The fundamental decisions forming the basis of logistics system planning are inventory policy, facility location and transport routing. These developments force ports to make every effort to be competitive in terms of cost and quality of services and to develop the port area into a logistics park and distribution service centre. Logistics is marketing oriented and it plays a key role in satisfying the companies' customers, and achieving a profit for enterprises. The expanding literature on intermodalism in developed countries stresses the importance of the process to their economies, and knowledge of their intermodal transport systems is useful in attracting international investors.

The purpose of this paper is to present the design of research methods involved in the success strategies for intermodal transport system of container port in Taiwan. Thus, this research has developed a multiple criteria decision-making model to address the problem. We concluded that Analytic Hierarchy Process (AHP) is the most suitable method for this research problem, thereby determining the selection criteria and their relative weights. This multiple criteria decision-making technique by using AHP has the capability to elicit expert judgment and provide consistent feedback to decision-makers. This process should have precise criteria that cover all aspects of the process. This research, by contrast, aimed to establish general criteria which could meet the different needs of each project and/or country. And given the capability of the "Expert Choice" software, the decision-makers can suspend any criteria which do not comply with their needs and can select the most suitable weight for each criterion. The criteria developed by this research should help to enable clear and fair evaluation, which will help achieve a win-win outcome for both private and public interests.

The generation of criteria is the most critical and time consuming. It starts with the national development goals from where more specific sector objectives can be derived. The specification of these goals is a first step to give the decision criteria a more operational meaning. The relevant goals and objectives are arranged in a hierarchy. The real contributions of the research activities to the objectives are subject to considerable uncertainty inherent in the research process and the diffusion of the results. The degree of uncertainty depends on the constraints imposed by the available resources and the prevailing conditions of the research system and the related environment. Consequently, additional criteria have to be considered in order to take into account the determinants of uncertainty. The generation of criteria results in an initial list of possible criteria. Any evaluation of transportation planning activities has to address the areas of national concern. They can be expressed in terms of national development goals. The goals provide the foundation for addressing public decision problems. Therefore, they are the logical point of departure for the development of decision criteria. National development goals can be broadly defined as economic growth, balanced social development, and efficient and effective public institutions. The public sector becomes more demand-oriented by bringing the user's perspective into the picture. Various methodological approaches have been developed to involve user's perspective into the process. In order to test the developed survey results and analyses the research findings. We focus on the survey assessment of results as well as on methodological aspects. In this paper, the data of evaluation are examined for the weighting value and validity test of the overall criteria by use a questionnaire survey from different groups in Taiwan. The research measures the weighting value and validity of the overall strategies and the test shows that the overall strategies have

highly reliability validity. More generally, its relevance and practicability to tackle real-world decision problems, particularly regarding group decision-making is to be examined. Having obtained a good understanding of the data acquired, this section aims to test design model developed for the research. The participants' perceptions are analysed by performing cross-tabulations together with the statistical techniques of factor analysis in order to analyse the relationship between the service purchase behaviour and the degree of satisfaction.

II. METHODS AND DATA COLLECTION

Data availability is critical part in every decision-making exercise. It will influence the choice of the most appropriate method and define the degree of detail and accuracy of the decision process. In a group setting, the number of participating experts is limited to ensure the practicability of the process. The context of the exercise is briefly described followed by a discussion on the six hierarchical levels. As mentioned earlier, the procedure is based on the AHP. The resulting list and its hierarchical structure presented in Figure 1 and Table 1. The list is divided into six hierarchies: goal, corporate objectives, criteria, sub-criteria, alternative activity and strategies. However, because of the importance of this element it was agreed to consider it as far as possible in the context of the distribution between expert groups. We will briefly discuss the indicators used in the hierarchy of potential impact to give an idea on how the criteria were worked, what information was required, and what concessions had to be made in practice.

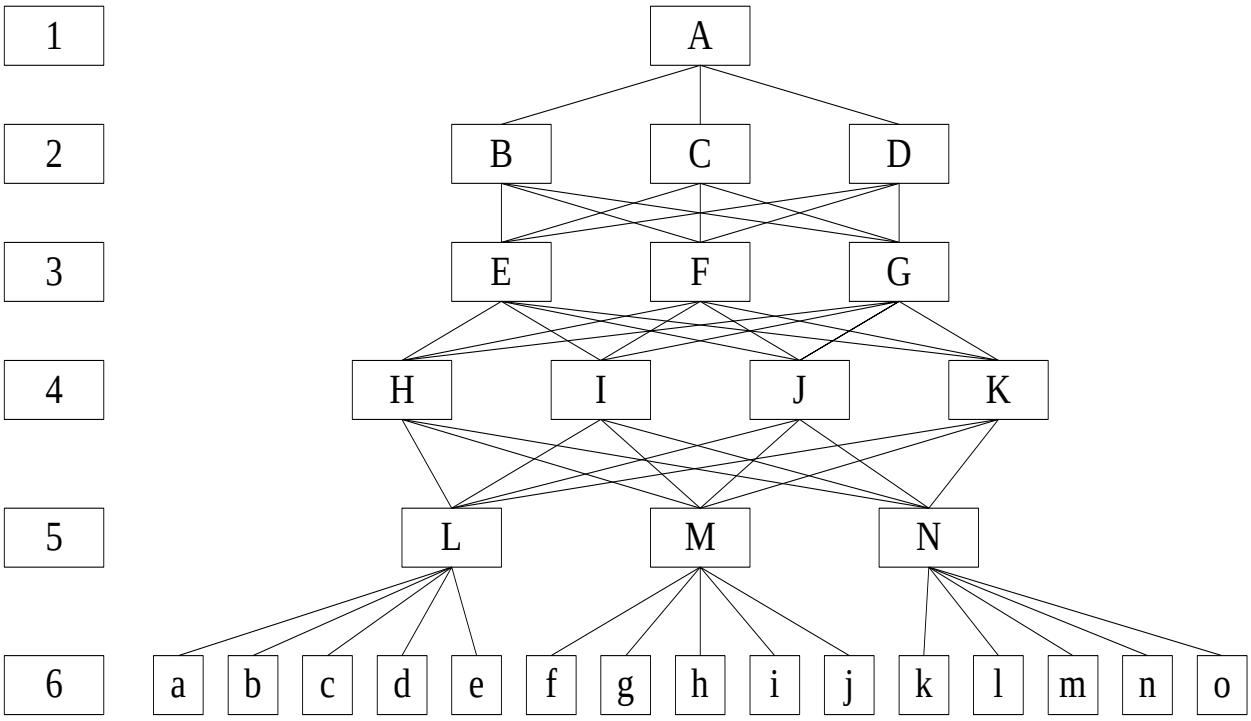

Figure 1: Intermodal Transport System Planning Structure of Container Ports

This research has been enhanced and has resulted in the development of a multiple objective decision model for the intermodal transportation system which can help participants to make trade-offs among a variety of objectives and incorporate the uncertainty into the decision making process. In particular, the following results have been achieved according to the review of the relevant literature in this area has been conducted. A results analysis based on experimental design methodology was performed to evaluate the influence of the model factors on the decision results. During the first stage, the defining decision criteria are identified in the form of a hierarchy of objectives or general criteria. Typically, this entails having clearly defined primary goals. The evaluation criteria that influence each of the general criteria are placed at the next level of the hierarchy and the sub-criteria related to the second level are placed at the tertiary level. During the second stage of the analysis, paired comparisons are made at each level of the hierarchy, giving value judgments and establishing priorities among the elements within each level of the hierarchy. The third stage involves a paired comparison of the chosen alternatives with each of the sub-criteria. As we explained the problem is identified and the decision's goal and evaluation criteria recognized, and the decision can be structured as a hierarchy.

Table 1: Hierarchical Structure List

1. Goal:	A. Selection intermodal transport system
2. Corporate objectives:	B. Market share
	C. Logistics process
	D. Diversification
3. Criteria:	E. Reliability
	F. Flexibility
	G. Strategic compatibility
4. Sub-criteria:	H. Location convenience
	I. Access to infrastructure development
	J. Access to finance
	K. Integrated transportation
5. Alternative activity:	L. Port service
	M. Marketing
	N. Logistics
6. Strategies:	
	a. Improve quality of port management
	b. Improve service of the people who assign in-port operations
	c. Improve efficiency of loading and discharging
	d. Establish service system of ship berthing
	e. Increase management of berth scheduling
	f. Industrialize port management
	g. Establish national trade centre
	h. Develop recreation area
	i. Decrease port expense
	j. Develop tourism
	k. Simplify management of customs
	l. Format intermodal links
	m. Improve the system of transportation for exterior
	n. Set up the port flow area
	o. Establish check area for container depot

Transportation planning project selection is of critical importance in terms of achieving high customer service level, cost savings and efficiency in the overall supply chain. On the other hand, providers of transportation services have been interested in finding out the salient freight transport selection factors in order to be competitive within freight transport market. These facts have directed the attention of transport and logistics researchers towards the problem of freight transportation selection as a result of this many empirical researches and reviews have been realised. The questionnaires in this research are carried out two parts. The first one focuses on acquiring the weighting values of the selection factors in five levels categories. The second questionnaire aims to test the reliability effectiveness for the strategies in this research. The questionnaires were mailed with a cover letter to the participants. The participants were asked to indicate their perceptions. According to the AHP level structure design, the questionnaire used in this study was generalized into five levels: the goal, the corporate objectives, the criteria, the sub-criteria and the alternative activity. Based on the AHP analysis, the variables were compared in pairs. The relative importance between two variables, from low to high, hence was ranked into five ranks: the number (1) for equal importance, (3) for slightly important, (5) for very important, (7) for extremely important, and (9) for absolutely important. And, there are rank (2), (4), (6), and (8) in between each ranks accordingly. Also the second questionnaires were asked to indicate their perceptions on each of these strategies according to a five-point Likert scale. The scale for each factor ranged from 1 = Least important to 5 = Most important. A stamped envelope was also sent for easy returning of the completed questionnaire. A total of 45 participants included 15 container carriers, 12 port operators and 18 academic experts responded to the questionnaire. Since 9 responses were not useable due to incomplete data, giving a response rate of 80 per cent to 36 responses were utilized for the study.

III. RESULTS OF THE SURVEY ANALYSIS

Firstly, the results of AHP measurement in the each level shown as Table 2. Secondly, the technique of factor analysis was utilized the number of variables to meaningful factors, each representing separately identifiable characteristics that could be considered as a set of principal components or determinants of success in shippers. The use of factor analysis has the function for descriptive statistics to collect the data matrices, and detect the presence of meaningful patterns among a set of variables.

Table 2: AHP Weighted Values

Factors		Weighted Values			Ranking		
		Carriers	Port Operators	Academic Experts	Carriers	Port Operators	Academic Experts
2	B	0.295	0.295	0.286	3	2	2
	C	0.394	0.423	0.575	1	1	1
	D	0.311	0.281	0.140	2	3	3
3	E	0.213	0.178	0.286	3	3	2
	F	0.484	0.587	0.449	1	1	1
	G	0.303	0.235	0.264	2	2	3
4	H	0.255	0.321	0.313	2	2	2
	I	0.280	0.148	0.424	1	4	1
	J	0.194	0.197	0.185	4	3	3
	K	0.280	0.334	0.078	3	1	4
5	L	0.372	0.437	0.509	1	1	1
	M	0.264	0.209	0.262	3	3	2
	N	0.364	0.354	0.229	2	2	3

The correlation matrix produced by SPSS software showed a considerable number of correlations exceeding 0.3. Furthermore, the anti-image correlation matrix revealed that all of the measures of sampling adequacy were well above the acceptable level of 0.5, confirming the suitability of our data for a factor analysis. The descriptive statistics were used for ranking the alternative activities in their order of importance. The original 15 variable strategies were analysed by the principle component factor analysis, a three factors solution with an eigen-value of ≥ 1. The analysis of the remaining 15 variables strategies yielded three significant factors in which explained 61.1 per cent of the total variance. These three factors indicated the different alternative activities and the 15 strategies variables loaded against each along with the relevant statistical values are given in Table 3.

Table 3: Principal Components Factor Analysis

Variables (Strategies)	Factor 1	Factor 2	Factor 3
a. Improve quality of port management	0.728		
b. Improve service of the people who assign in-port operations	0.708		
c. Improve efficiency of loading and discharging	0.703		
d. Establish service system of ship berthing	0.702		
e. Increase management of berth scheduling	0.657		
f. Industrialise port management		0.533	
g. Establish national trade area		0.507	
h. Develop recreation area		0.761	
i. Decrease port expense		0.731	
j. Develop tourism		0.614	
k. Simplify management of customs			0.569
l. Format intermodal links			0.786
m. Improve the system of transportation for exterior			0.758
n. Set up the port flow area			0.472
o. Establish check area for container depot			0.450
Eigen-value	3.99	2.88	2.66
Proportion of Variance explained	24.4%	19.3%	17.4%
Cumulative Variance Explained	24.4%	43.7%	61.1%
Alpha (α)	0.85	0.75	0.77

These factors were also considered satisfactory according to the reliability test of Cronbach's alpha with a value greater than 0.6. The literature on factor analysis shows that loadings equal to or greater than 0.40 are considered large enough to warrant interpretation. The ranking of sustainable strategies by the order of their importance with mean and standard deviation are also showing in Table 4.

Table 4: Sustainable Strategies for Intermodal Transport Systems

Sustainable Strategies	Ranking	Mean	Standard Deviation
Improve efficiency of loading and discharging	1	4.64	0.44
Improve quality of port management	2	3.99	0.47
Decrease port expense	3	3.92	0.63
Simplify management of customs	4	3.90	0.53
Improve service of the people who assign in-port operations	5	3.80	0.55
Industrialise port management	6	3.75	0.77
Format intermodal links	7	3.58	0.77
Improve the system of transportation for exterior	8	3.50	0.77
Establish service system of ship berthing	9	3.48	0.93
Develop recreation area	10	3.39	0.87
Increase management of berth scheduling	11	3.37	0.87
Establish check area for container depot	12	3.35	0.86
Develop tourism	13	3.07	0.72
Set up the port flow area	14	2.74	0.79
Establish national trade area	15	2.64	0.90

IV. RESULTS FINDINGS FOR STRATEGIES

The Cronbach's alpha coefficients (α) of the selection criteria construct for shippers' value from 0.85 to 0.77 in three factors group that indicates the reliability with high internal consistency of the construct. The survey results indicated some significant differences between the three groups of shippers in respect of three factors:

Factor 1: Port Service

- Improve quality of port management
- Improve service of the people who assign in-port operations
- Improve efficiency of loading and discharging
- Establish service system of ship berthing.
- Industrialize port management

Factor 2: Marketing

- Establish national trade centre
- Develop recreation area
- Decrease port expense
- Develop tourism
- Increase management of berth scheduling

Factor 3: Logistics

- Simplify management of customs
- Format intermodal links
- Improve the system of transportation for exterior
- Set up the port flow area
- Establish check area for container depot

Overall mean scores and standard deviations are ranked in order from highest importance to lowest importance in Table 6. 'Improve efficiency of loading and discharging'(μ=4.64), 'Improve quality of port

management'(μ=3.99), 'Decrease port expense' (μ=3.921) 'Simplify management of customs' (μ=3.90) and 'Improve service of the people who assign in-port operations'(μ=3.801) were determined as the most important top five development strategies of intermodal transport system selection criteria with respect to the perceptions of shippers' respondents. Factor analysis and principal components analysis was applied for the determination of the main components of development strategies of intermodal transport system selection criteria. Table 4 reveals the three sets of factors obtained through the factor analysis of the strategies variable concerning the selection criteria. These factor analysis results are stated as follows:

Factor 1: Port Service

This factor was represented by 5 variables with factor loadings ranging form 0.728 to 0.657 (Cronbach's alpha = 0.85).

Factor 2: Marketing

Five variables with loadings ranging from 0.761 to 0.533 (Cronbach's alpha =0 .75).

Factor 3: Logistics

This factor comprised five variables with loading ranging from 0.786 to 0.450 (Cronbach's alpha = 0.77).

V. CONCLUSION

The results of the factor analysis show a set of three separately identifiable alternative activities factors that have positive and significant impact on the sustainable strategies of intermodal transport systems in Taiwan. The empirical results present that there exist significant differences, especially regarding three alternative activities factors: "port service", "marketing" and "logistics". Firstly, "port service" activity gives more weights on efficiency and quality for port operation. In addition, logistics operation factor such as management of customs, intermodal links, accessibility to port, is not seriously considered. These findings indicate that container port operators should put more considerable importance on "port service", while shippers have the specific interest in these factors [Loo, 1999]. In addition, the current study shows that shippers and liners possess similar perspective for the importance of container operations in port, which is not much highly considered by terminal operators. Therefore, it is recommended that terminal operators make more efforts to reinforce their capabilities accommodating and supporting liners' operations and strategies in order to obtain and maintain their competitive advantage and position. It has been a long controversial argument that who has more influential power in the choice of the import/export and transshipment ports between carriers and shippers. For instance, Slack argued that liners are the most significant actor in the development strategies of the port. According to D'Este & Meyrick (1992), a port selection shifted from the shipper to the carriers since the shipping lines grew larger in their scale of operations. It takes a similar view of Hayuth, Hayuth & Fleming (1994), and Malchow & Kanafani (2001; 2004). On the contrary, Tiwary et al., (2003) argues that shippers have become possessing stronger bargaining and/or influencing power against shipping lines and over liners' service design. According to them, the organization of global strategic alliances of shipping lines has redesigned liner service routes in response to economic growth and shippers' needs. These arguments can be compromised by the finding of a recent research that shipping lines select their calling ports directly considering shippers' requirements and shippers realise their preference for a port by the choice of a line providing service route passing through that port [Woodburn, 2001].

In conclusion, ports, particularly container terminal operators, should focus their attention on the "port service" factors on which shippers and liners are commonly placing high priorities, when the terminal operators formulate, implement and evaluate their terminal management policy and operating strategy, as well as marketing plan. The current study mainly concentrated on different perspectives and priorities about port sustainable strategies factors among shippers, carriers and terminal operators. It will be a meaningful future study to test the explanation power of the port choice factors and real influences of major market players on container port development strategies factors. For instance, it would be possible to collect the scores of various container terminals for each port sustainable strategies factors and run a regression model examining the influences of these factors upon ports' market share and/or throughputs. In addition, a structural equation modeling could be employed to explore some direct and indirect relationships among port selection factors and port operational indices in further research.

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