

## INTEGRATION OF THE AHP AND SWOT ANALYSIS FOR PORT COMPETITION EVALUATION IN THE EASTERN ASIAN REGION

\*Wen-Chih HUANG, \*\*Junn-Yuan TENG, \*Miin-Jye HUANG and \*Sheng-Chieh WU

\*Dept. of Harbor and River Engineering, National Taiwan Ocean University  
P. O. Box 7-107 Keelung, 202, Taiwan.

\*\*Dept. of Industrial Management, Huaan University  
Shihdin Hsiang Taipei County, 223, Taiwan

\*huangwc@ntou66.ntou.edu.tw / \*\*jyteng@huaan.hfu.edu.tw

**Abstract:** This paper proposes an evaluation model to evaluate the competition among international ports in the Eastern Asian Region. The proposed model is combination of Analytic Hierarchy Process and SWOT analysis to evaluate competitive ports. The evaluation hierarchical structure of port competition is composed of eight levels. At the third level, we combine SWOT into the evaluation system. Strengths and weaknesses are internal environments. Opportunities and threats are external environments. There are eleven evaluation criteria are considered in the model, and each of criterion has one or more sub-criterion. There are eight competitive ports as Keelung, Taichung, Kaohsiung, Kobe, Hong Kong, Shanghai, Pusan and Singapore are considered. According to the results of AHP questionnaire survey and the evaluation method put forward in this paper can be utilized to conduct the comparison of the outranking of these eight competitive ports.

### Introduction

Competition is a terminology of economics, it appears in many papers, books and reports. These literatures could be classified into two levels. At the business operation level, business competition dominance is discussed. Where, some talk about individual industry and business global competition. They emphasize that businesses must improve their quality of management and strategy (Tang *et al*, 1995), cost and quality (Hamel *et al*, 1988), and methods to maintain a competitive advantage (Rothschild, 1984). Some discuss the core competence of businesses (Hamel *et al*, 1994). Core competence, submitted by Hamel in 1990, is applied to the study of market share and market position. Others study the competitive strategies of industry, country and cooperation (see Hood, 1988). The above-mentioned literature starts from the viewpoint of business competition. On the country level, some literature discuss international trade and fair trade for multinational business (see OECD, 1984). Porter's publication, *Competition Advantages of nations*, discusses the competition of nations and business from ten competitive countries (1990). When it comes to the assessment of countries competitiveness, we all know *The Competitiveness Yearbook* published by the International Institute for Management Development. To take the 1997 yearbook (IMD, 1997) for example, it considers domestic economy, internationalization, government, finance, infrastructure, management, science and technology, and people as the eight factors of competitiveness. These factors include 244 criteria (indicators). The indicator data consists of soft data and hard data. There are 84 items of soft data, compiled through a questionnaire survey of 2515 businessmen, and 160 items of hard data collected from official and non-official statistics over 46 countries and areas. A scoring method was used to calculate performance and ranks. The characteristics of multiple criteria, qualitative and quantitative are among these items.

SWOT analysis considers the strengths, weaknesses, opportunities, and threats as evaluation factors. Strengths and weaknesses are internal environments, while opportunities and threats are the external environments. The SWOT matrix includes four groups of factors: SO, ST, WO, and WT. According to the SWOT matrix, one could propose a future strategy. SWOT is generally used in situational analysis (see Wehrich, 1980). No quantitative data analysis is included. The local studies on port competition analysis applied the SWOT method to generate developing strategies (Keelung Harbor, 1998; Taichung Harbor,

1998; Kaohsiung Harbor, 1998; Lin, 1998). These studies consider the strengths, weaknesses, opportunities, and threats as four objectives individually and then derive some criteria. The criteria were quite different between the two ports. For example, the location of a port could be the strength for one port, but could be the weakness for another. SWOT analysis cannot express the degree of importance among the four factors and criteria or indicators under these factors. One cannot compare the dominance of these ports. This is the disadvantage of SWOT analysis.

Many studies have used AHP in transportation projects. Saaty (1988) formulated the AHP model to select Keelung, Taichung, and Kaohsiung harbors in Taiwan. Sharp (1987) applied AHP in the hauler selection. Bagchi (1989) used it to construct maritime carrier selection model. The local Institute of Transportation (1998) used it to evaluate the competition of international airports. The AHP method is a relatively young theory. Some of the topics on which researches concentrate are; economic/ management problems, political problems, social problems and technological problems (Vargas, 1990). AHP can deal with a variety of problems (Saaty, 1980) and combine the qualitative and quantitative criteria (Wedley, 1990). For competition problems, AHP can deal with predictions on behavior in chess (Saaty *et al*, 1980), portfolios in competition (Lauro *et al*, 1986), and competition dominance in businesses (Tang *et al*, 1995). The characteristics of port competition are as follows: (1) multiple criteria and indicators, (2) hierarchical evaluation criteria, (3) combining qualitative and quantitative criteria, (4) covering positive (effectiveness, strength, and opportunity) factors and negative (cost, weakness, and threat) factors, and (5) reflecting weights of criteria. Essentially, ports competition is a topic of multi-criteria decision-making problem, rather than a single objective problem.

In order to prevent the disadvantages of SWOT analysis and make use of AHP, this study applied the ideas of SWOT and integrated AHP together. The evaluation criteria are divided into two groups. Hardware and software facilities, operational efficiency, port management style, service charge, comprehensive plan, development style, and so on are internal factors under the strength and weakness factors. Political/economic stability and economic productivity of hinterland are external factors under the opportunity and threat factors.

### **Outline of Port Competition Hierarchical Analytic Structure**

This paper applies SWOT concept integrated in AHP hierarchy structure as analytic model. Strengths, weaknesses, opportunities, threats of SWOT as four factors are merged in the hierarchy structure. The method of design of hierarchy can refer to Vargas' paper (1990). Hierarchy design involves three interrelated processes: level and element identification, concept definition, and question formulation. The analysis process in this case is the same as Vargas, and describes as follow:

#### **1. Construct Hierarchical Analytic Structure**

The hierarchical structure involves eight levels; overall objective, environments, factors, concerns, goals, criteria, sub-criteria, and competitive ports (Figure 1.). Where, internal environment involves two factors and links to the three individual concerns. Two factors are strengths and weaknesses, and the three concerns are manpower, organization, and physical facilities. External environment involves opportunities, threats two factors, and politic, society, economy, and links to the four finance concerns.

#### **2. Select Criteria**

##### **(1) Factors that affect port competition**

The measurement of port operational performance has to be considered from the following three viewpoints: A. comparison among container terminals or berths in the same port, B. analysis of operational performance and competition among ports within an area and a country, C. analysis of competition among international ports. Comparisons among different container terminals or berths belong to the operational performance measurement, i.e. operational efficiency. When discussing competition analysis among domestic or international ports, we must consider both the operational efficiency and total

economical effectiveness of the ports contributing to the area and assessing the goal achievement. Competition analysis of international ports, this study is based on inter-port competition.

Maritime carriers are the customers of ports. Carriers create their maximum benefit by selecting suitable ports. To judge if ports are competitive, the factors carriers consider are as follows (Evergreen, 1998): A. size of hinterland and cargo source of ports, B. wharf hardware and software, C. national situation of ports, D. port operational strategies, E. laws and regulations. From the logistics operators' point of view, the factors they consider for selecting a transfer and distribution base are as follows: A. operational cost, B. just in time, C. Ship schedule and network density, High efficient processes. To sum up, cost and efficiency are mutual consideration of carriers and logistics operators.

#### (2) Category of evaluation indicators

There are several studies on the evaluation indicators of ports (Hsieh, 1995; Chen, 1993; Ho, 1983; Ni, 1993; Huang, 1997; Hsu, 1996). Moreover, Huang (1997) separated these indicators into two parts: efficiency and effectiveness. Effectiveness indicators involve the degree of congestion, ships' waiting time in port (without cost consideration), total cost, and IND (with cost consideration). Efficiency indicators include two parts: ship/berth indicators and container terminal indicators. The details are average service time for ships, ship average loading and discharge time, and ship average waiting time, container loading and discharge machine operational efficiency, container claim rate, terminal land use efficiency, movement capacity, and container process capacity.

#### (3) Select competition evaluation criteria

After taking several rules into consideration, such as: the comparison basis, quantification, and degree of difficulty, unification, and so on. This paper proposes eleven goals and thirty-one criteria or sub-criteria under seven concerns (see Figure 1.).

### 3. Question Formulation and Questionnaire Survey

This paper considered some issues in the question formulation phase: A. paired comparison for each level of factors and criteria. B. Scale of performance for each criteria; quantitative data are from official and non-official statistic, and measurement of non-quantitative criteria are questionnaire survey judged subjectively by experts. All questions should be answerable and consistent with the existing information (Vargas, 1990). C. Supply hierarchic structure chart and detail instructions of criteria. D. Provide experts with background information on competitive ports.

### 4. Hierarchy Evaluation

This step involves computing the total score for each port. The criteria weights, that is the representation of experts' preference, and port performance have been surveyed and collected. Then, except for AHP, the synthesis process could use many methods to produce the final score for each port. For example, Simple Additive Weighting (SAW) method, and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), and so on. According to the total score for each port, we can compare and produce the order of the ports.

### Numerical Example

This paper selects Keelung, Taichung, Kaohsiung, Kobe, Hong Kong, Shanghai, Pusan, and Singapore, the eight Eastern Asian Region ports as a numerical example. The numerical example is used to demonstrate the computational process of the proposed model proposed.

*Step 1.* construct hierarchical analytic structure: The structure involves eight levels, and thirty-one evaluation criteria (Figure 1.).

*Step 2.* select criteria: The criteria include efficiency and effectiveness groups, a total of thirty-one items (Table 1.).

*Step 3*. questionnaire survey: We received ten questionnaires from officials, experts, and carrier leaders.

*Step 4*. evaluation: This paper computes the weight of the items in each level, including eight ports in the Eastern Asian Region. The order of the ports using SAW are as follows: high competition- Singapore (0.42919), Hong Kong (0.40022), middle competition Kaohsiung (0.35064), Kobe (0.33724), low competition- Taichung(0.29293), Pusan(0.28874), Keelung(0.28850), and Shanghai(0.27064). From concerns' viewpoints, the order is organization (0.332), physical facilities (0.196), economy (0.124), manpower(0.102), and finance(0.099). Politic (0.088), society (0.058). From factor's viewpoints, the order is strengths (0.455), opportunities (0.247), weaknesses (0.175) and threats(0.123) (see Table 1).

### Conclusions

1. Discussions of competition dominance have appeared primarily in the strategic management field.
2. Indicators of port competition involve efficiency and effectiveness. Effectiveness covers cost factors, and is more sensitive to carriers.
3. The AHP method makes problems systemized and structured. Strength, Weakness, Opportunity, and Threat are the four factors that merge in the AHP hierarchy. The experts can reach concordance through questionnaire survey.
4. Qualitative data are collected through questionnaire surveys under a certain score, for example 1-5. Quantitative data maintains the original scale. After normalization, the performance can be put into a computation process together with the qualitative data.
5. The final orders of the ports are as follows: high competition- Singapore, Hong Kong, middle competition- Kaohsiung, Kobe, low competition- Keelung, Taichung, Pusan, and Shanghai.
6. From concerns' viewpoints, the order is as follow: organization, physical facility, economy, manpower, politic, finances, society. From factor's viewpoints, the order is strengths, opportunities, weaknesses and threats.

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Table 1. Weight of criteria and final score of ports

Objective (Wgt)	Environment (Wgt)	Factors (Weight)	Concerns (Weight)	Goals (Weight)	Criteria (Weight)	Sub-criteria (Weight)	Ports (Score)						
Evaluation of port competition (1.000)	A. Internal environment (.630)	C. Strength (.455)	G. Manpower (.102)	1. Labor quality (.102)	I. Operational style (.069)	2. Impact of custom service (.031)	Keelung (28850)*						
			H. Organization (.332)	N. Operational style & Cost (.151)			3. Operational efficiency (.025)	Taichung (0.29293)*					
			D. Weakness (.175)	I. Physical facilities (.075)			P. Location of port & cargo source of hinterland (.075)	V. Transportation system (.016)	5. Operation cost of carrier (.043)	Kaohsiung (0.35064)**			
									6. Port service charge (.039)	Hong Kong (0.40022)***			
									7. Ship mean time in port (.078)	Shanghai (0.27063)*			
									8. Loading & discharging ratio (.057)				
		9. Terminal movement capability ratio (.045)	Pusan (0.28874)*										
		10. Location of port (.012)		Kobe (0.33724)**									
		11. Sailing points (.011)			Singapore (0.42919)***								
		12. Schedule (.010)											
		13. Inbound/outbound (.028)											
		14. Transshipment ratio (.015)											
	15. Rail/highway (.012)												
	B. External environment (.370)	E. Opportunity (.247)	J. Political stability (.088)	27. Political stability (.088)		VI. Port facilities (.034)	16. Sea/river transport (.004)	17. No. of deep wharf (-14m) (.018)	18. Machinery (.007)				
					K. Society (.058)					28. Social stability (.058)	VII. Information system (.013)	19. Operation land for container (.009)	20. Container automation (.005)
		M. Finance (.099)	30. Economic stability (.056)	23. Land of warehouse/logistics (.024)		24. Investment plan (.014)							
					31. Financial stability (.099)		IX. Development style (.019)	25. Investor of port (.010)	26. Operator of port (.009)				
										F. Threat (.123)	O. Economic (.124)	30. Economic stability (.056)	31. Financial stability (.099)
	P. Political stability (.088)	27. Political stability (.088)	31. Financial stability (.099)										

Source: This paper surveys and calculates. Note: \*\*\* indicates high competition, \*\* middle competition, \* low competition.

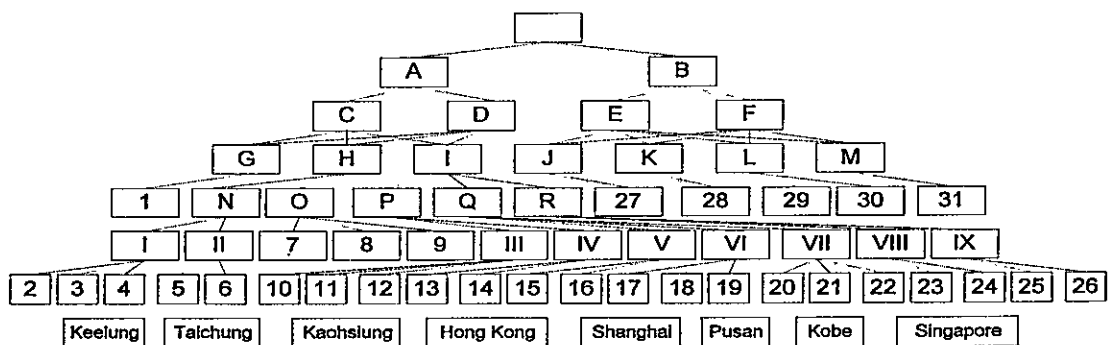


Figure 1 Hierarchy Structure

Note: A, B, C..... please refer to Table 1.