Journal of Marine Science and Technology

Volume 15 | Issue 3 Article 4

ANALYZING THE COMPETITIVE RELATIONS AMONG THE LOCATION IN THE ASIA-PACIFIC REGION FOR DEVELOPING THE RE-EXPORT TYPE OF GLOBAL LOGISTICS HUB

Kuo-Liang Lee
Associate Professor, Dept. of Marketing and Distribution Management, Overseas Chinese Institute of Technology, Taichung, Taiwan 407, R.O.C., lee.kl@ocit.edu.tw

Recommended Citation

Lee, Kuo-Liang (2007) "ANALYZING THE COMPETITIVE RELATIONS AMONG THE LOCATION IN THE ASIA-PACIFIC REGION FOR DEVELOPING THE RE-EXPORT TYPE OF GLOBAL LOGISTICS HUB," *Journal of Marine Science and Technology*: Vol. 15: Iss. 3, Article 4.
DOI: 10.51400/2709-6998.2392
Available at: https://jmstt.ntou.edu.tw/journal/vol15/iss3/4

ANALYZING THE COMPETITIVE RELATIONS AMONG THE LOCATION IN THE ASIA-PACIFIC REGION FOR DEVELOPING THE RE-EXPORT TYPE OF GLOBAL LOGISTICS HUB

Kuo-Liang Lee*

Key words: global logistics hub, quantitative SWOT, AHP, fuzzy theory, competitive relation, Grand Strategy Matrix, competing strategies.

ABSTRACT

This research empirically investigates competitive relations among locations developing the re-export type of global logistics hubs (GLH) in the Asia-Pacific region from the perspective of logistics service providers. A quantitative SWOT analytical procedure that integrates the AHP method and the fuzzy theory of graded mean integration representations was utilized to empirically evaluate the Multiple Criteria Decision Making (MCDM) problem. Respondents located Shenzhen, Busan and Kaohsiung locate in the SO quadrant and Shanghai, HK and Singapore in the WT quadrant. Shanghai could be expected to move into the leading group in the future. Finally, the concept of Grand Strategy Matrix (GSM) was used to suggest a suitable competitive strategy for location on particular competitive conditions.

INTRODUCTION

Modern commodities distribution has shifted from anticipatory logistics to a response-based logistics that focuses on predicting the final product demand. This emphasizes a quick response to customer demand. Logistics service providers (LSPs) and multinational corporations have thus decided to concentrate logistics functions such as warehousing, distribution, and reprocessing in a particular location, a global logistics hub (GLH). Such hubs have become increasingly important for LSPs and MNCs. Their location is of critical importance, not only in contributing to the efficient distribution of input/output cargos, but also in attracting MNCs and LSPs to distribute their commodities through the GLH [22, 23, 30].

In a logistics system, a GLH provides a place for firms to carry out functional activities, including transportation, storage, consolidation, assembly, inspecting, labeling, packing, financing, information, and R&D services, for varying periods of time [21, 27]. A number of governments have constructed or are planning GLHs to expand the capacity of existing industry and air/maritime transport infrastructure. Multifunctional logistics hubs have been established at major Asian port cities, including, Busan Logistics Park (Busan), Shanghai Waigaoqiao Bond Logistics Park (Shanghai), Kaohsiung Yes Logistics Zone (Taiwan), Schwartz Logistics hub (Shenzhen), Hong Kong International Distribution center (Hong Kong), and Kepple Distripark (Singapore).

From the viewpoint of MNCs, which both require and provide a variety of logistics functions, one challenging management issue for MNC managers is determining what types of logistics hubs should be established, along with where they should be located [24, 31]. In order to attract investment to stimulate their domestic economies, many port cities are planning or developing GLHs, and competition between them has significantly intensified. Each city has its own industrial, economic and transportation environment, resulting in the need for different types of GLHs. Hence, to develop a successful GLH and confront increasing competition, it is imperative that city administrators and planners properly understand the competitive position, or scenario, among market players from the perspective of MNCs, to gain competitive advantages in pitching GLHs to them.

Previous studies of GLHs have examined determinants affecting MNC evaluation of operations, logistics, distribution, and transshipment centers in specific regions. Previous research has generally selected several different candidate locations in specific regions and assessed their preference relations as the foundation for proposing relation strategies. Oum and Park [23] evaluated the location preference for regional distribution

Paper Submitted 03/22/06, Accepted 09/22/06. Author for Correspondence: K.L. Lee. E-mail :lee.kl@ocit.edu.tw.
**Associate Professor, Dept. of Marketing and Distribution Management, Overseas Chinese Institute of Technology, Taichung, Taiwan 407, R.O.C.*

centers focused on the Northeast Asian region. Tai and Huang [29] assessed hub port choice for container trunk lines in East Asia. Yeo and Song [33] looked at container ports in China and Korea. Lee *et al*. [18] also used port conditions to evaluate the efficiency of ports in the Asia-Pacific region. By analyzing these previous researches, it could be found that they selected several candidate locations in specific region to assess their preference relations (ranking orders) as the foundation and for proposing relation strategies depending on the location's ranking order and criteria. To our knowledge, however, there have been few empirical studies examining competitive relations (positions), which can show the location's position of strengths/weaknesses in internal environment and opportunities/threats in external environment, of GLH among the potentially competing locations so as to propose the suggestion strategies.

SWOT analytical method is very important in the process of strategy formulation [7, 11]. However, too often a SWOT analysis is merely a superficial and imprecise listing or an incomplete qualitative examination of internal and external criteria [16]. Quantitative analysis is one way of ameliorating these problems. David [11, 12] summarized various quantitative analysis methods for SWOT, including External Factor Evaluation Matrix (EFE) and Internal Factor Evaluation matrix (IFE). Kurttila [16] and Stewart *et al*. [28] combined the Analytic Hierarchy Process (AHP) with SWOT to create a new hybrid method for improving the usability of SWOT analysis. Although a consistency test is used to ensure the weight that was scored objectively by the evaluative group, to carry out SWOT analysis comparison on several enterprises simultaneously is difficult.

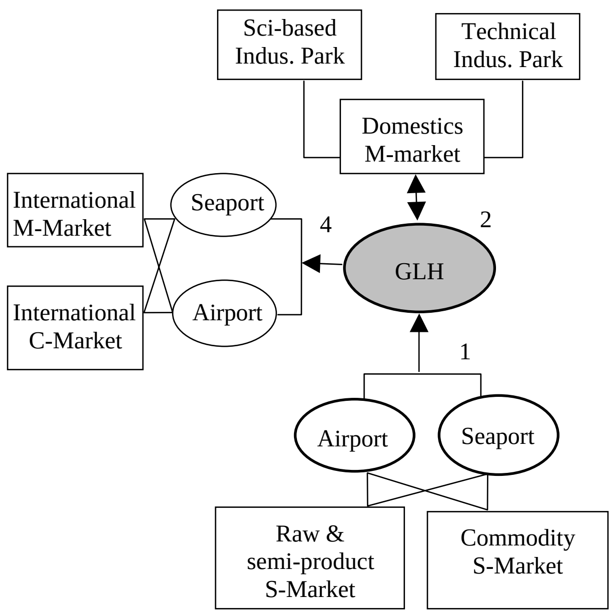
Previous studies have examined the determinants of operations, logistics, distribution, and transshipment center preferences in various regions [23, 29, 33, 17, 18, 20]. To our knowledge, however, there have been few empirical studies examining the competitive positions of GLHs in comparison to one another, with the goal of developing useful recommendations for GLH business strategy. This paper thus aims to evaluate the relative competitive position of GLHs using a quantified SWOT analytical method, for GLH location development in the Asia-Pacific region, from the perspective of Multi-National Corporations (MNCs) in Taiwan.

The GLH preference decision of MNCs is a multiple criteria decision-making (MCDM) problem. However, criteria and their relative weights differ from judge to judge. Further, criteria used in MCDM problems contain a mixture of quantitative and qualitative values. Under many conditions, the values for qualitative criteria are imprecisely defined - they are linguistic terms, or labels for groups of items or entities whose boundaries are often "fuzzy". Fuzzy set theory was developed to handle the fact that the key elements in human thinking are not numbers, but these fuzzy sets [34, 35].

This paper aims to empirically evaluate the competitive position, using a quantified SWOT analytical method, for location developing GLH in Pacific Asia region from the perspective of Multi-National Corporations (MNCs) in Taiwan. This paper is organized as follow. In Section 2, we identify GLH types from the viewpoint of international competition. In Section 3, a quantified SWOT analytical method, that integrates the concept of MCDM and the fuzzy theory of graded mean integration representations, is proposed to assess location competition among GLHs. An empirical study is then presented to discuss the competitive positions of GLHs in the Asia-Pacific region. Discussion and management implications are detailed in Section 4. Finally, the conclusions and findings are presented in section 5.

DEFINITION OF GLOBAL LOGISTICS HUB

By addressing inbound, operations, and outbound logistics activities [18], a GLH is defined as a location which integrates the operations of (see Figure 1): (1) the inbound side (including the international material & semi-product and production supply marketplace) and facilitates the purchasing of material, semi-product,



ILP: International Logistics Park
S-Market: Supply Market
M-Market: Manufacturing Market
C-Market:ConsumerMarket

Fig. 1. Activites of global logistics hub.

and product cargos; (2) an operation sides which integrates the environments of seaport, airport and domestic manufacturing marketplace to provide transportation, warehousing, reprocessing, and distribution; and (3) a demand side (including the international consumer and manufacturing marketplaces) that satisfies the requirement for a commodities consumption and cargo reprocessing.

Different locations offer a variety of competing conditions for development of a GLH. Based on modes of export and transshipment in international cargo flow, and the reprocessing functional activities, the reprocessing export (re-export) functional activity was proposed to define the GLH type. The distinctive operational features of this type (see Figure 1) are described below:

This type of GLH carries out reprocessing and transshipment of cargos from the raw & semi-product/ product supply marketplace “1” to the international manufacturing/consumer “4” marketplace after cargos reprocessing by the firms supporting the “4” marketplace. It provides transportation, warehousing, consolidation, reprocessing, and distribution services, with the participants being shipping or airline carriers, freight forwarders, hi-tech firms and customs brokers. In this type of GLH, a hi-tech industrial environment and port conditions are the key conditions, so few locations provide these functions in a specific region.

In response to the rapid development of global logistics, many locations have transformed the role of transshipment into re-export service [27]. In Taiwan, for example, foreign MNCs order information commodities from Original Equipment Manufacturers (OEM). These products consist of components imported from several international supply markets and key elements sourced from the domestic market in Taiwan. The activities of reprocessing and transshipment involved in OEM manufacturing create higher value-added services than transshipment alone.

METHODOLOGY

1. Target sample collection

This paper considers the activities of GLH and the key factors of transshipment, initial re-export, and deep re-export modes to extract the competitive indicators. We developed a structured questionnaire based on the seven stages outlined by [10]. The information to be sought was first specified, and then the following were determined: type of questionnaire and its method of administration, content of individual questions, form of response to and wordings of each question, sequence of questions, and physical characteristics of the questionnaire. The questionnaire was pretested and revised wherever necessary. The content validity of the questionnaire was tested through a theoretical review and pilot test. Questions in the questionnaire were based on previous studies and discussions with a number of logistics executives and experts.

The sample firms operate in a variety of industries including international manufacturing firms and logistics service providers. The eight-page questionnaire survey was sent to 300 managers of international manufacturers selected from the “List of Leading Firms in 2004 with Good Export and Import Performance” in Taiwan and 40 members of the Taiwan International Association. The revised questionnaire was sent to a manager in each of our target sample firms by ordinary mail, email or interview. After removal of invalid questionnaires, 79 remained, giving an effective return rate of 19.7%. The sample consists of 79 MNCs based in various industries (Table 1).

2. Evaluating method

In this section, the fuzzy quantified SWOT analytical method, which proposed by Chang and Huang [4], was utilized to evaluate the competitive position of a given GLH. The Analytic Hierarchy Process method was used to investigate the weights of evaluative criteria, while the graded mean integration representation of trapezoidal fuzzy numbers was used to assess the weighted score among competitive locations under linguistic environment.

(1) Quantified SWOT analytical method

The procedure of the quantified SWOT analytical method (see Figure 2) includes the following steps:

Step 1: Select candidate Asia-Pacific region location alternatives in competition with each other; for example, locations such as Hong Kong (HK) and Kaohsiung.

Table 1. Location of sample firms major Asian GLHs

Sample firms	Number of firms	Percentage of the sample
International manufacturing firms	33	41.8
Numbers of international logistics association	26	32.9
Shipping companies	6	7.6
Freight forwarders	14	17.7
Total	79	100%

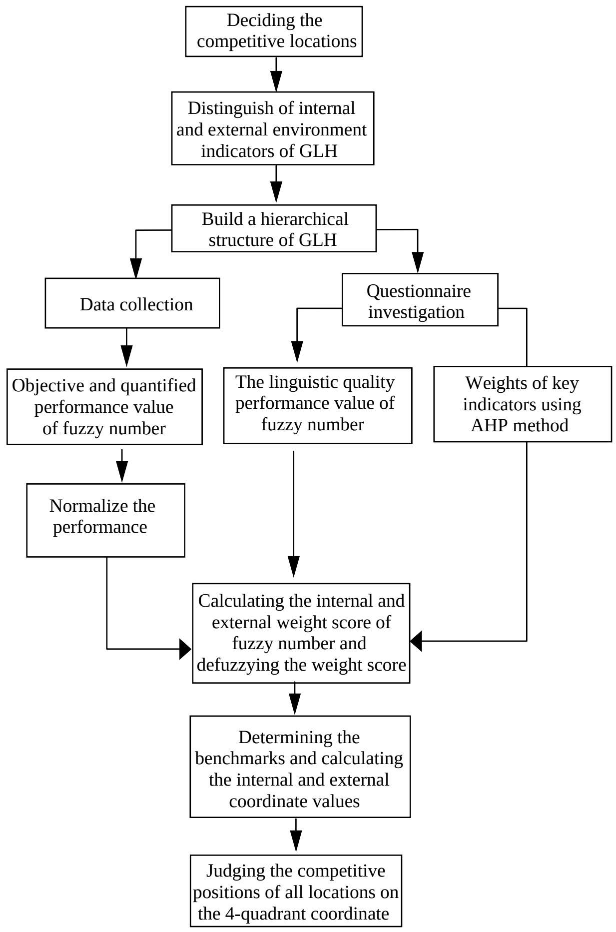


Fig. 2. Quantified SWOT procedures evaluating competitive position of GLH

Step 2: Distinguish between internal and external environmental criteria primarily based on the level of control GLH administrators and planners have over a specific criterion. Criteria under the control of the GLH itself are termed internal criteria, that cannot be completely controlled are called external criteria.

Step 3: Build a hierarchical structure of evaluation to examine the competitive position of candidate locations based on internal and external criteria.

Step 4: Collect data, read literatures to collect quantified performance measures for the candidate locations.

Step 5: A questionnaire investigation in 2 parts: the first being the weight of evaluative criteria (indicators) using the AHP method; the second, the linguistic quality performance of the candidate locations using trapezoidal fuzzy numbers.

Step 6: Normalize the performance values of the internal and external criteria. In order to analyze the quantified performance values of all evaluation criteria, normalization should be performed so that the performance values can be transformed into the dimensionless units so that the criteria can be compared with each other. We used the following normalization method:

$$\text{Effective criteria: } E_{ij} = \frac{P_{ij}}{Max_j(P_{ij})} \tag{1}$$

$$\text{Cost criteria: } E_{ij} = \frac{Min_j(P_{ij})}{(P_{ij})} \tag{2}$$

$$0 \le E_{ij} \le 1 \qquad \sum_j E_{ij} = 1$$

where P_{ij} and E_{ij} respectively represent the non-normalized and normalized performance value of the j^{th} location of the i^{th} evaluative criteria. The normalized performance value of "a" can be represented by the trapezoidal fuzzy number E_{ij} (a, a, a, a).

Step 7: Calculate the weighted score R_j of all locations (Table 2), by weight (w_i)* and fuzziness performance value E_j (c_j, a_j, b_j, d_j) then defuzzy the weight score using the graded mean integration representation method, as proposed by Chen and Hsieh [8].

Step 8: Determine the internal and external benchmarks with the following equations:

$$AI = \frac{I_1 + I_2 + \cdots + I_n}{n}, \quad j = 1, 2, \ldots\ldots n \tag{3}$$

$$AE = \frac{E_1 + E_2 + \cdots + E_n}{n}, \quad j = 1, 2, \ldots n \tag{4}$$

where AI and AE respectively represent the benchmark of the internal and environment evaluation, I_j and E_j respectively represent the weighted score of the j^{th} location's internal and external environment.

Step 9: Calculate and compare the coordinate values of internal and external assessment.

$$IS_j = I_j - AI_j, \quad j = 1, 2\ldots n \quad -1 \le IS \le +1 \tag{5}$$

$$ES_j = E_j - AE_j, \quad j = 1, 2\ldots n \quad -1 \le ES \le +1 \tag{6}$$

where IS_j represents the coordinate value of the j^{th} location's internal environment, and ES_j represents the coordinate value of the j^{th} location's external environment.

Step 10: Finally, all candidate locations are shown depicted in the 4-quadrant SWOT matrix to determine the competitive positions.

Table 2. The assessment of weighted score among competitive locations

Criteria	Weight	Unit	Locations (L_j) performance value			
(C_i)	(w_i)		L_1	L_2	- - - - -	L_n
C_1	w_1	Q	E_{11} (c_{11}, a_{11}, b_{11}, d_{11})	E_{12} (c_{12}, a_{12}, b_{12}, d_{12})	- - - - -	E_{1n} (c_{1m}, a_{1m}, b_{1m}, d_{1m})
C_2	w_2	N	E_{21} (a_{21}, a_{21}, a_{21}, a_{21})	E_{22} (a_{22}, a_{22}, b_{21}, a_{21})	- - - - -	E_{2n} (a_{2m}, a_{2m}, a_{2m}, a_{2m})
⋮	⋮	⋮	⋮	⋮	⋱	⋮
C_m	w_m	Q	E_{m1} (c_{m1}, a_{m1}, b_{m1}, d_{m1})	E_{m2} (c_{m2}, a_{m2}, b_{m2}, d_{m2})		E_{mn} (c_{mn}, a_{mn}, b_{mn}, d_{mn})
Weight score			E_1 (c_1, a_1, b_1, d_1)	E_2 (c_2, a_2, b_2, d_2)	- - - - -	E_n (c_n, a_n, b_n, d_n)
			R_1	R_2	- - - - -	R_n

Note: 1. Q: Quality; N: Quantity

2. Generalized trapezoidal fuzzy numbers $E_j\ (c_j, a_j, b_j, d_j) = \sum_{i=1}^{m} w_i \times E_{ij}$

3. Graded mean integration representation $R_j = \dfrac{c_j + 2a_j + 2b_j + d_j}{6}$

(2) AHP Method

The Analytic Hierarchy Process (AHP) method was initially proposed by Saaty [25] to solve multiple criteria decision problems. Using a systematic hierarchy structure, complex estimation criteria can be clearly and precisely represented. Ratio scales are utilized to make reciprocal comparisons for each element and each layer. After completing the reciprocal matrix, one can obtain comparative weights for each element. Consider problem of finding the weights of importance $w_1,\ldots, w_i, \ldots, w_j,\ldots, w_n$, on some elements in the next level, for the criteria $C_1,\ldots, C_i,\ldots, C_j,\ldots, C_n$. Saaty used the Normalization of Row Average (NRA) method [26] to obtain an exact priority vector $w = (w_1,\ldots, w_2,\ldots, w_j,\ldots, w_n)$. This method sums up each row element and standardizes it by summing all elements of the matrix. That is, allowing the a_{ij}, i, $j = 1, 2,\ldots, n$ to be the importance strength of C_i when compared with C_j, then

$$w_i = \frac{\sum_{j=1}^{n} a_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij}},\ i = 1, 2, \ldots, n \tag{7}$$

Consistency testing is an important issue for using Eq. (1) to find the priority vector. It contains two layers. The first layer checks whether the pairwise comparative matrix containing answers by decision makers is a consistency matrix, while the second checks the consistency of the hierarchy structure. Consistency is estimated by the Consistent Ratio (CR). The CR is inversely proportional to consistency - the lower the figure, the higher the consistency of answers. In general, if the CR is less than or equal to 0.1, the consistency is considered very high.

The ratio is equal to the consistency index (CI) divided by the random index (RI).

$$CR = \frac{CI}{RI} \tag{8}$$

The formula for C.I. is:

$$C.I. = \frac{\lambda - n}{n - 1} \tag{9}$$

n is the number of items being compared. The value for λ is simple the average value of the consistency vector. The random index is a direct function of the number of alternatives.

The AHP method will be utilized to investigate the weights of evaluative criteria. The pairwise comparisons utilized in AHP facilitate the conveyance of the preferences of respondents, and the measure of consistency enables analysis to return to the judgments, modifying them here and there to improve the overall consistency.

(3) Fuzzy theory

Fuzzy set theory was developed based on the premise that the key criteria in human thinking are not numbers, but linguistic terms or labels of fuzzy sets [2, 4]. Fuzzy set theory treats vague data as possibility distributions in terms of set memberships. Once determined and defined, the sets of memberships in possibility distributions can be effectively used in logical reasoning. The representation and operation of trapezoidal fuzzy numbers are the two major components of fuzzy set theory and are foundational to the analysis used in this research.

(a) The representation of generalized trapezoidal fuzzy numbers

Several researchers have discussed ways to represent fuzzy numbers [1, 3, 5, 14, 15, 32]. Adamo [1] and Campos *et al*. [3] used the α-preference of the fuzzy number. Yager [32] discussed two indices of fuzzy numbers, gravity and mean value. Heilpern [14] proposed an expected value fuzzy number based on the low and upper expected value. Kaufmann *et al*. [15] and Chen [6] proposed the average of four vertex values of a trapezoidal fuzzy number. Delagado *et al*. [13] presented a method using the r-cuts of fuzzy number method. Finally, Chen *et al*. [5] proposed the graded mean integration representation method that used a grading system to weight the average of left and right h-level values to represent the generalized fuzzy numbers.

To match the fuzzy MCDM algorithm developed in this paper, the graded mean integration representation method proposed by Chen *et al*. [4] is used to present the final ratings of evaluation values (weights score) of the GLH location alternatives. The graded mean integration representation method operation does not change the results of the representation values after increasing or decreasing a generalized fuzzy number into the original generalized fuzzy numbers group. It also possesses the advantages of easy implementation, and strength in solving problems. It will be used to rank the final superiority ratings of all alternatives.

In a universe of discourse of X, a fuzzy subset A of X is characterized by a membership function f_A, which maps each element x in X to a real number in the interval [0, 1]. The function value represents the grade of membership of x in A. A fuzzy number A [c, a, b, d, w] in $\Re$ (real line) is a trapezoidal fuzzy number if its membership function f_A: $\Re \rightarrow [0, 1]$ is (see Figure 3).

$$f_A(x) = \begin{cases} w(x-c)/(a-c), & c \le x \le a; \\ w & , c \le x \le b; \\ w(x-d)/(b-d), & b \le x \le d; \\ 0 & , \text{otherwise}, \end{cases} \tag{10}$$

Since,

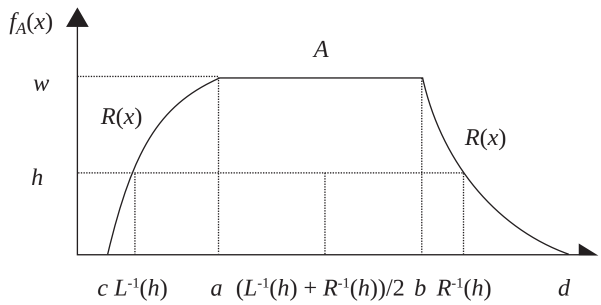


Fig. 3. Membership function of a trapezoidal fuzzy number $A = (c, a, b, d)$.

$$L(x) = w\left(\frac{x-c}{a-c}\right),\ c \le x \le a,$$

$$R(x) = w\left(\frac{x-d}{b-d}\right),\ b \le x \le d,$$

where $0 < x < 1$

Let $A_i = (c_i, a_i, b_i, d_i)$, $i = 1, 2, ..., n$, be n trapezoidal fuzzy numbers. The graded mean integration representation $R(A_i)$ of A_i is

$$R(A_i) = \frac{c_i + 2a_i + 2b_i + d_i}{6}. \tag{11}$$

Let $R(A_i)$ and $R(A_j)$ be respectively the graded mean integration representations of trapezoidal fuzzy numbers A_i and A_j. It is defined as

$A_i > A_j \Leftrightarrow R(A_i) > R(A_j)$;

$A_i = A_j \Leftrightarrow R(A_i) = R(A_j)$;

$A_i < A_j \Leftrightarrow R(A_i) < R(A_j)$

(b) The operation of trapezoidal fuzzy numbers

In this paper, the Second Function Principle, proposed by Chen [5], was used to perform arithmetical operations between generalized trapezoidal fuzzy numbers because it does not change the type of the membership function of the generalized fuzzy number, and reduces the trouble and tediousness of operations. Suppose $A_1 = (c_1, a_1, b_1, d_1, w_1)$, $A_2 = (c_2, a_2, b_2, d_2, w_2)$ are two generalized trapezoidal fuzzy numbers, $w = \min\{w_1, w_2\}$. Chen [5] has shown that the properties of arithmetical operations with the Second Function Principle are as follows.

(1) $A_1 \oplus A_2 = (c_1 + c_2, a_1 + a_2, b_1 + b_2, d_1 + d_2; w)$, (12)

where c_1, a_1, b_1, d_1, c_2, a_2, b_2, and d_2 are any real number.

(2) $A_1 \otimes A_2 = (c, a, b, d; w)$,

where $T = \{c_1c_2, a_1a_2, b_1b_2, d_1d_2\}$, $T_1 = \{a_1a_2, a_1b_2, b_1a_2, b_1b_2\}$, $c = \min T$, $a = \min T_1$, $b = \max T_1$, $d = \max T$.

If c_1, a_1, b_1, d_1, c_2, a_2, b_2, and d_2 are nonzero positive real numbers, then

$$A_1 \otimes A_2 = (c_1c_2, a_1a_2, b_1b_2, d_1d_2; w) \tag{13}$$

(3) $A_1 - A_2 = (c_1 - c_2, a_1 - a_2, b_1 - b_2, d_1 - d_2; w)$, (14)

(4) $A_1/A_2 = (c_1/d_2, a_1/b_2, b_1/a_2, d_1/c_2; w)$, (15)

where c_1, a_1, b_1, d_1, c_2, a_2, b_2, and d_2 are nonzero positive real numbers.

EMPIRICAL ANALYSIS

In this section, an empirical evaluation of locations for developing of re-export type of GLH is performed to demonstrate the computational process as described in this section of this quantitative SWOT analytical algorithm proposed herein.

Step 1: *The selection of candidate locations (alternatives) with competitive relations.*

With strong economic development since the early 80's and a shift in the global center of manufacturing to Asia, major ports in Far Eastern region have expanded rapidly. The demand for cargos in Far Eastern region will further increase in the future [9]. Hong Kong (China), Singapore, Shanghai (China), Busan (Southern Korea), Kaohsiung (Taiwan) and Shenzhen (China) are the six major competitive locations in the Far Eastern region (Containerization International, 2004). In this paper, these locations are selected as an example to evaluate the competitive position of location developing a GLH by the quantitative SWOT analytical method.

Step 2: *Distinguish between internal and external environment criteria.*

The 18 indicators depicted in Table 3 were based on the criteria of Lou [20] and Lin [19] for development of a global logistics hub of the re-export type.

Table 3. The indicators weights of GLH

Indicators	Weight	Sub-Criteria		Weight	Weight of sub-criteria versus objective
Internal indicators					
Industrial conditions	0.428	I_6	Reprocessing time	0.180	0.077
		I_7	Reprocessing facilities	0.133	0.057
		I_8	Indus. environ. legal guarantee	0.140	0.060
		I_{10}	Reprocessing cost	0.189	0.081
		I_{12}	Industrial cluster environment	0.246	0.105
		I_{15}	R&D cost	0.112	0.048
Regulation conditions	0.216	I_4	Reprocessing tax	0.421	0.091
		I_5	Zero custom tax	0.389	0.084
		I_9	Products original certificate	0.190	0.041
Transportation conditions	0.079	I_2	Ext-TR Convenience	0.481	0.038
		I_{13}	Re-proc. Ext. transportation	0.519	0.041
Environment quality	0.277	I_1	Political, economic, society stability	0.274	0.076
		I_3	Information abilities	0.198	0.055
		I_{14}	Financing deregulation	0.236	0.065
		I_{11}	Re-processing manpower quality	.0292	0.081
External indicators					
Location conditions	0.358	E_1	Location resistance	0.355	0.127
		E_2	Density of shipping line	0.645	0.231
Competition conditions	0.642	E_3	Regional industrial competition	0.606	0.389
		E_4	Parts cost	0.394	0.253

Step 3: *Build a hierarchical structure of evaluating the competitive position.*

We construct the hierarchical structure of the GLH (Figure 4). The description of indicators may be found in appendix A.

Step 4: *Collect data, reading to collect the objective and quantified performance.*

Quantified performance consists of actual statistical values. In this paper the location resistance and density of the shipping line are quantitative values (Table 4).

Step 5: *Survey the experts.*

The comparative importance value for the evaluation indicators of weights (see Table 3) of the re-export GLH obtained by the AHP method, is evaluated by a survey of experts. Importance is ranked on a 1-9 scale (the higher the better). The qualified performance of criteria is a fuzzy value that uses linguistic rating variables. Linguistic expressions of information are converted to and represented by trapezoidal fuzzy numbers, which in turn are employed in the preference rating system. In this paper, rating of performance was defined as S = {VL, L, M, H, VH}, where VL = Very Low, L = Low, M = Medium, H = High, VH = Very High. The set is used to evaluate the fuzzy ratings of locations versus various subjective sub-criteria above the alternative level, respectively. The sets are defined as follows: VL = (0, 0, 0, 0.3), L = (0, 0.3, 0.3, 0.5), M = (0.2, 0.5, 0.5, 0.8), H = (0.5, 0.7, 0.7, 1), and VH = (0. 7, 1, 1, 1).

Step 6: *Normalize the performance values of the internal and external criteria.*

In order to unify the scale of the quantitative indicators (Table 4) of potential GLH locations in the East Asia region, the quantitative indicators were normalized, as shown in Table 5. The normalized performance value of "a" can be represented by the trapezoidal fuzzy number of E_{ij} (a, a, a, a).

Step 7: *Calculate the weight score R_j of all locations.*

The calculation of weight average score R_j (as shown in appendix B) of re-export type GLH can be

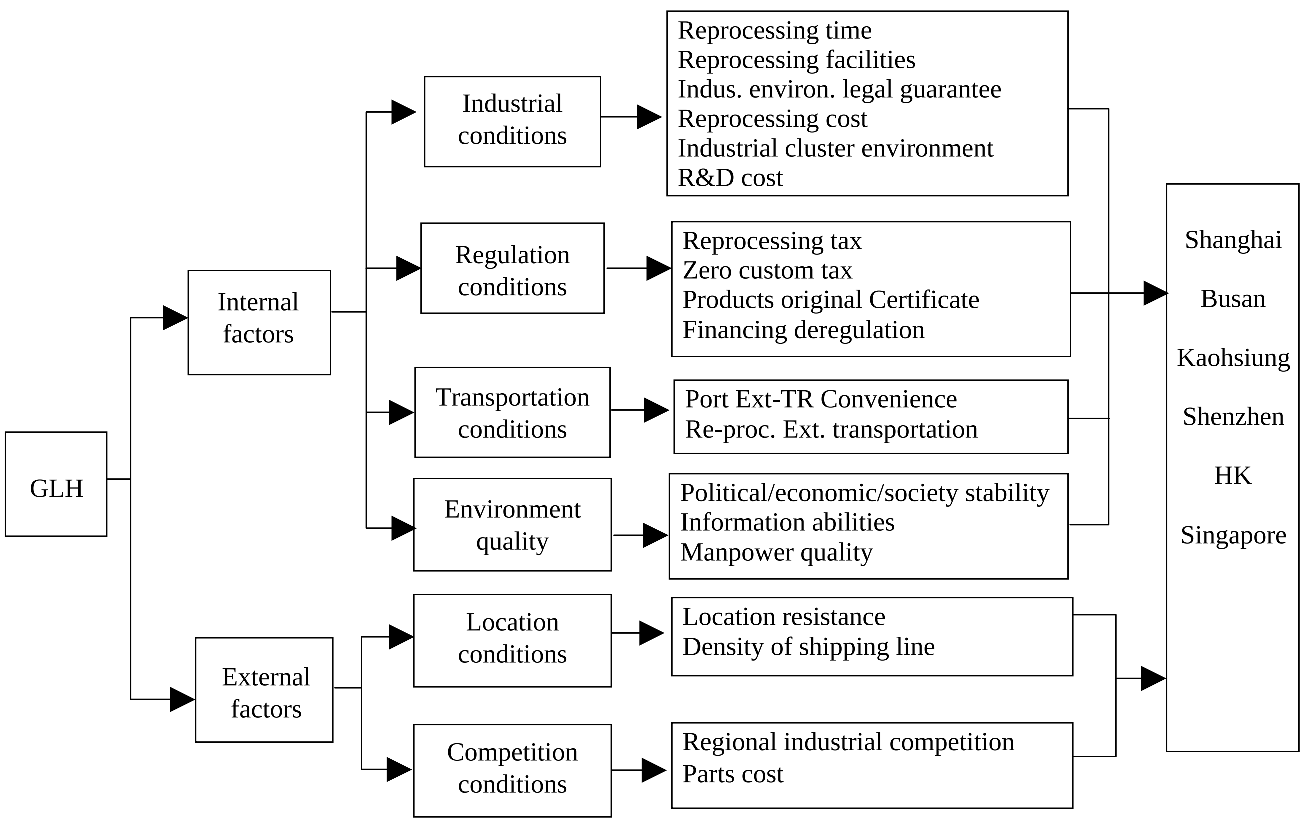


Fig. 4. Hierarchical structure of GLH.

Table 4. The quantitative performance of locations developing GLH in the East Asia region

Evaluative indicators		Unit	Locations					
			L_1	L_2	L_3	L_4	L_5	L_6
External criteria								
E_1	Location resistance	Miles	7288	8784	5401	6421	6356	17199
E_2	Density of shipping line	Lines	106	130	109	112	215	336

Note: 1. Shanghai (L_1); Busan (L_2); Kaohsiung (L_3); Shenzhen (L_4); HK (L_5); Singapore (L_6).
2. Source: Containerisation International Yearbook 2005.

Table 5. Normalize the quantitative performance of locations developing GLH in the East Asia region

Evaluative indicators		Unit	Locations					
			L_1	L_2	L_3	L_4	L_5	L_6
External indicators								
E_1	Location resistance	Miles	0.7411	0.6149	1.0000	0.8411	0.8497	0.3140
E_2	Density of shipping line	Lines	0.3155	0.3869	0.3244	0.3333	0.6399	1.0000

Note: Shanghai (L_1); Busan (L_2); Kaohsiung (L_3); Shenzhen (L_4); HK (L_5); Singapore (L_6).

Table 6. The benchmarks and coordinate values of GLH

Enviro.	Coordinate value	L_1	L_2	L_3	L_4	L_5	L_6	Benchmark
Internal	Weighted average value (SW)	0.708	0.752	0.749	0.786	0.722	0.683	0.734
	Coordinate value (SW)	–0.026	0.018	0.015	0.052	–0.012	–0.051	
External	Weighted average value (OT)	0.680	0.726	0.694	0.708	0.670	0.655	0.689
	Coordinate value (OT)	–0.009	0.037	0.005	0.019	–0.019	–0.034	

Note: 1. Shanghai (L_1); Busan (L_2); Kaohsiung (L_3); Shenzhen (L_4); HK (L_5); Singapore (L_6).
2. Coordinate value = Weighted average value-Benchmark.

obtained by multiplying the weights (w_i) with indicators of performance (E_{ij} (c_{ij}, a_{ij}, b_{ij}, d_{ij})). The weighted average value R_j of the generalized trapezoidal fuzzy numbers E_j (c_j, a_j, b_j, d_j) can be obtained by $\sum_{i=1}^{m} w_i \times E_{ij}$. After defuzzying the numbers through the graded mean integration representation method the weighted average score R_j can be obtained by $\frac{c_j + 2a_j + 2b_j + d_j}{6}$.

Step 8: *Determine the internal and external benchmarks and calculate and compare the coordinate values.*

The benchmarks can be obtained by average value of the weight score of all locations (see Table 6).

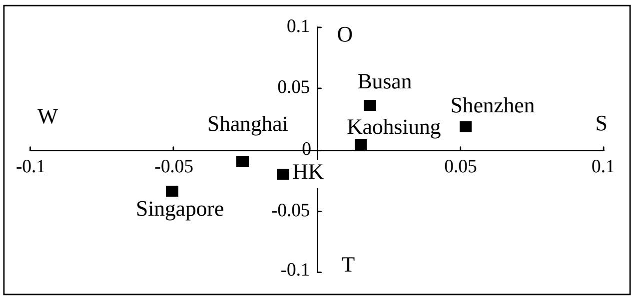
Step 9: *Calculate and compare the coordinate values.*

The coordinate values can be obtained by the weight score of the location subtract benchmark (see Table 6).

Step 10: *Locating the candidate locations on the SWOT matrix.*

Eventually, the coordinate values of all locations are allocated into one of the four quadrants (see Figure 5).

Figure 5 clearly shows the position of a location relative to other locations it is competing with. Such knowledge can aid GLH developers in selecting a strategy for developing a GLH. Analysis of the locations developing the re-export type of GLH from the standpoint of competitive position and conditions shows that Shenzhen, Busan, and Kaohsiung, locate in the SO quadrant due to competitiveness derived from their high-tech industrial environment. Because the re-export type of GLH does not place major emphasis on port conditions, but instead focuses on high-tech industrial



S: Strength; W: Weakness; O: opportune; T: Threaten

Fig. 5. The competitive position of GLH in Pacific-Asia region.

conditions, Hong Kong, Busan and Singapore locate in the WT quadrant. Since Shanghai is aggressively improving the infrastructure (including Great Yangshan Island and Little Yangshan Island) and the operations system of the port, and the industrial environment (including developing science-based technology parks and a distribution park), Shanghai can be expected to move from the third quadrant toward the leading group (first quadrant) in the future.

1. Discussion and implication

In the SWOT, the first quadrant stands for the strengths and market opportunities of the enterprises [4]. Enterprises in this quadrant can use their strengths to adopt strategies, such as market penetration, market development, and product development, to form competitive strength. If an enterprise in the first quadrant has extra resources, forward, backward and Enterprises in the second quadrant are those with market development opportunities but on the horizontal integration, may be efficient strategies.

weak side of the competition. The most urgent issue is to eradicate their weaknesses to intensify competitive strength. If they lack unique competences, they may consider intensifying their competitive strength through joint venture or horizontal merger strategies. Enterprises in the third quadrant are of low competitive strength and face threats from other competitors. Defensive strategies, such as focusing on the most favored markets, can be used to avoid threats. Divestiture or liquidation should be adopted if these strategies fail. Enterprises in the fourth quadrant are those possessing competitive strength but facing greater threats than opportunities. Diversification or joint venture should be adopted to reduce threats.

The quantified SWOT used in this study not only shows the competitive relations between locations developing GLHs, but also serves as a reference for development strategies on the basis of the Grand Strategy Matrix (GSM) [4]. Just as in the GSM, enterprises are sorted into the 4 quadrants according to their categories (Figure 6). However, in the GSM, the ordinate stands for the external environment (opportunities, threats) while the abscissa stands for the internal environment (strengths, weaknesses).

In case of Kaohsiung, several strategies may serve as a brief illustration of development of a re-export type of GLH (Table 7). The strategies depend on these SO quadrant's strategies of market development, market penetration, product development, forward integration, backward integration, horizontal integration and concentric diversification. ForSuch as the strategy of "market penetration", supporting participants might include banking, insurance, e-commerce, marketing, and other

Rapid market growth

	Quadrant II Market development Market penetration Product development Horizontal integration Divestiture Liquidation	**Quadrant I** Market development Market penetration Product development Forward integration Backward integration Horizontal integration Concentric diversification	
Weak Competitive Position			**Strong Competitive Position**
	Quadrant III Retrenchment Concentric diversification Horizontal diversification Conglomerate Diversification Divestiture Liquidation	**Quadrant IV** Concentric diversification Horizontal diversification Conglomerate Diversification Joint ventures	

Slow market growth

Fig. 6. The grand strategy matrix

Table 7. SO strategies of Kaohsiung developing GLH

Strategy	Definition	Description
Market development	Expand into new markets	Sign Free Trade Agreements (FTA) to expand economic hinterland for exploiting new consumption and supply markets or establish long-term relations
Market penetration	In the existing market, attract new customers.	Upgrade supporting logistics activities such as marketing, financing and information to attract new multinational corporations.
Product development	Develop new production and improve traditional production	Provide a improved industrial cluster environment, human resources, taxation of production value-adding, and relevant inducements for construction of an intelligent industrial environment.
Backward integration	Integrate the upstream market of the supply side	Sign an FTA with Japan (upstream) to improve the channel relationship with Taiwan (downstream) in the provision of key parts and components
Forward integration	Integrate the downstream market of the consumption side	Improved the relationship between Taiwan (upstream) and China (downstream), including promoting direct shipping links
Horizontal integration	Combine the advantageous resources to jointly design and develop new production	Establish hi-tech industrial parks, such as the Taichung Science Park, to stimulate cluster effects and upgrade competitiveness.
Concentric diversification	Increase shared technologies and markets of new production under existing production	Improve shared environments, such as the construction of information platform among information industries, to expand services and competitiveness of existing production.

logistics integration companies that provide financing, information, marketing, and R&D services and charge fee from primary or functional participants.

CONCLUSION

We analyze the competitive relations in GLH development in Busan, Shanghai, Kaohsiung, Hong Kong, Shenzhen, and Singapore in Pacific-Asia region. In this study, a quantified SWOT procedure that integrates the MCDM concept and the fuzzy AHP method was proposed to help decision makers assess the competitive position of a given global logistics hub (GLH). The method shows similarities to the GSM concept, and thus may be combined with the GSM for strategy formulation.

The performance values for qualitative criteria are often imprecisely defined. The employment of trapezoidal fuzzy numbers and linguistic values characterized by trapezoidal fuzzy numbers facilitates the human rating based on 'feeling'. Hence, the fuzzy AHP method is used to integrate various linguistic assessments and weights to evaluate the location suitability and determine the best selection.

Results showed that Shenzhen, Busan and Kaohsiung locate in the SO quadrant, due to their advantages in the internal environment and opportunities in the external environment. Shanghai, HK and Singapore locate in the WT quadrant, given their weaknesses in internal environment and threats in the external environment. However, since Shanghai is actively improving its infrastructure and industrial environment, it should migrate into the SO quadrant soon.

The research contributes to GLH studies by evaluating competitive relations from investor (manufacturer) perspectives. Although numerous studies have examined determinants affecting MNC evaluation of specific types of GLH, few have specifically examined the competitive positions of GLH locations relative to each other, so as to propose strategies for better marketability and development. Further, a comparison of the competitive positions of GLH in Busan, Shanghai, Kaohsiung, Hong Kong, Shenzhen, and Singapore is useful for GLH administrators in more readily identifying competitive relations and proposing competitive strategies.

The study findings have several management implications. The quantified SWOT analysis of the GLH locations gives a clear indicator of their relative competitive positions. This may aid GLH administrators and planners in further examination and elaboration of their competitive strategies. The concept of the Grand Strategy Matrix (GSM) is used to suggest suitable strategies based on its competitive position. In the case of the competitive position of Kaohsiung, several strategies serves as a brief illustration of potential directions for GLH development, based on strategies for enterprises in the SO quadrant of the Grand Strategy Matrix.

REFERENCE

1. Adamo, J.M., “Fuzzy decision trees,” *Fuzzy Sets and Systems*, Vol. 4, pp. 207-219 (1980).
2. Bellman, R.E. and Zadel, L.A., “Decision-Making in a Fuzzy Environment,” *Management Science*, Vo. 17, No. 4, pp. 141-164 (1970).
3. Campos, L. and Verdegay, “Linear Programming Problems and Ranking of Fuzzy Numbers,” *Fuzzy Sets and systems*, Vol. 32, pp. 1-11 (1989).
4. Chang, H.H. and Huang, W.C., “Application of a Quantification SWOT Analytical Method,” *Journal of Mathematical and Computer Modeling*, Vol. 43, pp. 158-169 (2006).
5. Chen, S.H., “Operation on Fuzzy Numbers with Second Function Principle and its Applications,” First LFSA Congress, session 8.4, Palma de Mallorea, Spain (1985).
6. Chen, S.M., “A New Method for Tool Steel Material Selection under Fuzzy Environment,” *Fuzzy Sets and Systems*, Vol. 92, pp. 265-274 (1989).
7. Chen, S.J., Huang, C.L., and Huang, F.P., *Fuzzy Multiple Attribute Decision Making Methods and Applications*, Springer, Berlin (1992).
8. Chen, S.H. and Hsieh, C.H., “Representation, Ranking, Distance, and Similarity of L-R Type Fuzzy Number and Application,” *Australian Journal of Intelligent Processing Systems*, Vol. 6, No. 4, pp. 217-229 (2000).
9. Chou, C.C., Chu, C.W., and Liang, G.S., “Competitiveness Analysis of Major Ports in Eastern Asia,” *Journal of the Eastern Asia Society for Transportation Studies*, Vol. 5, October, pp. 682-697 (2003).
10. Churchill, G.A., *Marketing Research: Methodological Foundation*, 5th ed., The Dryden Press, New York (1991).
11. David, F.R., *Strategic Management*, Prentice-Hall, NJ (1998).
12. David, F.R., *Strategic Management, Concepts and Cases*, Prentice Hall, NJ (2001).
13. Degado, M., Vila, M.A., and Voxman, W., “On A canonical Representation of Fuzzy Numbers,” *Fuzzy Sets and Systems*, Vol. 93, pp. 125-35 (1998).
14. Heilpern, S., “Representation and Application of Fuzzy Numbers,” *Fuzzy Sets and Systems*, Vol. 91, pp. 259-268 (1997).
15. Kaufmann, A. and Gupta, M.M., *Introduction of Fuzzy Arithemetic Theory and Application*, Van Nostrand Reinhold (1991).
16. Kurttila, M., Pesonen, M., Kangas, J., and Kajanus, M., “Utilizing the Analytic Hierarchy Process (AHP) in SWOT Analysis - A Hybrid Method and Its Application to a Forest-Certification Case,” *Forest Policy and Economics*, Vol. 1, pp. 41-52 (2000).
17. Lee, H.S., Chou, M.T., and Kuo, S.G., “Evaluating Port Efficiency in Pacific Asia Region with Recursive Data Envelopment Analysis,” *Journal of the Eastern Asia Society for Transportation Studies*, pp. 544-559 (2005).
18. Lee, K.L., Huang, W.C., Kuo, M.S, and Lin, S.C., “Competitiveness Modal of International Distri-Park using the Virtual Value Chain Analysis,” *Journal of The Eastern Asia Society for Transportation Studies*, pp. 313-325 (2001).
19. Lin, S.C., Liang, G.S., and Lee, K.L., “Applying Fuzzy Analytic Hierarchy Process in Location Mode of International Logistics on Airports Competition Evaluation,” *Journal of Marine Science and Technology*, Vol. 14, No. 1, pp. 25-38 (2006).
20. Lou, G.S., “The Competitive Strategy of Global Logistics System of International Port,” Master Thesis Department of Harbor and River, National Taiwan Ocean University (2004).
21. Lu, C.S., “Market Segment Evaluation and International Distribution Centers,” *Transportation Research Part E* Vol. 39, pp. 49-60 (2003).
22. McGinnis, M.A. and Kohn, J.W., “Logistics Strategy-Revisited,” *Journal of Business Logistics*, Vol. 21, No. 1, pp. 1-17 (2002).
23. Oum, H.O. and Park, J.H., “Multinational Firms’ Location Preference for Regional Distribution Centers: Focus on the Northeast Asian Region,” *Transportation Research Part E*, Vol. 40, pp. 101-121 (2004).
24. Prahalad, C. and Doz, Y., *The Multinational Mission: Balancing Local Demands and Global Vision*, Free press, New York (1987).
25. Saaty, T.L., *The Analytic Hierarchy Process*, McGraw-Hill, New York (1980).
26. Saaty, T.L. and Vargas, L.G., *The Logic of Priorities*, Kluwer-Nijhoff, Boston, MA (1982).
27. Sheu, J.B., “A Hybrid Fuzzy-Based Approach for Identifying Global Logistics Strategies,” *Transportation Research Part E*, Vol. 40, pp. 39-61 (2004).
28. Stewart, R.A., Mohamed, S., and Daet, R., “Strategic Implementation of IT/IS Projects in Construction: A Case Study,” *Automation in Construction*, Vol. 11, pp. 681-694 (2002).
29. Tai, H.H. and Hwang, C.C., “Analysis of Hub Port Choice for Container Trunk Lines in Eastern Asia,” *Journal of the Eastern Asia Society for Transportation Studies*, pp. 907-919 (2005).
30. United Nations, “Facing the Challenge of Integrated Transport Services,” (UNCTAD/SDD/MT/7), United Nations Conference on Trade and Development, New York (1995).
31. Vos, B. and van den Berg, E., “Assessing International Allocation Strategies,” *International Journal of Logistics Management*, Vol. 7, No. 2, pp. 69-84 (1996).
32. Yager, R.R., “A Procedure for Ordering Fuzzy Subsets of the Unit Interval,” *Information Sciences*, Vol. 24, pp. 143-161 (1981).
33. Yeo, K.T. and Song, D.W., “An Evaluation of Container

Ports in China and Korea with the Analytic Hierarchy Process," *Journal of the Eastern Asia Society for Transportation Studies*, Vol. 5, October, pp. 726-741 (2003).
34. Zadeh, L.A., "Fuzzy Sets," *Information and Control*, Vol. 8, pp. 338-353 (1965).
35. Zadeh, L.A., "The Concept of a Linguistic Variable and its Application to Approximate Reasoning, Part I, II and III," *Information Science*, Vol. 8, pp. 199-249, pp. 301-357; Vol. 9, pp. 43-80 (1975, 1976).

APPENDICES

Appendix A. The description of evaluative indicators of GLH

Indicators	Description
Internal indicators	
Political, economic, social stability	The internal environmental stability of a location will affect the investment of MNCs
Ext-TR Convenience	The convenience of extension transportation between port and reprocessing areas will affect time and cost efficiencies
Information capabilities	Providing convenient information services to MNCs in logistics, commerce, and finance
Zero customs tax	Affects the transshipment and reprocessing cost of cargos
Reprocessing time	Provides timely performance
Reprocessing facilities	Manufacturing facilities providing deep (hi-tech) reprocessing abilities
Reprocessing deregulation	Deregulation of deep reprocessing activities will attract MNCs
Industrial environment lLegal guarantees	Legalization of reprocessing environment will attract MNCs of manufacturing companies
Product country of origins certification	Affects product branding
Reprocessing cost	Costs such as facilities, labor etc
Re-processing manpower quality	Affects the quality of product value-added
Industrial cluster environment	The ability of vertical and horizontal industries to cluster affects the efficiency of deep reprocessing
Financial deregulation	Affect the investment of foreign MNCs
R&D cost	Affects the deep reprocessing cost of cargos
External indicators	
Location resistance	The distance from location to main consumer market, affects the distribution cost and time
Density of shipping lines	The frequency of voyages by all shipping lines from the location's port to main marketplace
Regional industrial competition	Affects the selection of deep reprocessing activities by MNCs
Components cost	The cost of parts and components for deep reprocessing

Appendix B. The fuzziness evaluation value of re-export type GLH

Indicators	Weight	Unit	Fuzziness preference value					
			L_1	L_2	L_3	L_4	L_5	L_6
Internal indicators								
Political Economic Society Stability	0.076	5 scales	(0.562, 0.771, 0.771,0.958)	(0.564, 0.713, 0.713, 0.844)	(0.437, 0.646, 0.646, 0.854)	(0.563, 0.771, 0.771, 0.958)	(0.604, 0.813, 0.813, 0.979)	(0.667, 0.780, 0.780, 0.906)
Reprocessing cost	0.038	5 scales	(0.625, 0.833, 0.883, 0.989)	(0.613, 0.729, 0.729, 0.938)	(0.354, 0.563, 0.563, 0.771)	(0.646, 0.854, 0.854, 1.000)	(0.417, 0.625, 0.625, 0.833)	(0.094, 0.292, 0.292, 0.500)
Zero custom tax	0.055	5 scales	(0.538, 0.753, 0.753, 0.968)	(0.538, 0.782, 0.782, 0.936)	(0.559, 0.774, 0.774, 0.976)	(0.602, 0.817, 0.817, 1.000)	(0.602, 0.807, 0.807, 0.989)	(0.624, 0.701, 0.701, 0.905)
Reprocessing tax	0.091	5 scales	(0.522, 0.739, 0.739, 0.956)	(0.656, 0.885, 0.885, 0.967)	(0.587, 0.793, 0.793, 0.978)	(0.587, 0.804, 0.804, 1.000)	(0.457, 0.674, 0.674, 0.880)	(0.478, 0.696, 0.696, 0.902)
Ext-TR Convenience	0.084	5 scales	(0.559, 0.774, 0.774, 0.978)	(0.538, 0.753, 0.753, 0.968)	(0.581, 0.785, 0.785, 0.978)	(0.538, 0.753, 0.753, 0.96)	(0.624, 0.828, 0.828, 1.000)	(0.624, 0.781, 0.781, 0.989)
Reprocessing time	0.077	5 scales	(0.511, 0.723, 0.723, 0.936)	(0.574, 0.787, 0.787, 0.979)	(0.596, 0.808, 0.808, 0.989)	(0.617, 0.830, 0.830, 1.000)	(0.447, 0.659, 0.659, 0.872)	(0.468, 0.681, 0.681, 0.894)
Re-processing human quality	0.057	5 scales	(0.323, 0.538, 0.538, 0.753)	(0.559, 0.774, 0.774, 0.979)	(0.602, 0.817, 0.817,1.000)	(0.602, 0.817, 0.817, 1.000)	(0.473, 0.688, 0.688, 0.903)	(0.365, 0.581, 0.581, 0.796)
Indus. Environ. legal Guarantee	0.060	5 scales	(0.374, 0.593, 0.593, 0.813)	(0.549, 0.769, 0.769, 0.989)	(0.571, 0.791, 0.791, 1.000)	(0.528, 0.747, 0.747, 0.967)	(0.549, 0.758, 0.758, 0.945)	(0.593, 0.802, 0.802, 0.989)
Logistics Hub information abilities	0.041	5 scales	(0.532, 0.745, 0.745, 0.957)	(0.553, 0.766, 0.766, 0.968)	(0.553, 0.660, 0.660, 0.968)	(0.511, 0.723, 0.723, 0.936)	(0.596, 0.798, 0.798, 0.957)	(0.660, 0.862, 0.862, 1.000)
Products original Certificate	0.081	5 scales	(0.467, 0.689, 0.689, 0.911)	(0.533, 0.756, 0.756, 0.978)	(0.556, 0.778, 0.778, 1.000)	(0.444, 0.667, 0.667, 0.889)	(0.533, 0.755, 0.755, 0.967)	(0.533, 0.756, 0.756, 0.967)
Industrial cluster enviro.	0.081	5 scales	(0.505, 0.716, 0.716, 0.926)	(0.632, 0.832, 0.832, 0.989)	(0.653, 0.842, 0.842, 0.989)	(0.632, 0.842, 0.842, 1.000)	(0.421, 0.632, 0.632, 0.316)	(0.358, 0.568, 0.568, 0.768)
Reprocessing facilities	0.105	5 scales	(0.505, 0.705, 0.705, 0.895)	(0.611, 0.811, 0.8111, 0.968)	(0.589, 0.789, 0.789, 0.968)	(0.653, 0.853, 0.853, 1.000)	(0.505, 0.716, 0.716, 0.916)	(0.400, 0.611, 0.611, 0.811)
Re-proc. Ext. transportation	0.041	5 scales	(0.319, 0.532, 0.532, 0.745)	(0.511, 0.234, 0.234, 0.936)	(0.468, 0.681, 0.681, 0.894)	(0.617, 0.830, 0.830, 1.000)	(0.383, 0.596, 0.596, 0.809)	(0.511, 0.723, 0.723, 0.936)
Financing deregulation	0.065	5 scales	(0.489, 0.702, 0.702, 0.915)	(0.553, 0.766, 0.766, 0.968)	(0.468, 0.681, 0.681, 0.894)	(0.532, 0.745, 0.745, 0.957)	(0.638, 0.840, 0.840, 1.000)	(0.596, 0.798, 0.798, 0.681)
R&D cost	0.048	5 scales	(0.565, 0.783, 0.783, 0.989)	(0.500, 0.717, 0.717, 0.935)	(0.391, 0.609, 0.609, 0.826)	(0.587, 0.804, 0.804, 1.000)	(0.544, 0.761, 0.761, 0.973)	(0.435, 0.652, 0.652, 0.870)
Weighted average value $(SW) = E_j\ (c_j, a_j, b_j, d_j)$			(0.496, 0.709, 0.709, 0.916)	(0.563, 0.748, 0.748, 0.958)	(0.545, 0.750, 0.750, 0.949)	(0.577, 0.790, 0.790, 0.978)	(0.521, 0.732, 0.732, 0.884)	(0.499, 0.691, 0.691, 0.867)
Weighted average value $(SW) = R_j$								
External indicators								
Location resistance	0.127	Miles	(0.741, 0.741, 0.741, 0.741)	(0.615, 0.615, 0.615, 0.615)	(1.000, 1.000, 1.000, 1.000)	(0.841, 0.841, 0.841, 0.841)	(0.850, 0.850, 0.850, 0.850)	(0.314, 0.314, 0.314, 0.314)
Density of shipping line	0.231	Lines	(0.316, 0.316, 0.316, 0.316)	(0.387, 0.387, 0.387, 0.387)	(0.324, 0.324, 0.324, 0.324)	(0.333, 0.333, 0.333, 0.333)	(0.640, 0.640, 0.640, 0.640)	(1.000, 1.000, 1.000, 1.000)
Regional industrial competition	0.389	5 scales	(0.691, 0.799, 0.799, 0.962)	(0.697, 0.877, 0.877, 0.956)	(0.521, 0.790, 0.790, 0.936)	(0.521, 0.729, 0.729, 0.938)	(0.562, 0.601, 0.601, 0.958)	(0.546, 0.611, 0.611, 0.763)
Parts cost	0.253	5 scales	(0.608, 0.801, 0.801, 0.901)	(0.754, 0.892, 0.892, 0.991)	(0.505, 0.795, 0.795, 0.945)	(0.571, 0.791, 0.791, 1.000)	(0.461, 0.606, 0.606, 0.901)	(0.451, 0.566, 0.566, 0.625)
Weighted average value $(OT) = E_j\ (c_j, a_j, b_j, d_j)$			(0.589, 0.680, 0.680, 0.769)	(0.629, 0.734, 0.734, 0.789)	(0.532, 0.706, 0.706, 0.806)	(0.531, 0.668, 0.668, 0.802)	(0.591, 0.643, 0.643, 0.856)	(0.597, 0.652, 0.652, 0.726)
Weighted average value $(OT) = R_j$								

Note: 1. Shanghai (L_1); Busan (L_2); Kaohsiung (L_3); Shenzhen (L_4); HK (L_5); Singapore (L_6)

2. Weighted average value of generalized trapezoidal fuzzy numbers $E_j\ (c_j, a_j, b_j, d_j) = \sum_{i=1}^{m} w_i \times E_{ij}$

3. Weighted average value of graded mean integration representation $R_j = \frac{c_j + 2a_j + 2b_j + d_j}{6}$