

# *Use of Fuzzy AHP to Determine Port Hinterland Development Assessment Criteria for Free Trade Zone*

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# *Abstract*

- *The primary functions of Free Trade Zone is to encourage private enterprises with a series of duties and tax.*
- *The purpose of this paper is to explore the key successful factors of hinterland development on Free Port based on Fuzzy AHP approach, and offer some specific suggestions for government.*
- *The finding can be illustrated as :*
  - (1) Port hinterland hold a critical role of complement area between ship-cargo handling area and local port city area.*
  - (2) Current logistics functions of FTZ need to extend to multi-function parks.*
  - (3) The key successful factors of FTZ's port hinterland in Taiwan.*

**Keywords:** *Free Trade Zone, Port, Hinterland, Fuzzy AHP*

# *Catalogue*

- 1 、 Introduction**
- 2 、 Definition and Assessment Criteria of FTZ's port hinterland**
- 3 、 Methodologies**
- 4 、 Empirical Study**
- 5 、 Conclusions**

# 1 • Introduction

- Establishment of Taiwanese Free Trade Zones was deemed as one of important projects under the slogan of “*Challenge 2008—prioritize development project of the National*”
- The preferential incentives for Tenant Company entering in the FTZ illustrated:
  - ✓ Goods to be transported from overseas into a free trade zone .
  - ✓ Machineries and equipment to be transported from overseas into a free trade zone.
  - ✓ For the goods to be sold by a business entity in a tax zone or a bonded area.
- Taiwan’s FTZ can benefit companies in many respects.

# *1.1 Free Trade Zone in Taiwan*

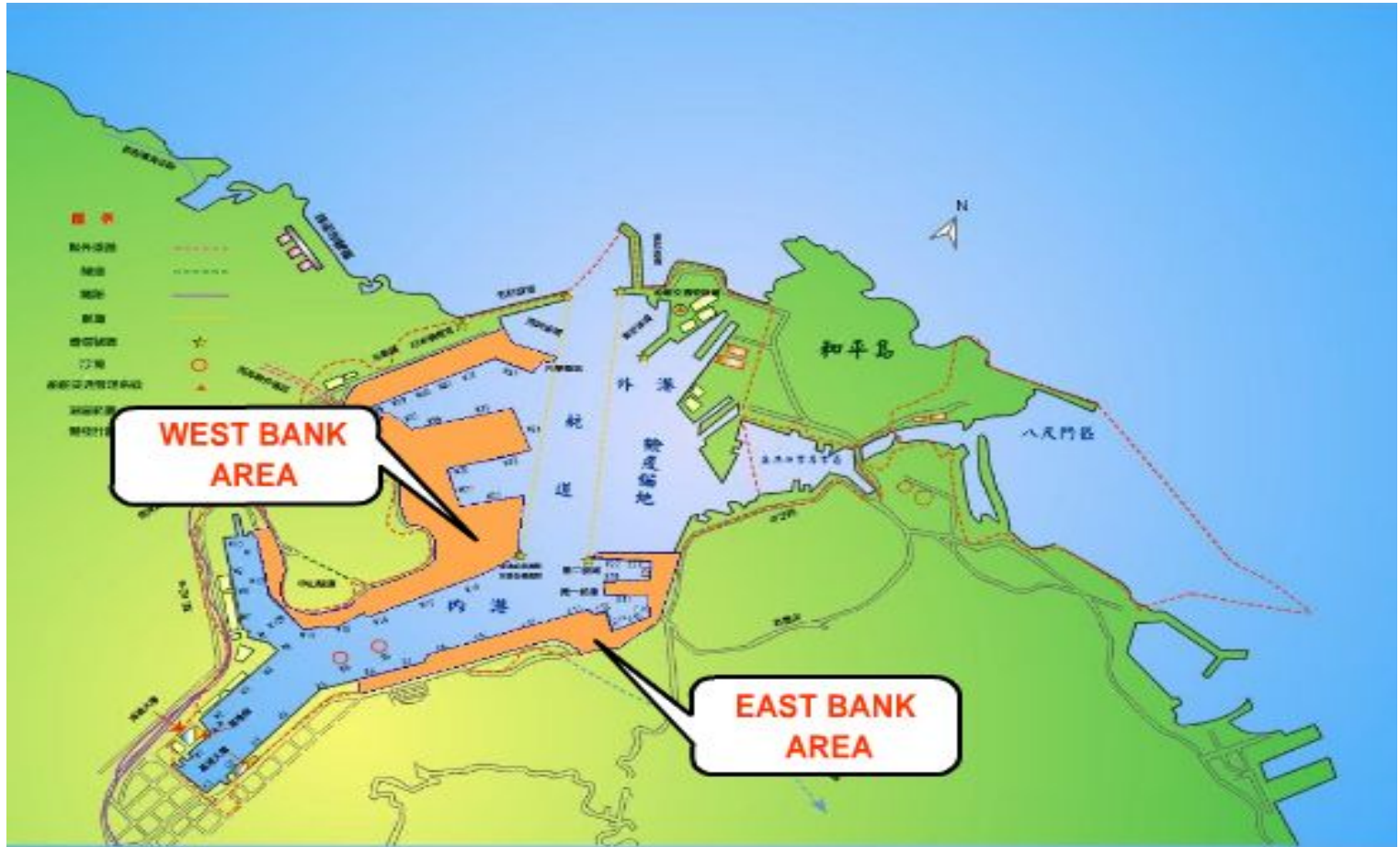
*According to Article 1 of “Act for the Establishment and Management of Free Trade Zones” enacted in July 2003 revealed establishment objective of Taiwan’s port Free Trade Zone were aimed for :*

- *developing the mode of operation for a global logistics and management systems,*
- *effecting aggressive promotion of trade liberalization and internationalization,*
- *facilitating the smooth flow of personnel, goods, finance, and technology,*
- *upgrading the national competitive power,*
- *furthering the national economic development( Executive Yuan, 2004*

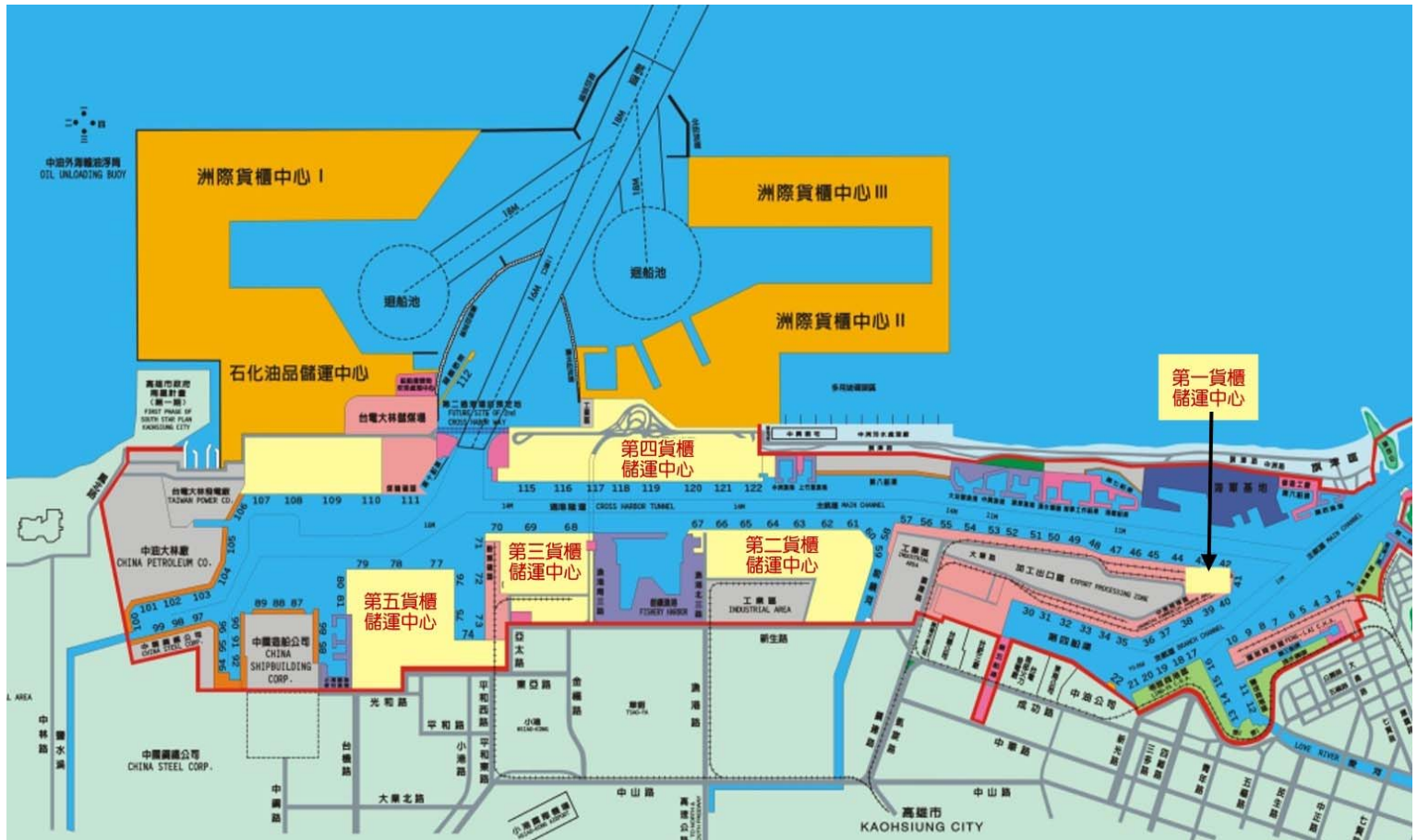
- According to aforementioned Act Taiwan government assigned port authority planned and formulated management regulations such as “Regulations Governing Entry, Exit, and Residence in the Keelung Free Trade Zone” in 2004, other four Free Trade Zones including Kaohisiung port, Taipei Port, Taichiung Port and Taoyuan Air Cargo Park were designated by Executive Yuan in the same year of 2005.



# Designated Area of Keelung port FTZ



# Designated Area of Kaoshiung port FTZ



*Table 1 : Total trade number of Free Trade Zone (Unit: NT\$1,000 )*

	2006			2007(1-7)		
	<i>Import</i>	<i>Export</i>	<i>Sub- trade</i>	<i>Import</i>	<i>Export</i>	<i>Sub-total</i>
<i>Port FTZ</i>	50,195	18,993	69,188	675,592	681,827	1,357,419
<i>Port FTZ</i>	3,052,689	1,378,341	4,431,030	1,172,440	1,742,439	2,914,879
<i>Port FTZ</i>	4,464,397	3,008,376	7,472,773	1,377,268	1,809,167	3,186,435
<i>Port FTZ</i>	715,307	407,887	1,123,194	803,610	554,419	1,358,029
<i>Taiyuan</i>						
<i>Air Cargo</i>	68,646	991,581	1,060,227	8,561,650	73,787,835	82,349,485
<i>Park FTZ</i>						
<i>Total</i>	8,351,234	5,805,178	14,156,412	12,590,560	78,575,687	91,166,247

*Table 2 : Tenant companies numbers of Free Trade Zone*

<i>Port Name</i>	<i>Operation date</i>	<i>2005</i>	<i>2006</i>	<i>2007.6</i>
<i>Port FTZ</i>	<i>2004.9.</i>	<i>4</i>	<i>8</i>	<i>13</i>
<i>Port FTZ</i>	<i>2005.6</i>	<i>1</i>	<i>1</i>	<i>1</i>
<i>Port FTZ</i>	<i>2005.1</i>	<i>7</i>	<i>11</i>	<i>15</i>
<i>Port FTZ</i>	<i>2005.12</i>	<i>3</i>	<i>7</i>	<i>12</i>
<i>Taoyuan Air Cargo Park FTZ</i>	<i>2005.11</i>	<i>5</i>	<i>75</i>	<i>79</i>
<i>Total Amount</i>		<i>20</i>	<i>102</i>	<i>120</i>

## *1.2 Research Purpose*

- Main purpose of Free Trade Zone is to extend the current functions of *Global logistic development project*
- The important characteristics of Free Trade Zone illustrated by *Center for Economic Planning and Development of Administrative Yuan*
- The purpose of this paper attempted to:
  1. Review the performance of tenant company's numbers and trade transaction numbers of Taiwan's FTZ.
  2. Figure out main issues for developing port hinterland of FTZ in the respect of implementation and operation system.
  3. Explore assessment criteria for developing port hinterland of FTZ at the present.

## 2 · Definition and Assessment Criteria of FTZ's port hinterland

Table 3 : Functional Classification of Port hinterland

Classification	Function & Facility	Content
Logistic Function	Main Function	Large scale of transshipment and storage functions, a part of fabricating, processing, labeling packing and other value-added service functions with some supporting functions from Container Terminal
	Investment Facility	Logistic warehouse, , Storage Warehouse and Empty Container Storage Yard
Fabricating and Processing Function	Main Function	Except Transshipment, Storage function and other basic logistic functions, Focusing on cargo fabricating and processing to implement big unit value added logistic service
	Investment Facility	Fabricating facility, Processing Facility and other related supplementary investment
Waterfront Recreation usage place	Main Function	Utilizing the rim of waterfront facility is to provide local resident and port user some functions of leisure and entertainment activities
	Investment Facility	Leisure, Recreation, Maritime Park and etc.
Commercial and Business Function	Main Function	Except a large transshipment and storage functions, Commodity promotion, exhibiting and meeting related task established in the fabricating or processing place
	Investment Facility	Exhibition Hall, Business Facility, , Restaurant, lodging and entertainment facilities.
R& D and Venture Function	Main Function	For developing sustainable logistic and port industry we can fulfill educational, Research and venture business in Multiple functions of port hinterland usage place
	Investment Facility	Educational facility, Research facility, Venture facility, and etc.

## 2 · Definition and Assessment Criteria of FTZ's port hinterland

- These preliminary important assessment factors collected from in-depth personal interview and related literature review were summarized as 5 assessment dimension with 21 assessment criteria.

Table 4 : Main assessment criteria for port hinterland of Free Trade Zone

Dimension	Assessment Criteria	Literature Source
Political-Economic Environment	Stability of Political Climate	Walker(1981) 、 Qing Qiao Yang(2003)
	Direct sailing Across	in-depth personal interview(2007)
	Economic Scale of Market	KMI and CAU(2000) 、 Zhong Shi Bai(2001) 、 Yurimoto and Masui(1995) 、 in-depth personal interview(2007)
	Globalization of International Trade and Foreign Currency Exchange Systems	KMI and CAU(2000)

## 2 · Definition and Assessment Criteria of FTZ's port hinterland

Table 4 : Main assessment criteria for port hinterland of Free Trade Zone

Dimension	Assessment Criteria	Literature Source
Operational Environment	Administrative Efficiency of Local Government Institution	Qing Qiao Yang(2003)
	Simplification of Custom Clearance Procedure and Single Window type administrative Service	KMI(2000) 、 in-depth personal interview(2007)
	Efficiency of Port Operation	KMI(2000) 、 Qing Qiao Yang(2003)
	Integration of Custom Clearance and Port Logistic Information System	KMI(2000)
Cost Environment	Labor Cost	Schmenner(1982) 、 Qing Qiao Yang(2003)
	Land Cost	Yurimoto and Masui(1995) 、 Qing Qiao Yang(2003) 、 in-depth personal interview(2007) 、
	Raw Material Purchasing Cost	Min and Melachrinoudis(1996)
	Transport and Distribution Cost	Min and Melachrinoudis(1996)

## 2 · Definition and Assessment Criteria of FTZ's port hinterland

Table 4 : Main assessment criteria for port hinterland of Free Trade Zone

Dimension	Assessment Criteria	Literature Source
Infrastructure Facility Environment	Perfect Port Logistic Facility	KMI(2000)
	Abundant Scale of Port Logistic Hinterland	KMI and CAU(2000)
	Efficiency of Multi-Mode Transport Access Network	KMI and CAU(2000)
	Frequency of Sailing Schedule and Diversification of	KMI(2000) 、 Qing Qiao Yang(2003)
Preferential Incentives Environment	Soundness of Investment Mechanism and Incentive Alternatives	Yurimoto and Masui(1995) 、 KMI(2000)
	Reduction and Relief of Corporate Tax, Add-Valued Tax and Local Tax for invested Company	KMI(2000) 、 Cohen and Lee(1989)
	Relief of Custom duties and Value-added Tax on Cargo	KMI(2000) 、 Cohen and Lee(1989)
	Financial Aid for invested company	Yurimoto and Masui(1995) 、 KMI(2000)

# 3 • Methodologies

## 3.1. Fuzzy set theory

- The fuzzy set theory is designed to deal with the extraction of the primary possible outcome from a multiplicity of information that is expressed in vague and imprecise terms.
- Cun-He Xu(1998) Fuzzy set theory treats vague data as possibility distributions in terms of set memberships.
- In a universe of discourse  $X$ , a fuzzy subset  $A$  of  $X$  is defined by a membership function , which maps each element  $x$  in  $X$  to a real number in the interval  $[0, 1]$ . The function value represents the grade of memberships of  $x$  in  $A$ .

$$f_A(x) = \begin{cases} (x - c)/(a - c), & c \leq x \leq a \\ (x - b)/(a - b), & a \leq x \leq b \\ 0, & \text{otherwise} \end{cases}$$

- With  $-\infty < c \leq a \leq b < \infty$  the triangular fuzzy number can be denoted by  $(c, a, b)$ .

# 3 • Methodologies

## 3.1. Fuzzy set theory

- Let  $A_1 = (c_1, a_1, b_1)$  and  $A_2 = (c_2, a_2, b_2)$  be fuzzy numbers.  
According to the extension principle, the algebraic operations of any two fuzzy numbers  $A_1$  and  $A_2$  can be expressed as
- Fuzzy addition  $\oplus$ :  $A_1 \oplus A_2 = (c_1 + c_2, a_1 + a_2, b_1 + b_2)$ ;
- Fuzzy subtraction  $-$ :  $A_1 - A_2 = (c_1 - b_2, a_1 - a_2, b_1 - c_2)$ ;
- Fuzzy multiplication  $\otimes$ :  $k \otimes A_2 = (kc_2, ka_2, kb_2)$   $k \in \mathfrak{R}$   $k \geq 0$   
 $A_1 \otimes A_2 \cong (c_1c_2, a_1a_2, b_1b_2)$   $c_1 \geq 0, c_2 \geq 0$
- Fuzzy division  $/$ :  $A_1 / A_2 \cong (c_1/b_2, a_1/a_2, b_1/c_2)$ ,  $c_1 \geq 0, c_2 \geq 0$

# 3 • Methodologies

## 3.2. Fuzzy AHP

- Fuzzy AHP approach is used to measure relative weights for evaluation these key factors.
- The systematic steps for evaluating relative weights using fuzzy AHP to be taken are described below((Cun-He Xu,1998, Ji-Feng Ding, 2006).

Step 1. Develop a hierarchical structure

Step 2. Collect pair-wise comparison matrices of decision attributes

Step 3. Transform relative importance into triangular fuzzy number

Step 4. Build fuzzy positive reciprocal matrices

Step 5. Calculate the fuzzy weights of the fuzzy positive reciprocal matrices

Step 6. Defuzzify the fuzzy weights to crisp weights

Step 7. Normalize the crisp weights

# 4 • *Empirical Study*

## 4.1 *Questionnaire design, data collect and Geometric Average analysis*

- One Two activity systems and eight functional activities with twenty-eight functional related activities, as shown in Table1
- The respondents are divided into three groups being composed of government official, academics researcher, senior manager of ocean carrier, freight forwarder, warehouse operator respectively.
- The author collected from the twenty-two respondents, or which return mail ratio represents about 22% of the total Sixty four mails.

# 4 • Empirical Study

## 4.1 Questionnaire design, data collect and Geometric Average analysis

Table 5 : Geometric Average Statistics of Assessment Dimension and Criteria

Assessment Dimension	Assessment Criteria	Code	Geometric Average	Rank
Political-Economic Environment A1	Stability of Political Climate	a1	7.13	16
	Direct Sailing Across	a2	8.28	1
	Economic Scale of Market	a3	7.44	10
Operational Environment A2	Simplification of Custom Clearance Procedure and Single Window type administrative Service	b1	7.85	3
	Efficiency of Port Operation	b2	7.68	4
	Integration of Custom Clearance and Port Logistic Information System	b3	7.67	5
Cost Environment A3	Labor Cost	c1	7.33	12
	Land Cost	c2	7.18	15
	Transport and Distribution Cost	c3	7.26	14
Infrastructure Facility Environment A4	Maturity of Port Logistic Facilities	d1	7.59	6
	Abundant Scale of Port Logistic Hinterland	d2	7.49	9
	Efficiency of Multi-Mode Transport Access Network	d3	7.36	11
	Frequency of Sailing Schedule and Diversification of	d4	8.04	2
Preferential Incentives Environment A5	Soundness of Investment Mechanism and Incentive Alternatives	e1	7.52	7
	Reduction and Relief of Corporate Tax, Add-Valued Tax and Local Tax for invested Company	e2	7.49	8
	Relief of Custom duties and Value-added Tax on Cargo	e3	7.30	13

# 4 • Empirical Study

## 4.2 FAHP analysis

### 4.2.1 Build fuzzy positive reciprocal matrix

Table 6 : fuzzy positive reciprocal matrices for assessment dimension

	A1	A2	A3	A4	A5
A1	(1,1,1)	(0.25,1.055,4)	(0.2,0.717,4)	(0.2,0.746,3)	(0.25,0.969,4)
A2	(0.25,0.948,4)	(1,1,1)	(0.2,0.74,4)	(0.2,0.992,3)	(0.25,0.77,4)
A3	(0.25,1.395,5)	(0.25,1.351,5)	(1,1,1)	(0.5,1.651,5)	(0.333,1.681,5)
A4	(0.333,0.134,5)	(0.333,1.008,5)	(0.2,0.606,2)	(1,1,1)	(0.33,0.999,5)
A5	(0.25,1.032,4)	(0.25,1.299,4)	(0.2,0.595,3.03)	(0.2,1.001,3.03)	(1,1,1)

### 4.2.2 Calculate the fuzzy weights, Defuzzify the fuzzy weights and normalize the crisp weights

Table 7 : Related weight calculation of each assessment dimension

	A1	A2	A3	A4	A5
A1	(1,1,1)	(0.25,1.055,4)	(0.2,0.717,4)	(0.2,0.746,3)	(0.25,0.969,4)
A2	(0.25,0.948,4)	(1,1,1)	(0.2,0.74,4)	(0.2,0.992,3)	(0.25,0.77,4)
A3	(0.25,1.395,5)	(0.25,1.351,5)	(1,1,1)	(0.5,1.651,5)	(0.333,1.681,5)
A4	(0.333,0.134,5)	(0.333,1.008,5)	(0.2,0.606,2)	(1,1,1)	(0.33,0.999,5)
A5	(0.25,1.032,4)	(0.25,1.299,4)	(0.2,0.595,3.03)	(0.2,1.001,3.03)	(1,1,1)
Geometric Average	(0.349,1.128,3.314)	(0.349,1.133,3.314)	(0.276,0.718,2.496)	(0.331,1.041,2.673)	(0.369,1.046,3.314)
Fuzzy Weight	(0.023,0.223,1.919)	(0.023,0.224,1.919)	(0.018,0.142,1.491)	(0.023,0.205,1.596)	(0.024,0.206,1.979)
Defuzzify Weight	0.482	0.483	0.346	0.407	0.472
Normalize Weight	0.220	0.221	0.158	0.186	0.222

# 4 • Empirical Study

## 4.3 Calculate the integrated weight for each layer

Table 8 : Integrated weigh value of Assessment Criteria for FTZ's Port hinterland

Assessment Dimension	Weight Value(A)	Assessment Criteria	Code	Weight Value(B)	Integrated Weight Value(C=A*B)	Rank
Political-Economic Environment A1 (0.220)	0.22	Stability of Political Climate	a1	0.363	0.0799	4
	0.22	Direct Sailing Across	a2	0.299	0.0658	8
	0.22	Economic Scale of Market	a3	0.337	0.0741	5
Operational Environment A2 (0.221)	0.221	Simplification of Custom Clearance Procedure and Single Window type administrative Service	b1	0.247	0.0546	9
	0.221	Efficiency of Port Operation	b2	0.372	0.0822	2
	0.221	Integration of Custom Clearance and Port Logistic Information System	b3	0.381	0.0842	1
Cost Environment A3 (0.158)	0.158	Labor Cost	c1	0.343	0.0542	10
	0.158	Land Cost	c2	0.321	0.0507	13
	0.158	Transport and Distribution Cost	c3	0.337	0.0532	11
Infrastructure Facility Environment A4 (0.186)	0.186	Maturity of Port Logistic Facilities	d1	0.257	0.0478	14
	0.186	Abundant Scale of Port Logistic Hinterland	d2	0.215	0.0400	16
	0.186	Efficiency of Multi-Mode Transport Access Network	d3	0.283	0.0526	12
	0.186	Frequency of Sailing Schedule and Diversification of	d4	0.248	0.0461	15
Preferential Incentives Environment A5 (0.222)	0.222	Soundness of Investment Mechanism and Incentive Alternatives	e1	0.327	0.0726	6
	0.222	Reduction and Relief of Corporate Tax, Add-Valued Tax and Local Tax for invested Company	e2	0.311	0.0690	7
	0.222	Relief of Custom duties and Value-added Tax on Cargo	E3	0.362	0.0804	3

# 5 • *Conclusions*

- Taiwan's port FTZ has implemented several years. The function of port hinterland still is confined to the place available for fabricating, processing, logistic, trade.
- Some finding could be summarized as following:
  1. Port hinterland hold a critical role of complement area between ship-cargo handling area and local port city area. Taiwan government should reconsider insufficient space of port hinterland development issues for new port construction and old port reconstruction in the perspective of maritime cluster, this concept could facilitate and induce core cluster industrial sector entering to FTZ, such as global logistic park, international trade and business park, new venture park, R&D park, IT designing Park, Maritime leisure park,etc.
  2. Assessment Dimensions of FTZ's port hinterland based on ranking order of weight value are preferential incentives environment, political-economic environment, operational environment and infrastructure facility environment..

# 5 • *Conclusions*

3. Assessment Criteria of FTZ's port hinterland based on ranking order of Intergraded weight value are Integration of Custom Clearance and Port Logistic Information System, Efficiency of Port Operation, Relief of Custom duties and Value-added Tax on Cargo, Stability of Political Climate, Economic Scale of Market, Soundness of Investment Mechanism and Incentive Alternatives, Reduction and Relief of Corporate Tax, Add-Valued Tax and Local Tax for invested Company, Direct Sailing Across Taiwan Strait, Simplification of Custom Clearance Procedure and Single Window type administrative Service, Labor Cost, Transport and Distribution Cost, Efficiency of Multi-Mode Transport Access Network, Land Cost, Maturity of Port Logistic Facilities, Frequency of Sailing Schedule and Diversification of Shipping Route and Abundant Scale of Port Logistic Hinterland.

## 5 • *Conclusions*

4. Key successful factors of FTZ's port hinterland in Taiwan are direct-sailing across Taiwan Strait, frequency of sailing route, convenience of custom clearance process and one-stop administrative service window, efficiency of port operation, integration of custom and port logistic information, adequacy of port logistics facilities, soundness of investment system and incentive measures, exemption or deduction of corporate tax and local taxes, sufficiency of port hinterland for logistics functions, economic scale of market, efficiency of intermodal transport network, labor cost, exemption and deduction of custom duty and value-added tax for cargo, transport and distribution cost, land cost and political stability.

## 5 • *Conclusions*

5. Due to the past unstable political atmosphere between Taiwan government and Mainland China over decade, “Three Links” talk has no any further progressed. Especially for sea freight trade across Taiwan Strait should be delivered via a third place like Hong Kong or Japanese island, it arises numerous operating expenses and sailing time for Taiwanese and Mainland China carriers. Such issues has been resolved since both sides of governments signed the Direct Sailing Agreement in the December 2008.
6. Customs office may team up a combined audit taskforce to conduct inspection of the autonomous management being performed by a free trade zone enterprise in respect of its good control and management, on-line computerized customs clearance and other account-related operation and may also conduct physical inventory of the goods involved .

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