A POLICY-MAKING FRAMEWORK FOR ENHANCING THE KAOHSIUNG PORT'S ECONOMIC RESILIENCE

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SUMMARY

This paper is a revised and expanded version of a paper entitled 'Influential indicators for measuring Kaohsiung port resilience' presented at the International Forum on Shipping, Port, and Airports (IFSPA 2013), Hong Kong Polytechnic University, Hong Kong, 3–5 June 2013.

The analytic hierarchy process (AHP) method commonly used in the issue of decision making was performed in this study to propose a policy-making framework for enhancing the Kaohsiung port's economic resilience. A three-level hierarchical structure with 19 attributes is proposed and tested. Results indicate that adjusting the shipping policy is perceived as the most critical strategic dimension to enhance container port resilience. This is followed by increasing incentives, adjusting port operational strategy and exploiting market opportunities. Overall, results show that the five most important strategies for enhancing international container ports' resilience are training of international marketing personnel, economic deregulation of shipping market across the Taiwan-Strait; subsidising the throughput of containers transhipment, subsidising coastal shipping operations and the alteration of dedicated terminals for rent. This study contributes in proposing a policy-making framework to enhance the container port's economic resilience, and this framework could also be generalised to other ports.

NOMENCLATURE

T/P	Transpacific route
F/E	Far East-Europe (F/E)
UNCTAD	United Nations Conference on Trade and Development
TIPC	Taiwan International Ports Co., Ltd.
AHP	Analytic hierarchy process
a_{ij}^{m}	An element of matrix A of an individual (expert) m
i, j	Criteria (attribute) *i, j*
m	Expert m
a_{ij}^{hp} -	Geometric mean of all experts a_{ij}^{m}
hp	Aggregate measure of the matrix
w	Vector weights
CR	Consistency ratio
CI	Consistency index
RI	Random consistency index

1. INTRODUCTION

More than 90% of the world's goods are shipped in containers by overseas (Marlow, 2010[12]). Accordingly, a container port is not only an integral part of many logistics systems but a key vulnerability of a nation's economy. Given the considerable port disruptions caused by major environmental changes, port authorities need to develop their resilience capability to rapidly recover from disruptions and enhance their competitiveness (Justice *et al*., 2016[8]).

The concept of resilience has been emphasised in this dynamic marketplace. Notably, Taleb (2013)[28] argues that the best way for firms to deal with uncertainty and dynamic issues is by adopting an antifragile instead of a forecast strategy. There has been a stream of research investigating resilience in the port field (Becker & Caldwell, 2015[2]; Cox *et al*., 2011[6]; Justice *et al*., 2016[8]; Mansouri *et al*., 2010[11]; Omer et al., 2012[16]; Reggiani, 2013[18]; Wang & Ducruet, 2013[32]). However, most of the literatures on port resilience are focused on European or North American regions and a few studies investigated port resilience in the Asia-Pacific region. Given the fact that the East Asian region is regarded as the major shipping market in the world because of its pivotal position between Trans-Pacific (T/P) and Far East-Europe (F/E) container trunk routes, it is therefore worthy to evaluate the issue of port resilience in the Asia Pacific region and fill a gap in the literature.

The changing structure of liner shipping services had significantly affected the deployment of service routes and changed the spatial pattern of the port system in the Asian region (Wang & Ducruet, 2013[32]). Compared with other regions around the world, the container port sector in the Asia-Pacific region has undergone significant change in the past few years and has been growing in a dynamic manner. This study specifically focuses on Taiwan. As an island-based economic entity in the centre of the Asia-Pacific region, the country is highly dependent on foreign trade for its prosperity. Taiwan handled 2.36% of the world's port traffic (15.3 million TEUs) and controlled 2.62% of the world's fleet in terms of deadweight tonnage and was ranked as having the 10th largest container port traffic in the world (UNCTAD, 2015[31]). However, because of the emergence of large-scale container ships and the reorganisation of world shipping strategic alliances (Tai & Lin, 2013[27]), Taiwan's container ports have faced several critical issues, such as a decrease in the number of ports of call and a reduction in frequency of sailings. At the start of 2012, therefore, the Taiwanese government decreed an organisational change in the ownership of the ports, forming the TIPC (Taiwan International Ports Co., Ltd.) to increase efficiency and competitiveness.

Facing the significant change of shipping marketplace, it is imperative for the Kaohsiung port to realise the port's economic resilience. Since there seems to be a lack of empirical studies examining the resilience of port systems in reacting to an uncertain financial and economic marketplace in the Asian region, this study aims to propose a policy-making framework to enhance ports' economic resilience in the case of the Kaohsiung port. The results could help port authorities or terminal operators develop their resilience strategies and further enhance the port's adaptive capacity. Moreover, the framework based on this study could be generalised to other ports. Accordingly, the objectives of this study are:

1. To evaluate the economic resilience of the Kaohsiung port by depicting the structural changes of the container shipping market in the East Asian region
2. To propose a policy-making framework to enhance container ports' economic resilience

2. THE STRUCTURAL CHANGE OF THE CONTAINER SHIPPING MARKET IN THE EAST ASIAN REGION

Data of frequency of sailings and liner service routes published by the CI yearbook and UNCTAD were collected in this study to depict the structural changes of the container shipping market in the East Asia region and are presented in Figure 1. Located between the T/P and F/E routes, the Keelung and Kaohsiung ports were two main ports in the Asian region in the 1970s (see Figure. 1-a). In the 1980s (Figure. 1-b), the Busan port served as the main port in North Asia because of the rapid development of foreign direct investment and economic growth in Korea.

With respect to mainland China, the open-door policy attracted many foreign investors. Several container ports, along with the coastal line, were established and operated in the 1990s. The Shanghai port, as shown in Figure 1-c, specifically served as the main hub in the East Asian region. The vessel upsizing trend in the containership sector resulted in the emergence of the hub-and-spoke port network and has consequently greatly increased the number of containers being handled and thus the revenue of ports. Accordingly, Figure 1-d depicts the Kaohsiung, Hong Kong and Singapore ports as mega-hub ports that had the highest concentrations of large vessels, density frequencies and major container carriers (Robinson, 1998[19]) in the East Asian region in the 2000s.

Because of the booming economy of mainland China and the container vessel upsizing trend, container carriers have redeployed their trunk routes at Chinese ports. As shown in Figure 1-e, Busan, Shanghai and Shenzhen ports have served as the mega hub ports since the 2010s, while the Kaohsiung port has lost its mega hub position. It is important to note that the deployment of T/P routes has patterns of parallelization and of being soloed in F/E routes (Tai, 2012a[25]). In addition, the recent emergency of a daily frequency service has forced container carriers to cooperate with other carriers, and thus the strategic alliance of liner shipping has been reorganised. Accordingly, carriers have only selected a few ports as mega hubs. As shown in Figure 1-f, China's ports have played an important role in its cargo source in the East Asian region, whereas the Kaohsiung port has lost out by now having less frequent trunk routes.

Both container vessel upsizing and the global financial crisis have significantly affected the deployment of service routes. To save costs, the hub-and-spoke system is commonly employed by container carriers and across the world only a few ports have been selected as mega hubs. The Kaohsiung port, one of the top three container ports in 1999, lost its mega hub port position because of the structural change of the shipping marketplace. Thus, the resilience of the Kaohsiung port is becoming weak. Similarly, several major container ports, including Kobe, Tokyo, LA, Long Beach and Felixstowe, have lost their vital roles in the shipping marketplace. In this uncertain financial marketplace, these container ports have to develop a resilience strategy to get sustained competitive advantage.

3. PORT ECONOMIC RESILIENCE

Resilience comes the Latin verb "resilio" meaning to rebound (Rose & Wei, 2013[20]) and has been frequently discussed in the field of security management (Barnes & Oloruntoba, 2005[1]; Cox *et al*., 2011[6]; Jüttner & Maklan, 2011[9]; Mansouri *et al*., 2010[11]; Steen & Aven, 2011[23]). Reggiani (2013)[18] reviewed the literatures and noted that they are two different ways of defining resilience. One defines the resilience as a system to be a measure of the speed of its return to equilibrium. Another definition refers a firm's ability to cope with the consequences of unavoidable risk in order to return to its original operations after being distributed (Jüttner & Maklan, 2011[9]). To summarise, resilience can be defined as "the adaptive capability to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function" (Ponomarov & Holcomb, 2009, 131).

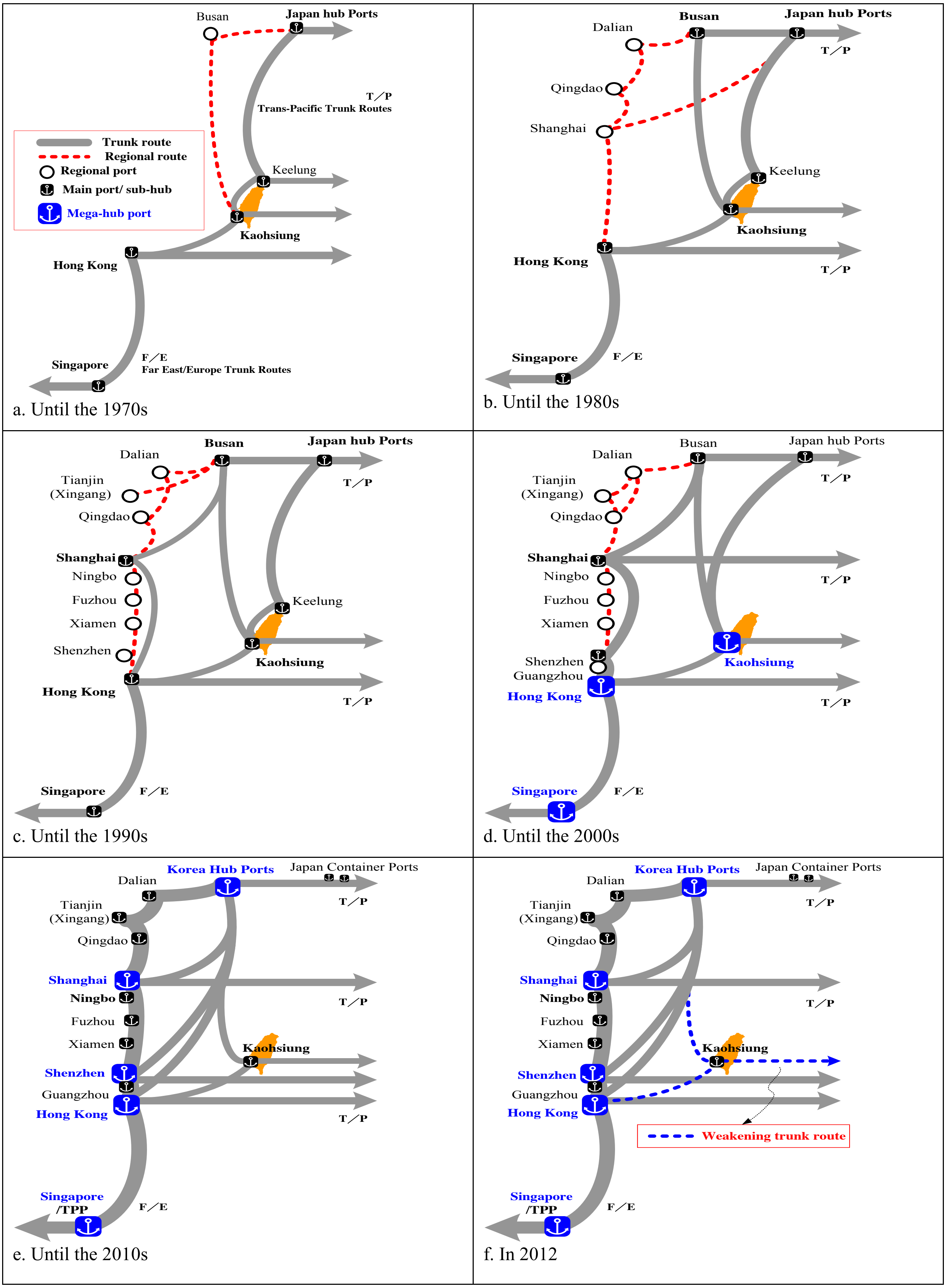

Figure 1: [The deployment of trunk routes in East Asia from 1970 to 2012]

A natural disaster or unexpected event will have a negative impact in microeconomic and macroeconomic terms (Hallegatte, 2014[7]). Thus, economic resilience can be defined as the ability of the economy to cope, recover, and reconstruct and therefore to reduce the welfare losses in microeconomic and macroeconomic terms (Hallegatte, 2014[7]). Since a container port plays an import role in accelerating the economic development of a country, this study specifically focuses on port economic resilience and defines it as the ability of a port to provide and maintain an acceptable level of service in the face of major economic changes or disruptions.

A number of studies have investigated resilience strategies. For example, Mansouri *et al*. (2010)[11] examines the resilience of port infrastructure systems. Three resilience strategies are proposed to reduce ports' vulnerabilities: (1) integrated security and safety design; (2) technological redundancy investment and (3) infrastructural redundancy and support investment. Cox *et al*. (2011)[6] also proposed four dynamic transportation system resilience strategies to speed up recovery, including removal of operating impediments, management effectiveness, speed up of restoration, and input, substitution, import substitution, inventories. Jüttner and Maklan (2011)[9] evaluate supply chain resilience in the global financial crisis. The results of their study indicate that supply chain resilience could significantly decrease supply chain vulnerability. Thus, a firm could enhance their supply chain resilience by improving their flexibility, visibility, velocity and collaboration capabilities.

Recently, Becker *et al*. (2015)[2] used two US ports as cases to identify resilience strategies. When they conducted interviews with stakeholders, 128 unique strategies were identified, which could be classified into seven types: (1) building codes and land use regulation, (2) long-range planning, (3) construction and design strategies, (4) private sector and insurance policies, (5) emergency response, preparation and recovery, (6) research, and (7) networks and new ways of thinking. Justice *et al*. (2016)[8] suggested that the application of complex adaptive systems may be a useful means for port managers to face unforeseen events. By adopting this system, port resilience can be enhanced through innovation.

It is important to note that the aforementioned studies have failed to take into account shipping carriers' operations and the global economic environment. Tai (2012b)[26], therefore, took strategic and market structure factors into consideration to evaluate the potential vulnerability, resilience and adaptive capability of Taiwanese container ports. He found that the TIPC could enhance the ports' resilience by adjusting the shipping policy, amending port operational strategies, exploring new markets and increasing incentives in relation to the dramatic change in the trunk route structure in Taiwan. Thus, reviewing prior studies on port resilience could provide our study with a theoretical foundation for identifying resilience strategies for container ports.

To comprehensively identify resilience strategies for container ports, four container shipping executives working for major Taiwanese container shipping companies, OOCL, EMC, WHL, and YML and one executive working in the newly founded TIPC, were interviewed for this study on a face-to-face basis. Based on the literature review on port resilience and these interviews, 19 strategic attributes to improve container port resilience were identified, shown in Table 1, and classified into four categories of major factors: adjustment of the shipping policy; adjustment of port operational strategy; exploration of market opportunities and increase of incentives.

4. THE AHP FRAMEWORK

The AHP is a multiple criteria decision-making (MCDM) method for formulating and analysing decisions (Saaty, 1980[21]) that has been widely used to solve shipping and transportation problems (Manca & Brambilla, 2011[10]; Notteboom, 2011[15], Yang *et al*., 2014[33]). Thus, an AHP method commonly recommended by previous studies on shipping was applied to evaluate the importance of strategies to improve container ports' economic resilience. The AHP method typically involves three steps (Saaty, 1980[21]; Saaty & Vargas, 1994[22]; Subramanian & Ramanathan, 2012[24]):

Step 1: Constructing a hierarchy

The first step is decomposing the decision-based problems into a hierarchy. Drawing on previous studies and personal interviews, a three-level hierarchical structure was constructed and is shown in Figure 2. The highest level of the hierarchy is the overall goal. The second level with four factors is the strategic dimensions for the Kaohsiung ports' resilience. Finally, 19 attributes associated with each factor in the second level are linked to the third level.

Table 1: [A resilience strategy for a container port]

Factors	Attributes	MOTC (2012)	MOTC (2013)	Tai (2012a)	Lui (2012)	Yang *et. al.* (2012)	UNCTAD (2011/2012)	Chen *et. al.* (2012)	Chiang (2010)	Cheon *et al.* (2010)
F1: Adjustment of the shipping policy	Economic deregulation of the shipping market across the Taiwan-Strait	★			★			★		
	Deregulation of fleet capacity across the Taiwan-Strait	★		★	★	★		★		
	Deregulation of port investment from foreign and Chinese capital	★		★				★		
	Expansion of cargo resources through regional trade agreements	★					★			
	Deregulation of expanding foreign terminal investments	★	★				★		★	
F2: Adjustment of the port operational strategy	Reinforcement of activities-connected to hinterland economy	★	★						★	
	Diversification of terminal fare construction	★				★		★		★
	Personnel training of ports' specialised staff	★	★	★	★					★
	Establishment of public container terminals		★	★	★	★				
	Alteration of dedicated terminals for rental system		★	★	★	★		★		
F3: Exploiting market opportunities	Collaboration with shipping carriers on occupational activities		★	★	★			★		★
	Collaboration with freight forwarders on logistics		★	★				★		
	Training of international marketing personnel		★	★				★		★
	Development of additional activities, such as real estate		★	★						
F4: Increasing incentives	Subsidising f trunk-route vessels' calling ports		★		★	★			★	
	Subsidising feeder-route vessels' calling ports		★		★				★	
	Subsidising the throughput of containers transhipment		★		★				★	
	Subsidising state-run shipping companies		★	★	★	★		★	★	
	Subsidising coastal shipping operations		★	★		★		★	★	

Step 2: Obtaining the weights in various hierarchies

The second step is making comparative judgments and obtaining the weights in different hierarchies. In this step, pairwise comparisons are performed to determine the relative importance of the elements in each level. Elements in each level are compared in pairs with respect to their importance to an element in the next level. The first of the pairwise comparisons is performed at the top of the hierarchy, working down, and can be reduced to a number of square matrices $A = \lfloor a_{ij} \rfloor_{n\times n}$ as in the following:

$$A = \lfloor a_{ij} \rfloor_{n\times n} = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix}_{n\times n} \tag{1}$$

The matrix has reciprocal properties, which are:

$$a_{ji} = \frac{1}{a_{ij}} \tag{2}$$

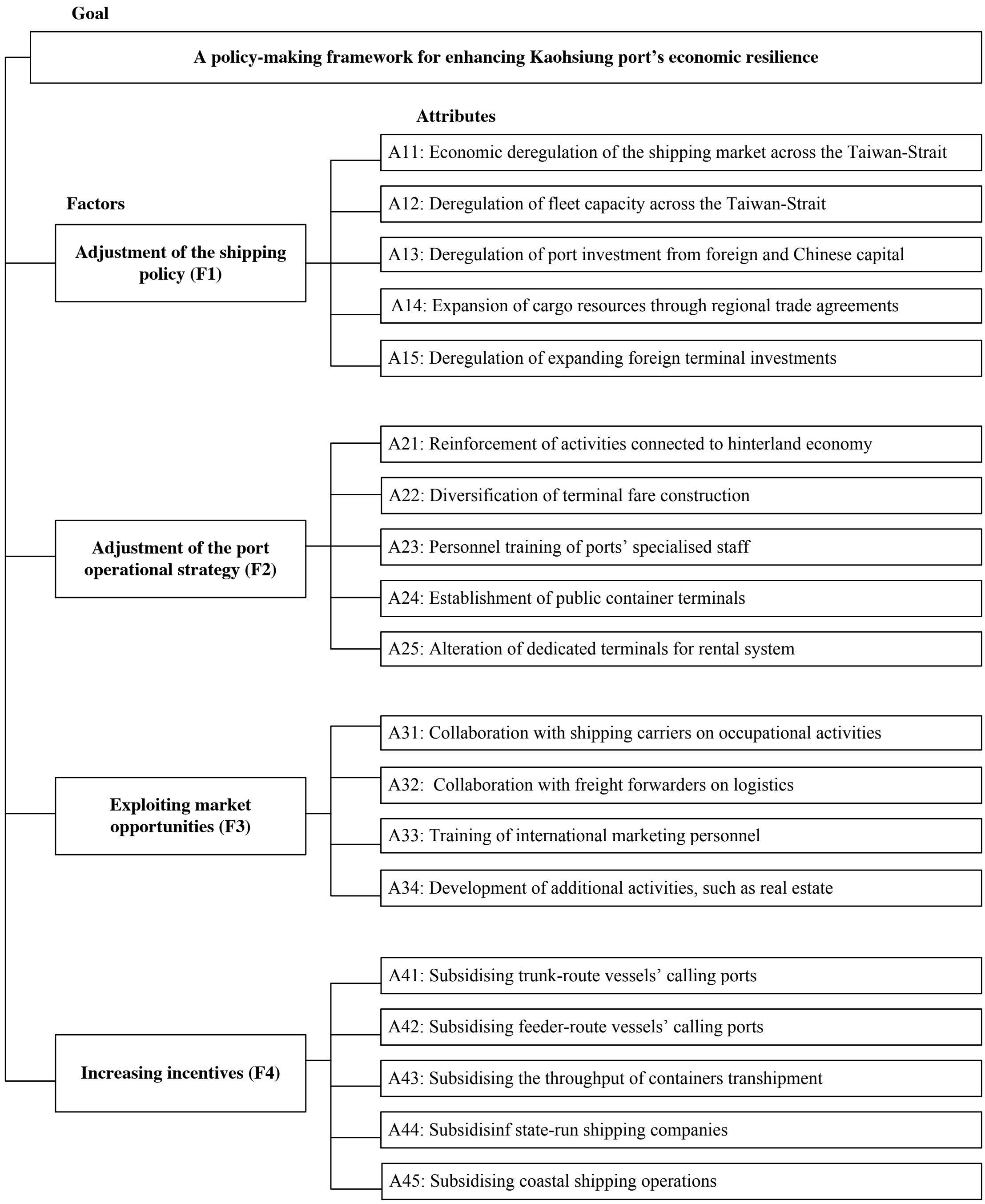

Figure 2: [The evaluation model of the AHP]

After making all of the pairwise comparisons at level 2, the pairwise comparison matrix was constructed. Similarly, the pairwise comparison procedure was applied to each of the factors with respect to the second level. A geometric mean was performed to aggregate the pairwise comparisons for all samples. First, the aggregate measure of the pairwise comparisons was calculated using an equation (3), and then the weights were computed using another equation (4). The vector of the weights, w= $\lfloor w_1, w_2, w_3, ... w_n \rfloor$, was calculated based on Saaty's eigenvector method. The resulting weights' elements can be termed local weights:

$$a_{ij}^{hp} = \sqrt[M]{\prod_{m=1}^{M} a_{ij}^{m}} \tag{3}$$

where:

a_{ij}^{m} - an element of matrix A of an individual (expert) m (m=1, 2, …., M), and

a_{ij}^{hp} is the geometric mean of all experts a_{ij}^{m}.

$$w_i = \frac{\left[\prod_{j=1}^{n} a_{ij}^{hp}\right]^{1/n}}{\sum_{i=1}^{n}\left[\prod_{j=1}^{n} a_{ij}^{hp}\right]^{1/n}} \tag{4}$$

for all i=1, 2, …., n.

Saaty (1980)[21] notes that there is a relationship between the vector weights, w, and the pairwise comparison matrix, A, as shown in equation (5):

$$Aw = \lambda_{max} w \tag{5}$$

The λmax value is a critical validating parameter in the AHP and is used as a reference index to screen information by calculating the consistency ratio (CR) of the estimated vector. The consistency index (CI) for each matrix of order n can be obtained from equation (6):

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{6}$$

Next, the CR can be calculated using equation (7):

$$CR = \frac{CI}{RI} \tag{7}$$

where RI is the random consistency index obtained from a randomly generated pairwise comparison matrix. The value of RI from the matrices in the order of 1 to 10, as suggested by Saaty (1980)[21], is shown in Table 2. All CR values in this study, as shown in Table 3, were less than 0.1, suggesting that all judgments were consistent. If the CR value had been greater than 0.1, the values of the ratio would have been indicative of inconsistency in this respect and, accordingly, we would have had to reconsider and revise the original values in the pairwise comparison in matrix A. The local weights were computed for the illustrative judgment matrices using eigenvector method; the corresponding values λmax, CI, and CR are shown in the Appendix.

Table 2: [Random consistency indices (RI)]

N	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty (1980)[21]

Table 3: [Consistency test for goal and crucial factors]

Level	Consistency Ratio (C.R.)	Consistency Test
Goal	0.001711	Accepted
Factors		
F1: Adjustment of the shipping policy	0.001184	Accepted
F2: Adjustment of the port operational strategy	0.001100	Accepted
F3: Exploiting market opportunities	0.000243	Accepted
F4: Increasing incentives	0.000636	Accepted

Step 3: Synthesising priorities

The final step is a priority synthesis that constructs an overall priority rating. The global weights are synthesised from the second level down, by multiplying the local weights by the corresponding criterion in the level above and adding them for each element in a level according to the criteria affected.

5. THE AHP SURVEY AND RESULTS

Data were collected through an AHP questionnaire survey. A nine-point scale of relative importance recommended by Saaty (1980)[21], ranging from "1=equal importance" to "9=extreme importance" was used in this study. The sample for this study was container shipping executives, including shipping carriers, research institutes and the TIPC. The AHP survey questionnaire, with a covering letter and a stamped addressed return envelope, was sent to the managers of container shipping executives and experts in Taiwan in March 2012. The total usable number of responses was 16 and all analyses were carried out using the IT program *Expert Choice 11.5 for Windows*.

Table 4: [The weights for each criterion]

Factors	**Whole samples (16)**		TIPC (5)		Shipping carriers (7)		Research institute (4)	
	Weight	Rank	Weight	Rank	Weight	Rank	Weight	Rank
F1	0.270	1	0.272	2	0.217	3	0.366	1
F2	0.237	3	0.277	1	0.197	4	0.252	2
F3	0.229	4	0.233	3	0.264	2	0.164	4
F4	0.264	2	0.218	4	0.321	1	0.218	3

Note: *Local weight is derived from judgments with respect to a single criterion

Table 5: [Local weight and global weight for each criterion]

attributes	**Whole samples(16)**			TIPC(5)			Shipping carriers(7)			Research institute(4)		
	Local weight	Global weight	Rank	Local weight	Global weight	Rank	Local weight	Global weight	Rank	Local weight	Global weight	Rank
A11	0.232	0.0626	2	0.229	0.0623	3	0.253	0.0549	7	0.195	0.0714	3
A12	0.204	0.0551	8	0.226	0.0615	4	0.186	0.0404	14	0.203	0.0743	2
A13	0.176	0.0475	15	0.182	0.0495	12	0.170	0.0369	15	0.170	0.0622	5
A14	0.199	0.0537	10	0.188	0.0511	10	0.161	0.0349	17	0.292	0.1069	1
A15	0.189	0.0510	13	0.175	0.0476	15	0.230	0.0499	10	0.140	0.0512	8
A21	0.179	0.0424	19	0.164	0.0454	17	0.177	0.0349	18	0.199	0.0501	9
A22	0.218	0.0517	11	0.196	0.0543	8	0.246	0.0485	11	0.199	0.0501	9
A23	0.184	0.0436	17	0.184	0.0510	11	0.179	0.0353	16	0.190	0.0479	13
A24	0.182	0.0431	18	0.201	0.0557	7	0.160	0.0315	19	0.198	0.0499	12
A25	0.238	0.0564	5	0.255	0.0706	1	0.239	0.0471	13	0.214	0.0539	6
A31	0.243	0.0556	7	0.245	0.0571	6	0.201	0.0531	8	0.323	0.0530	7
A32	0.244	0.0559	6	0.300	0.0699	2	0.216	0.0570	6	0.221	0.0362	15
A33	0.274	0.0627	1	0.248	0.0578	5	0.294	0.0776	1	0.260	0.0426	14
A34	0.239	0.0547	9	0.207	0.0482	13	0.289	0.0763	2	0.196	0.0321	18
A41	0.186	0.0491	14	0.155	0.0338	19	0.150	0.0482	12	0.312	0.0680	4
A42	0.194	0.0512	12	0.169	0.0368	18	0.226	0.0725	5	0.165	0.0360	16
A43	0.232	0.0612	3	0.214	0.0467	16	0.236	0.0758	3	0.230	0.0501	11
A44	0.175	0.0462	16	0.220	0.0480	14	0.160	0.0514	9	0.141	0.0307	19
A45	0.214	0.0565	4	0.243	0.0530	9	0.228	0.0732	4	0.152	0.0331	17

Note: * Local weight is derived from judgments with respect to a single criterion
**Global weight is derived from multiplication by the weight of the criteria

The 16 respondents of this study are actively involved in container shipping and have worked in the liner shipping industry for over 10 years. Thus, they had sufficient practical experience to answer the questions and to ensure the reliability of the survey findings. Among the 16 respondents, five were senior managers working for the TIPC, seven were managers working for various container shipping carriers and four were employees working for research institutes, namely the Harbor and Marine Technology Centre of the Department of Transportation and the Department of Shipping and Transportation Management at National Kaohsiung Marine University.

The local weights of each factor are shown in Table 4. Results indicate that adjusting the shipping policy (F1, 0.270) was perceived by the whole sample as the most critical factor in improving port resilience, followed by increasing incentives (F4, 0.264), adjustment of the port operational strategy (F2, 0.237), and exploiting market opportunities (F3, 0.229). Specifically, those employees from the research institute also perceived adjusting shipping policy as the most critical factor. In contrast, adjusting the ports' operational strategy (F2, 0.277) and increasing incentives (F4, 0.321) were perceived by the representatives of the TIPC and shipping carrier firms as the most important strategies, respectively. It is important to note that the weight ranking judged by the TIPC and shipping carrier employees was completely different. The major reason could be that the TIPC and shipping carriers' viewpoints are those of the supplier and the customer, respectively. The shipping carrier managers thus perceived the increase of incentives as the most important factor for enhancing the Kaohsiung port's economic resilience. Additionally, leasing a terminal has been viewed as a burden for terminal operators in the circumstance of cargo sources being insufficient. Therefore, if the TIPC cannot provide incentives to attract container carriers, only local container carriers, such as YML, EMC and WHL, will lease a terminal in Taiwan. Conversely, foreign shipping carriers will cease their operations in the Kaohsiung port.

Table 5 shows the local and global weights of each attribute. The global weights were synthesised from the second level down by multiplying the local weights by the corresponding criterion in the level above and adding them to each element in a level according to the criteria affected. The findings show that training of international marketing personnel (A33, 0.0627); economic deregulation of the shipping market across the Taiwan-Strait (A11, 0.0626) and subsidising the throughput of containers transhipment (A43, 0.0612) were perceived by the entire sample as the three most critical strategies in improving the Kaohsiung port's resilience. With respect to the TIPC, the alteration of dedicated terminals for the rental system was judged as a crucial indicator (A25, 0.0706). On the other hand, training of international marketing personnel (A33, 0.0776) and expansion of cargo resources through regional trade agreements (A14, 0.1069) were perceived by the shipping carrier and research institute employees as the most crucial strategies, respectively.

6. DISCUSSIONS AND CONCLUSIONS

This study proposes an AHP model for decision makers to evaluate the importance of various strategies to improve the Kaohsiung port's resilience. The main findings of this study are twofold. First, drawn from the data of frequency of sailings and liner service routes published by the CI yearbook, the structural changes to the route networks in the East Asian region have been presented. The results show that the vulnerability of the Kaohsiung port has increased and consequently, it lost its mega hub port position because of container vessel upsizing and the daily frequency service. Thus, it is imperative for container port authorities to formulate resilience strategies to decrease their vulnerability and improve their adaptive capability.

Second, this study proposes a policy-making framework for enhancing port economic resilience in the case of the Kaohsiung port and demonstrates that adjusting shipping policy is the most crucial strategy to enhance the resilience of the Kaohsiung port, followed by increasing subsidies, changing port operational strategies and exploiting market opportunities. Moreover, the training of international marketing personnel, the economic deregulation of the shipping market across the Taiwan-Strait and subsiding the throughput of containers transhipment were perceived by the container shipping executives as crucial strategies to enhance port resilience.

This study has several practical implications for the TIPC and government administrators. First, given the fact that adjusting the shipping policy appears to be the most crucial strategy to enhance the Kaohsiung port's resilience, the Taiwanese government must continue negotiating with mainland China regarding the economic deregulation of the shipping market and fleet capacity. Specifically, allowing foreign shipping carriers to carry cross-strait transhipment cargo could mean that the former continue to lease the terminal in the Kaohsiung port and treat this as a mega hub port in the East Asia region. If the limitation of foreign shipping carriers carrying transhipment cargo cannot be eliminated, this study suggests that the Taiwanese government should adopt Hong Kong's model. This model views the service route between Hong Kong and Taiwan not as a cabotage issue in 1997 and allowed foreign carriers to operate in the service route. Thus, the trunk routes between Taiwan and China should also be defined as a *special route*, and both foreign and domestic shipping carriers were freely allowed to move between the ports across the Taiwan Strait.

Second, favourable incentives and subsidies are also needed to increase the number of container carriers' call at the Kaohsiung port. In this way, trunk route and feeder route vessels are likely to call here more often, which in turn will increase the port's transhipment cargo. Finally, Taiwanese port authorities, who adopted an organisational change in the ownership of the ports and formed the TIPC in March 2012, could be more flexible in their strategic operations. Thus, they should train international marketing talents and work with members of the logistics industry to provide a one-stop logistics service.

One of the major contributions of this study is that it proposes an economic resilience policy-making framework for a container port focused in the Asia-Pacific region. Moreover, this study contributes to supporting the design of a series of policy measures to enhance container port resilience. Hence, a series of policy measures, such as training of international marketing personnel; economic deregulation of the shipping market across the Taiwan-Strait and subsidising throughput of containers transhipment should be implemented and marketed by government administrators or port authorities to enhance port resilience. Finally, several container ports, such as Kobe, Long Beach and Felixstowe, have become more vulnerable in this dynamic marketplace and a resilience policy-making framework based on this study could be generalised to other ports such as these.

From a theoretical perspective, this study contributes to the literature by proposing a resilience policy-making framework for international container ports. However, it has several limitations. First, methodologically, it uses the AHP process to identify the importance of various resilience strategies and to rank them. The use of regression analysis or structural equation modelling might be helpful in identifying causal relationships between strategies and port resilience or adaptive capacity in a future study. Finally, this study proposes only a three-level hierarchical structure with 19 attributes and focuses solely on the Kaohsiung port in Taiwan. For model generalisation purposes, further studies should take regional factors and other external variables such as market variability and regional competition into account.

In conclusion, this paper is the first to empirically identify crucial economic resilience strategies and to propose a framework for enhancing a container port's economic resilience in the Asia-Pacific region.

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APPENDIX

Table A1: [Pairwise comparison judgment matrix and relative weights with respect to the goal]

Goal	F1	F2	F3	F4	Relative Weights
F1	-	1.12333	1.09890	1.10493	0.270
F2		-	1.01668	0.90768	0.237
F3			-	0.79905	0.229
F4				-	0.264

Note: Consistency ratio = 0.001711469 (λ =4.004569622, C.I.=0.001523207)

Table A2: [Pairwise comparison judgment matrix and relative weights with respect to shipping policy adjustment (F1)]

Goal	A11	A12	A13	A14	A15	Relative Weights
A11	-	1.23186	1.36718	1.14385	1.12162	0.232
A12		-	1.13038	1.06273	1.16283	0.204
A13			-	0.86036	0.96791	0.176
A14				-	1.03335	0.199
A15					-	0.189

Note: Consistency ratio = 0.001184091 (λ =5.005257364, C.I.= 0.001314341)

Table A3: [Pairwise comparison judgment matrix and relative weights with respect to port operational strategy (F2)]

Goal	A21	A22	A23	A24	A25	Relative Weights
A21	-	0.78007	1.01440	0.95044	0.78261	0.179
A22		-	1.12175	1.24866	0.88639	0.218
A23			-	0.94603	0.81722	0.184
A24				-	0.71775	0.182
A25					-	0.238

Note: Consistency ratio = 0.001100238 (λ =5.004885056, C.I.= 0.001221264)

Table A4: [Pairwise comparison judgment matrix and relative weights with respect to exploiting market opportunities] (F3)

Goal	A31	A32	A33	A34	Relative Weights
A31	-	0.97859	0.91507	1.00769	0.243
A32		-	0.86096	1.03080	0.244
A33			-	1.14288	0.274
A34				-	0.239

Note: Consistency ratio = 0.000242655 (λ =4.000647889, C.I.=0.000215963)

Table A5: [Pairwise comparison judgment matrix and relative weights with respect to increasing incentives (F4)]

Goal	A41	A42	A43	A44	A45	Relative Weights
A41	-	0.96823	0.80292	1.04523	0.87169	0.186
A42		-	0.77996	1.13190	0.96821	0.194
A43			-	1.27335	1.05262	0.232
A44				-	0.78528	0.175
A45					-	0.214

Note: Consistency ratio = 0.000636328 (λ =5.002825298, C.I.= 0.000706325)

