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Knowledge Management and the Development of Maritime Research Institutes

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Abstract This study first reviews the structures and services of several leading maritime research institutions and then employs the knowledge management model to assess the performance of the existing maritime research institutes in Taiwan. Maritime research institutions(MRI) in Taiwan belong to one of the following three types of organization: a government-supported organization, a non-profit corporation (NPC), and a private consulting firm. Finally, based on a comprehensive questionnaire survey and post-survey interviews with shipping professionals, the best type of maritime research organization is proposed. This study employs the AHP (Analytic Hierarchy Process) technique to propose and develop an appropriate type of maritime research institution in Taiwan. However, a maritime research institution cannot perform well without an appropriate knowledge management structure. Thus, this research aims to evaluate the performance differences between three types of maritime research institutions. The hierarchical structure is composed of three major criteria: knowledge creation, knowledge storage, and knowledge application. These three major criteria comprise nine sub-criteria: data collection, data mining, knowledge collaboration, data security, data integration, data transfer, information sharing and exchange, advisory planning, and innovation promotion. Using these nine sub-criteria the 30 surveyees were asked to evaluate the performance of the three types of shipping research institutions. The authors found non-profit corporations have the highest overall performance, followed by private consulting firms and lastly, government agencies. The research findings could be used as a road map if a new maritime research institution has to be developed in the fast growing maritime economics. These findings can also be used by the extant maritime research organizations to improve their performance on those sub-criteria and criteria with the greater degree of importance.

Keywords: Knowledge management, maritime research institutions, AHP

1. Introduction

A strong maritime nation needs not only a strong commercial freight vessel fleet, but also a well founded maritime university and research organizations. In Taiwan, several universities and colleges provide courses on maritime business studies, and their academic curricula basically include port, ship, and logistics management. Course designs of maritime studies are supervised by the Ministry of Education to control the quality of the teaching. One of the most important functions of maritime research institutes is to provide shipping and port information

and manage themaritime knowledge they possess. Thus, knowledge management is an important issue to the maritime research institutes; however, to the best of the authors' knowledge, this topic has not been discussed before. As many large ocean carriers are headquartered in the Asian Pacific region, carriers in the Asian region are obtaining a strong foothold in the global shipping industry. However, few well-known maritime research institutes are based in Asian except Maine-Net of Japan and Chinese Shipping Net of China. How to build up and maintain a good maritime institute is a matter of urgency for many experts in the Asian maritime industry. The knowledge management technique is broadly used for the identification, capture, and leverage of knowledge (Manasco, 1996), and it is appropriate to apply it to evaluate the performance of different types of maritime research institutes in Taiwan.

2. Theoretical development and literature review

2.1 Definition of Knowledge Management

Nonaka (1994) and Tiwana and Ramesh (2001) indicated there are two major criteria ofknowledge in organizations, namely, tacit and explicit.An organization is not only an information-processing unit but also a knowledge-creating entity (Nonaka, Toyama and Nagata, 2000).Knowledge management(KM) includescoding, storing, and transmittingknowledge in organizations. It isalso argued that it is the capability to create and to utilize knowledge that is the most important source of a firm's sustainable competitive advantage (Alavi and Leidner, 2001). KM processes comprise three steps: acquisition, creation, and sharing (Rusly, Corner and Sun, 2012), with knowledge sharing being the last but by no means the least important step in KM processes. Chua (2004) identified three levels in the KM system, namely, the fundamental service, the knowledge service, and the display service. The fundamental service contains storage and communication functions; the knowledge service contains knowledge creation, knowledge sharing, and knowledge value added functions; and the display service contains individualized display and visualized display functions. Interactive Web 2.0 technology is one of the enablers of mobile KM; it allows knowledge transmission and sharing to take place in a real time manner. Web 2.0 allows users to mutually cooperate and interact in a social media platform, and makes it possible for all usersto createand generate content in a virtual community. However, the Web 2.0 platform is still not available among major maritime research institutes' databases.

2.2 Elements of Knowledge Management

Plessis (2005) studied what drives KM in today's business environment, and indicated that some of the possible drivers of KM include geographically dispersed work environments; the increased volume of knowledge available to organisations;

the advent of new technologies, including the Internet; the need for quick and efficient decision-making; and knowledge attrition. Taiwan and Ramesh (2001) stated that KM system objectives include (1) finding knowledge, (2) creating new knowledge, (3) packaging and assembling knowledge, (4) applying knowledge, and (5) reusing and revalidating knowledge. Corresponding technology enablers of these KM objectives include (1) using search-and-retrieval tools that scan both formaland informal sources of knowledge; (2) collaboration support tools, rationale capture tools, decision repositories, and externalization tools; (3) customized publishing tools, information-refinery tools, pushtechnology, and customized discussion groups; (4) search, retrieval and storage tools to help organize and classifyboth formal and informal knowledge; and (5) customer-support knowledge bases, services discussion databases, project databases, and communities of practice. Organizational processesof a KM technology framework are supported by publishing, distribution, nonintrusive capture, communication, dialogue, informal conversations, knowledge maps, data mining,tacit knowledge capture,brainstorming, knowledge discovery, collaboration, coordination, distribution, and connectivity. Thomas et al. (2001) claimed that KM is the problem of capturing, organizing, and retrieving information, evoking notions of data mining, text clustering, databases, and documents. Collins et al. (2010) studied and confirmed the inter-relationship between KM, supply chain technology investments, and overall firm performance.Cowie et al. (2009) employed a mobile KM and decision support system to assist archaeologists in dealing with soils. Dean (2005) indicated there are six elements for successful KM: (1) defining the business goals of the KM system; (2) performing a knowledge audit; (3) creating a visual map; (4) developing a KM strategy; (5) purchasing or building appropriate tools for capturing, analyzing, categorizing and distributing knowledge; and (6) periodically re-assessing the value of the KM system. To sum up, a KM structure comprises three major criteria that can be divided into nine sub-criteria (as shown in Table 1).

Table 1 Hierarchical Structure of Knowledge Management

Major criteria	Sub-criteria
Knowledge creation	data collection, data mining, collaborative operations
Knowledge storage	data safety, data integration, data distribution
Knowledge application	data sharing, consultancy planning, innovation promotion

Source: compiled by this research.

3. Development of maritime research institutions

3.1 International Maritime Research Institutions

The organization structure and research scopes of five major internationally renowned maritime research institutions along with their departments' functions

and capabilities are summarized in Table 2. These five institutions are all headquartered in traditional maritime countries.

Table 2 Structure, functions, & capability of major international maritime research institutions

Structures / Title of Institutions	Organizational structure	Research Scopes	Departmental Functions	Capability
Institute of Shipping Economics and Logistics (1954 founded in German)	A non-profit corporation with logistics system, maritime economics, logistics information department, publishing departments and a library.	Logistics information distribution, shipping market forecast, software R&D, logistics models & management consultancy.	Logistics Dept.: integration &planning. Transport Economic Dept.: market analysis & forecast. Information Dept.: optimization, simulation, &auto ID technique	Simulation & optimization, transport system planning, knowledge management, monitoring & tracking, e-commerce, and logistics information planning.
Astrup Fearnley (1869 founded in Norway)	A private corporation with bulk shipping broker, offshore shipping service, consultancy, and publishing departments.	Shipping , offshore service, energy & finance	Tramp shipping dept.: brokerage. Operation dept.: logistics &maritime operation consultancy. Publishing dept.: books & journal publishing.	Bulk cargo & oil databank, offshore operation service, ship valuation & brokerage, M&A finance planning

Drewry Shipping Consultants (1970 founded in the U.K.)	Private corporation with industrial consultancy and publishing departments	Logistics & SCM, shipping strategy, bulk shipping & port management.	Industry consultancy : industry analysis &corporate strategy. Journal publishing.	Strategy & financial planning, industry survey, technical operation.
Clarkson Group (1852 founded in the U.K.)	Private corporation with brokering, financial, operation support, and R&D departments.	Bulk shipping brokering, S&P brokering, R&D on financial and shipping market	Brokers : Bulk shipping chartering with S&P finance Operation department : maritime operational support, journal publication.	Ship maintenance &repair arrangement, finance consultancy, bulk shipping & brokering, LNG application abroad, port and shipping agency.
Marine Net (2000 founded in Japan)	Private corporation with major Japanese general trading company invested in the Marine Net.	Shipping, NBs leasing and second hand vessel S&P, ocean weather forecast.	Liner & bulk shipping report, and newbuildings order and delivery report.	Web capability: Marine Net website. Databank technique: KP Database.

Source: compiled by this research.

3.2 Maritime Research Institutions (MRIs) in Taiwan

Taiwan is the 7th largest ship-owning economy in terms of the total deadweight of its fleet (UNCTAD, 2012). There are three famous maritime research institutions currently operating in Taiwan (see Table 3). The first two have many decades of operation history, while the third, the Taiwan Association of Maritime Safety & Security, is a new institution with ambitious development goals. Thus far, there is no local maritime research institution incorporated as a private consulting firm.

Table 3 Structure, functions, & capability of major maritime research institutes in Taiwan

Title of MRIs	Organizational Structure	Research Scope	Dept. Functions	Technical Capability
Harbor & Marine Technology Centre (HMTC), Institute of Transportation, MOTC	Government agency with three research subsections, a director, a deputy director, and a chief secretary.	Harbor construction, Coastal development, ocean weather information, and port management.	Section 1: Harbor construction & design. Section 2: ocean weather information Section 3: port management & coastal development	Harbor Environment Information System Integration and Application, Electronic chart, Harbor environment monitoring.
Chinese Maritime Research Institute	A non-profit corporation with research, planning, and publishing committees.	Shipping market report,shipping technology management, and project consultancy	Research committee: research, planning committee: training publishing committee: Journal publishing	Ship M&R planning, maritime law, port policy advice, navigation safety information system development.
Taiwan Association of Maritime Safety & Security	A non-profit corporation with secretary general and assistant researchers.	Sea safety, sea security, sea environment, and risk management.	Team work: research and administration.	Maritime safety and security forum, Taiwan sea safety database.

Source: compiled by this research.

3.3 Taxonomy of Maritime Research Institution (MRI)

In a review of the development of maritime institutions locally and globally, the authors found the extant maritime research institutions can be grouped into three types: government agency, non-profit corporation, and private consultant firm (see Table 4). It was found that most maritime research institutions in the traditional maritime countries are operated as private consulting firms except the German Institute of Shipping Economics and Logistics.

Table 4 Alternatives to set up a MRI

Taxonomy	Title of MRIs
Government Agency	Harbor & Marine Technology Centre of the Institute of Transportation of the Ministry of Transportation and Communication.
Non-Profit Corporation	Chinese Maritime Research Institute, Taiwan Association of Maritime Safety & Security, Institute of Shipping Economics and Logistics
Private Consulting Firm	Astrup Fearnley, Drewry Shipping Consultants, Clarkson Group, Marine Net

Source: compiled by this research.

3.4 Organizational Structure of Maritime Research Institutes (MRI)

According to the review of the five international well-known MRIs and three local major MRIs in Taiwan, the departmental structures of MRIs and their functions are summarized and shown in Figure 1. Basically, the following three departments are the basis for most of the MRIs: data collection and research department, consulting department, and information and publishing department (see Figure 1).

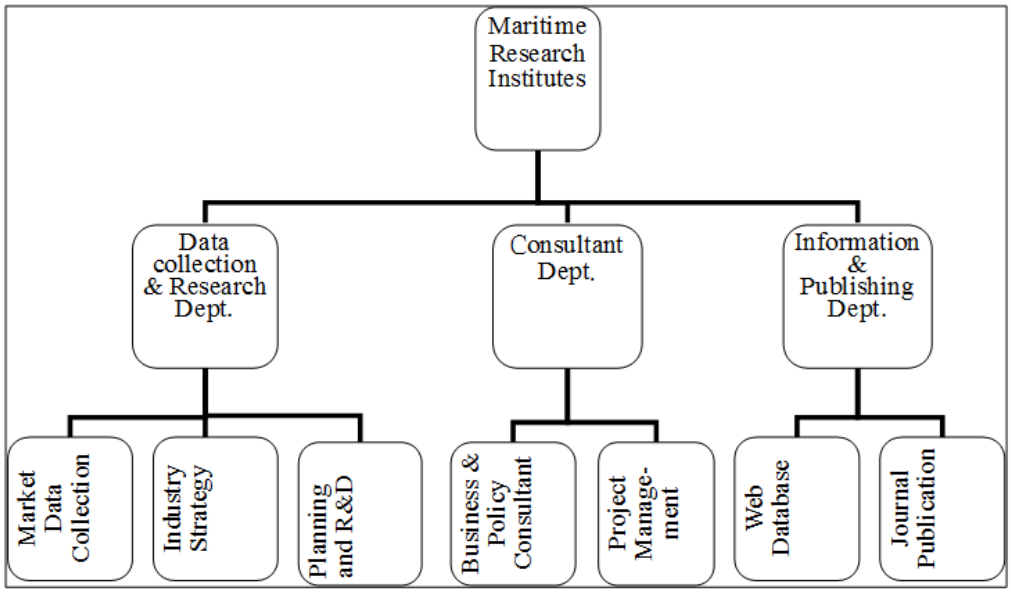

Figure 1 Possible Organizational Structure of Major Maritime Research Institutes Worldwide
Source: Compiled by this research.

3.5 Research Methodology and Structure

The AHP technique is employed to investigate the perception of executives/experts in the shipping industry regarding the importance of the nine criteria for the building up of an appropriate maritime research organization in Taiwan. The AHP technique was first proposed by Saaty (1977), and there are four major steps in implementing this technique. (1) reviewing the literature and summarizing the influence of the sub-criteria on the decision-making process, (2) grouping similar sub-criteria into one major criterion, (3) ensuring criteria in the same level of a hierarchy have a low level of correlation with each other, and (4) making a pairwise comparison of the sub-criteria and criteria in the same level of a hierarchy to obtain the relative degree of importance of the sub-criteria and criteria for the decision-making process.

Questions regarding pairwise comparison were included in a questionnaire according to the following research structure (see appendix). There are three measurement criteria under the goal: knowledge creation, knowledge storage, and knowledge application. Each criterion contains three performance sub-criteria (see Figure 2).

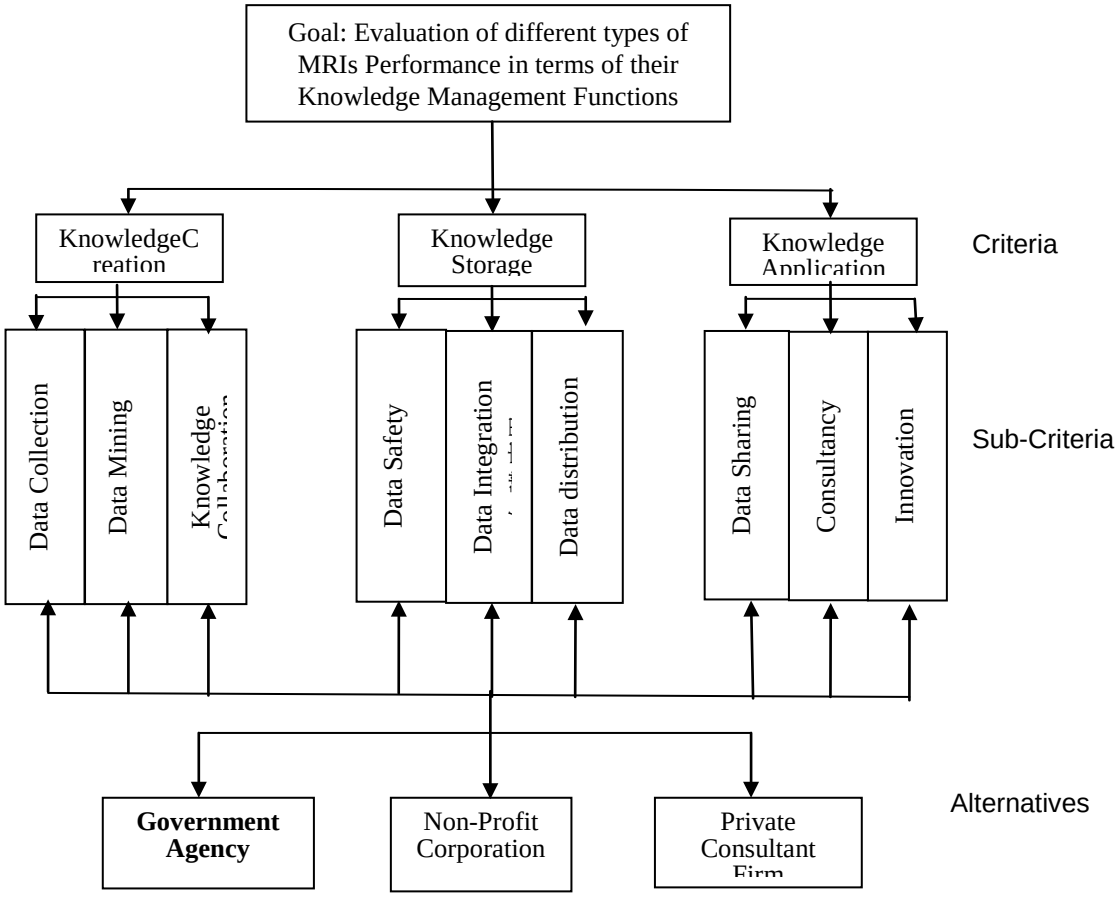

Figure 2 Hierarchical Measurement Structure of MRI's Performance
Source: this research

4. Research Processes and Findings

4.1 Questionnaire administration

Thirty-three copies of the questionnaire were posted, of which thirty copies were returned (see Table 5); onlysix of these met the inconsistency test requirement (see Table 6).

Table 5 Profile of the Returned Questionnaires

Respondents' organization	Copies of questionnaire distributed	Copies of questionnaire returned
Evergreen Marine Corp.	3	2
K-Line (Taiwan)	5	5
Wan-Hai Lines	2	2
Asia Pacific Logistics International Co.	5	5
APL	3	3
Maersk Lines (Taiwan)	1	1
Chinese Maritime Research Institute	1	1
China Maritime Institute	1	1
Kaohsiung Customs Bureau	8	6
Taiwan Shin Sheng Shipping Daily News	1	1
China Daily Shipping News	1	1
Dong Hwa University	1	1
Sun Yat-Sen University	1	1

Source: this research

Table 6 Overall inconsistency ratio of the 30 returned questionnaires

PID	Name	Overall Inconsistency
0	Facilitator	0.2518
2	P2	0.3138
3	P3	0.249
4	P4	0.2559
5	P5	0.0099
6	P6	0.0024
7	P7	0.2355
8	P8	0.1633
9	P9	1.7472
10	P10	0.2826
11	P11	0.4956
12	P12	0.1336
13	P13	0.4333
14	P14	0.0186
15	P15	0.3073
16	P16	0.000
17	P17	0.2372
18	P18	0.0023
19	P19	0.168
20	P20	0.5529
21	P21	0.2712
22	P22	0.2104
23	P23	0.2107
24	P24	0.2046
25	P25	0.0287
26	P26	0.1879
27	P27	0.5005
28	P28	0.308
29	P29	0.3522
30	P30	0.2348

Source: this research

4.2 Research Findings

The absolute weight (global weight) of the nine sub-criteria and three major criteria influencing the performance of an MRI are exhibited in Table 7. Overall performance of the three types of organizations is calculated according their sub-criteria's weights as found in Table 8, and these are shown in Figure 3. The non-profit corporation is found to be the best performer as it outperforms the other two types of MRIs on the information distribution criteria, which has the highest degree of importance among the three KM criteria.

Table 7 Absolute Weight of the Nine Sub-criteria and Three Criteria of Knowledge Management

Goal	Criteria	Sub-criteria			Ranking of the weight of importance
Evaluation the Performance of Taiwan MRIs	Knowledge Creation 0.298	Data Collection	0.354	0.106	5
		Data Mining	0.259	0.077	8
		Knowledge Collaborative Operation	0.387	0.115	3
	Knowledge Storage 0.241	Data Safety	0.371	0.089	6
		Data Integration	0.343	0.083	7
		Data Distribution	0.287	0.069	9
	Knowledge Application 0.461	Sharing	0.399	0.184	1
		Consultancy	0.236	0.109	4
		Innovation Promotion	0.364	0.168	2

Source: this research

Table 8 Performance Score of the Three Types of MRIs on the Nine Sub-Criteria and Three Major Criteria

Sub-Criteria Major Criteria	Government Agency (GA)	Non-Profit Corporation (NPC)	Private Consultancy (PC)	Best Performer
Knowledge Creation	0.299	0.348	0.353	PC
Knowledge storage	0.371	0.347	0.282	GA
Knowledge application	0.292	0.354	0.354	NPC & PC
Data collection	0.292	0.335	0.373	PC
Data Mining	0.257	0.328	0.414	PC
Knowledge collaborative operation	0.330	0.372	0.299	NPC
Data safety	0.459	0.273	0.268	GA
Data integration	0.330	0.344	0.327	NPC
Information distribution	0.325	0.445	0.230	NPC
Sharing	0.416	0.358	0.226	GA
Consultancy planning	0.215	0.375	0.410	PC
Innovation promotion	0.195	0.334	0.471	PC

Source: this research.

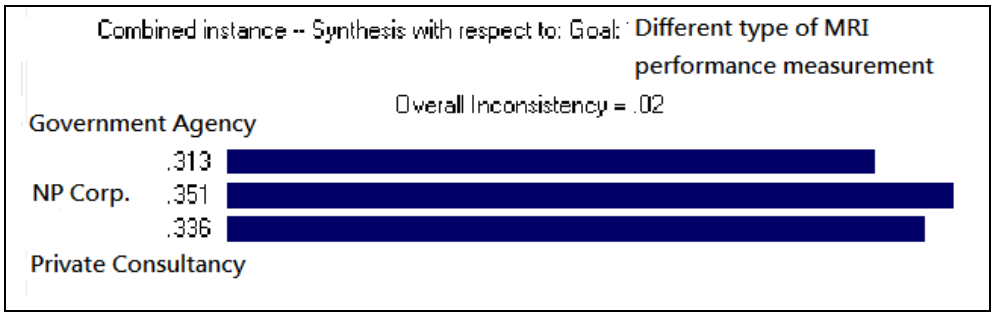

Figure 3 Overall Performances of the Three Types of MRIs
Source: this research.

5. Conclusions and Suggestions for Future Research

5.1 Conclusions

Maritime research institutions are the heart of the shipping industry, and most major traditional maritime countries have at least one major maritime research institution. Emerging maritime powers, such as China and Korea, are building and promoting their major maritime research institutions. Taiwan is no exception, and it is considering improving the performance of its original maritime research institutions. At the same time, it wants to set up a large maritime research institution in Kaohsiung where the largest Taiwanese port is situated. From the KM viewpoint, knowledge sharing has the highest degree of importance to influence the overall performance perceived by its potential users. The development of Web 2.0 enables users to share their information with other users. Thus, any future maritime research institution should reinforce its website contents to make experts' collaborative operations and users' sharing functions available on their websites on the basis of 'the more you give, the more you have'. Sharing is not only a benefit but has become a necessity in modern maritime research institutions in terms of KM. Closed loop and paid websites provided by the maritime research institutions in the traditional maritime countries will soon face their performance ceiling as they are not willing to share their knowledge with non-paying users.
Maritime research institutions in the fast growing maritime economies such as China and Korea as well as Taiwan should move in the other direction, rather than following the traditional maritime countries' suit. The Chinese Maritime Research Institute (CMRI) in Taiwan is now striving to incorporate the spirit of Web 2.0 into its website, thus making all its data accessible to all users across the world, and has worked hard to make collaborative writing and operations possible over its future website.

5.2 Suggestions for Future Research

As this research surveys only potential users in Taiwan, a survey of potential users in the major maritime nations to generalize the research findings is encouraged. A comparative study on the development pattern of the maritime research institutes in the traditional maritime countries in Europe and the emerging maritime powers in Asia could also generate more fruitful research results in the future.

Appendix

『STUDY OF KNOWLEDGE MANAGEMENT AND THE DEVELOPMENT OF MARITIME RESEARCH INSTITUTES』

Dear Director/President/Executive,

I am an associate professor at National Taiwan Ocean University. I am writing to you to ask if you would kindly participate in a survey to measure the performance of the three types of maritime research institutes (MRI) and the importance of the nine sub-criteria influencing the overall performance of an MRI. This is an academic study, and the survey results will not be disclosed to any third party. No geographical or other comparisons will make it possible to identify companies by name.

Since there are only a few shipping companies/shipping news/shipping universities in Taiwan, your opinion is vitally important to my academic research. If you are not sure of the answer to a question, please provide your best-estimated response. If you wish to receive a summary of the survey findings, please return the completed tear-off slip below to me separately, and I will be happy to send the summary to you once the research is completed. Please send the slip in a separate envelope if you want to safeguard the anonymity of the questionnaire.

I would like to thank you in advance for your kind participation in this survey.

Yours faithfully,

T.C. Lirn/ Associate Professor, Department of Shipping & Transportation Management,
National Taiwan Ocean University

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Name of Surveyee:____

Correspondence Address: ____

____

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Questionnaire Structure: TheTaiwan government now intends to develop itself into a maritime knowledge hub in eastern Asia. There are three possible types of maritime research institutes (MRIs). An MRI can be a government agency, a non-profit corporation, or a private consulting firm.The research aims to look into the degree of importance of the three major functions (namely, knowledge creation, knowledge storage, and knowledge application) and nine sub-functions (data collection, data mining, knowledge collaboration; data safety, data integration, data distribution, data sharing, consultancy, and innovation) influencing Taiwan's decision to choose one of the three types of MRIs to develop its maritime knowledge hub. Explanations on the definition of the three major functions are shown as below.

（1）Knowledge creation: the process by which shipping knowledge is generated.

（2）Knowledge storage: the storage and transmission of shipping knowledge.

（3）Knowledge application: the distribution and application of shipping knowledge.

II、Explanation and examples of terms and scales used:

If you think criterion (A) is 9 times more important than criterion (B) in our government maritime research organization's developing decision making, then please circle as follows:

CRITERION	Intensity of Relative Importance																	CRITERION
Knowledge Creation (A)	⑨	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Knowledge Storage (B)

Circling ⑨means: From shipping experts'perspective, criterion (A) (Knowledge Creation) has extreme importance for our government maritime research organization's developing decision making when compared with criterion (B) (Knowledge Storage).

If you think criterion (C) is 7 times more important than criterion (B) in our government maritime research organization's developing decision making, then please circle as follows:

CRITERION	Intensity of Relative Importance																	CRITERION
Knowledge Storage (B)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	⑨	Knowledge Applications (C)

Circling ⑨means: From shipping experts'perspective, criterion (C) (Knowledge Applications)is far more important than criterion (B) (Knowledge Storage) when our government measures the degree of performance of a maritime research organization

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Scales of relative importance:

Intensity of Relative Importance	Definition
9	Extreme importance
8	Demonstrated to extreme importance
7	Demonstrated importance
6	Strong to demonstrated importance
5	Essential or strong importance
4	Moderate to strong importance
3	Moderate importance of one over another
2	Equal to moderate importance
1	Equal importance

The survey

Part one: The Criteria Comparison

First Tier Comparison: the relative importance of each major criterion for maritime research institutes' selection decision

CRITERION	Intensity of relative importance																	CRITERION
Knowledge creation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Knowledge storage
Knowledge creation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Knowledge application
Knowledge storage	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Knowledge application

Second Tier Comparison: Relative importance of each sub-criterion for maritime research institutes' selection decision

(1) Knowledge creation: data collection, data mining, and knowledge collaboration.

SUBCRITERION	Intensity of relative importance																	SUBCRITERION
Data collection	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Data mining
Data collection	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Knowledge collaboration
Data mining	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Knowledge collaboration

(2) Knowledge Storage: data safety, data integration, and data distribution.

SUBCRITERION	Intensity of relative importance																	SUBCRITERION
Data safety	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Data integration

Data safety	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Data distribution
Data integration	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Data distribution

(3) Knowledge Application: data sharing, consultancy, and innovation.

SUBCRITERION	Intensity of relative importance																	SUBCRITERION
Data sharing	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Consultancy
Data sharing	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Innovation
Consultancy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Innovation

Part Two: Evaluating major types of Maritime Research Institutes(MRIs)

Please circle one of the five ratio scales 1, 2, 3, 4, 5 to evaluate the performance of the 9 sub-criteria for each type of MRIs. Circling ⑤ means an MRI has the highest possible performance with reference to the specific sub-criterion; Circling ① means the lowest possible performance)

Types of MRIs Sub-Criteria	Government Agency	Non-Profit Corporation	Private Consultanting Firm
Data collection	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Data mining	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Knowledge collaboration	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Data safety	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Data integration	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Data distribution	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Data Sharing	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Consultancy	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Innovation	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Triangle fuzzy set utilized three values to represent a semantic wording.For example, a triangle fuzzy set A can be defined by μ. A. (x) = triangle mf(x,[10,40,60]), where A is the fuzzy set of semantic wording - “Very Poor”.

Circling 1 out of the five ratio scales, it indicates the airport has a very poor performance on the sub-criterion, and the triangle fuzzy set values are (_____, _____, _____).

Circling 2, it indicates the airport has a poor performance on the sub-criterion, and the triangle fuzzy set values are (_____, _____, _____) .

Circling 3, it indicates the airport has a fair performance on the sub-criterion, and the triangle fuzzy set values are (_____, _____, _____) .

Circling 4, it indicates the airport has a good performance on the sub-criterion, and the triangle fuzzy set values are (_____, _____, _____) .

Circling 5, it indicates the airport has an excellent performance on the sub-criterion, and the trapezoid fuzzy set values are (_____, _____, _____) .

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