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COMPARATIVE ANALYSIS ON PORT PERSONNEL SELECTION USING HYBRID ANALYTICAL HIERARCHY PROCESS (h-AHP)

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Abstract: Logistics industry plays an important role in the nation's economic and social opportunities in delivering positive multiplier effects such as improved market accessibility and occupation. Every aspect of logistics, namely maritime logistics is growing not only in specific nation but also globally. This reflects on the need for qualified, innovative and performed individuals to fill the manpower force. This study focuses on specific criteria required for marine logistics personnels especially in port operations and application of multi criteria decicion making approaches (MCDM) in analysing the selection of candidates. The results show that all approaches end up with the same candidate to be the best personnel hence supporting the consistency in decision making.

Keywords: Port personnel, Multi criteria decision making, Analytical Hierarchy process, PROMETHEE, maritime logistics

Introduction (Include Literature Review)

Logistics assists the flow of goods within and ahead of national borders and is deemed a significant component of the modern economy. It is a key enabler for economic sectors such as manufacturing, agriculture, and retails. Therefore, the logistics industry is important as it would improve economic and social opportunities of a nation in delivering positive multiplier effects such as improved market accessibility and occupation. A good business performance measurement system is a very powerful tool to excite and monitor

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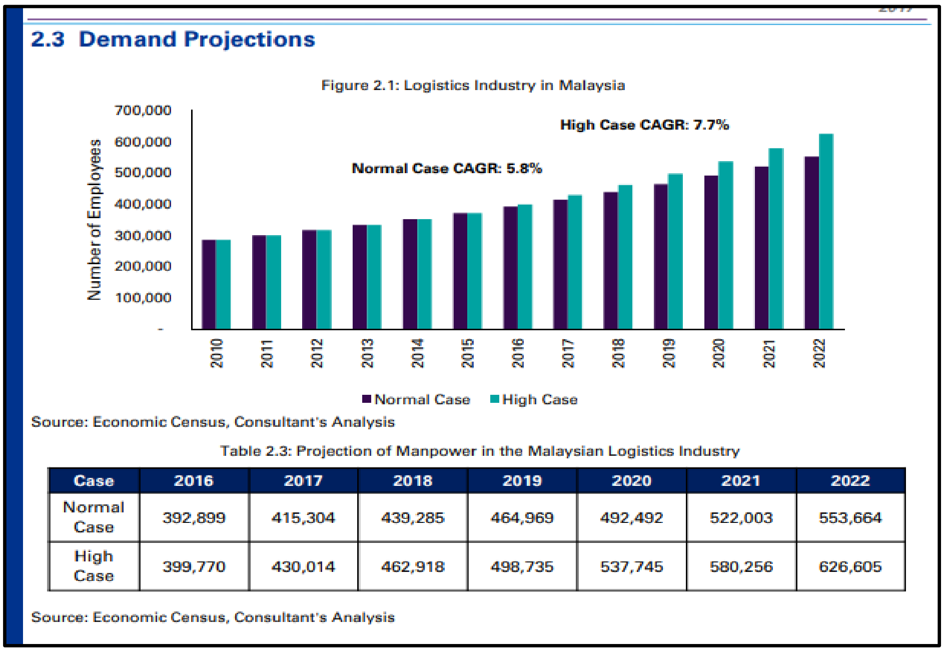
employees of a company. Nowadays, logistics industry has become a critical component in the commercial link, and it is very important on how to find the optimal performance in sea-trade and 90% of global trade in Malaysia is done through marine transport (UNCTAD, 2019).

As the marine logistics industry grow globally, the need for talents and manpower to support the industry also grow. In Malaysia, in order to remain competitive, all industry players need to act fast in line with the development of technology produced through Industry 4.0, hence among the steps that can be taken is by strengthening the education system based on the field of maritime technology. Highly skilled graduates are much needed by the industry especially in the field of software system design and development as well as artificial intelligence program operators (NST, 2017; Cicek et al., 2019). In Malaysia also, the employment market is rigid in nature, where people who have been in an industry for years accumulating specific knowledge and skills are at a loss when they are retrenched because all that hard-earned knowledge is not suitable for other industries (The Malaysian Lawyer, 2020). In this study, several models and criteria for talents and professionals especially for marine logistics industry were considered and adapted to develop performance evaluation model that can be adopted and useful for helping the country to become the marine nation as shown in Figure 1.



Case	2016	2017	2018	2019	2020	2021	2022
Normal Case	392,899	415,304	439,285	464,969	492,492	522,003	553,664
High Case	399,770	430,014	462,918	498,735	537,745	580,256	626,605

Source: Economic Census, Consultant's Analysis

Figure 1: Demand Projections of Manpower for Malaysian Logistics Industry

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Since performance evaluation is something that should be comprehensive while considering a lot of indicators, it should be reliable and consistent. The chosen indicators must be selected carefully and most of the time are weighted subjectively. Different levels of working positions as well as different job scope conjure different opinion and views about the indicators. Qu et al. (2015) have proposed a hybrid model in measuring the performance of professionals in marine logistics industry for their innovation and technology only. In the study, three main criteria are considered namely job performance, work ability and work attitude, followed by several other sub criterias (Lee et al., 2008; Kececi et al. 2015).

Extensive adaptation of multi criteria decision making approach (MCDM) such as Analytical Hiearchy Process (AHP) can be seen in constructing the performance evaluation metrics within various organisations. In this study, in line with the growing needs for talents or manpower In maritime logistics specifically focusing on port personnels, criteria for measuring their performance are explored using various combination of AHP. Hence, the objectives of this study are to adopt various combination MCDM approaches to AHP in evaluating the performance of port personnels and to compare the performance of each of the combinations (Korkmaz, 2019; Demirci & Kilic, 2019; Küçükoğlu et al., 2017; Kececi et al., 2015).

Method

The ultimate goal of this study is to measure the performance of the port personnels based on the three main elements: Job performance, Work Ability and Work Attitude. Table 1 shows the elements to be considered as the indicators for the performance.

Table 1. Performance Indicators for Port Personnels performance

Goal indicator	Level indicator	Secondary Indicators	Tertiary indicators
	Job Performance (V_1)	Productivity(V_{11})	Job experience (V_{111})
			Workplace (V_{112})
			Organization Rule (V_{113})
		Personnel Behaviour(V_{12})	Leadership(V_{121})
			Work Culture(V_{122})
			Effective Communication(V_{123})

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	Work Ability (V_2)	Social Influence(V_{21})	Reputation(V_{211})
			Success Rate(V_{212})
			Referral Centre(V_{213})
		Core Competence(V_{22})	Keen Insight and Flexibility (V_{221})
			Logical Thinking(V_{222})
			Innovation Ability(V_{223})
	Work Attitude (V_3)	Teamwork(V_{31})	Sharing Knowledge(V_{311})
			Cooperation Spirit(V_{312})
			Team Diversity(V_{313})
		Job Satisfaction(V_{32})	Confidentiality(V_{321})
			Responsibility(V_{322})
			Enthusiasm for Work(V_{323})
			Discipline(V_{324})

Data setting

Close-structured questionnaires were distributed to several maritime scholars in Malaysia, Indonesia, Vietnam and Phillippines, so as to gain their views on evaluation indicators or criteria for measuring the performance of port personnels. The expert sampling technique was applied as this technique focuses on getting responses from a group of qualified decision-makers, based on their experience and expertise within maritime logistics industry.

In this study, there are two parts of questionnaire which are Part A and Part B. In Part A, the objective of the questionnaire is to determine the evaluation indicators of the performance in marine logistics industry and also whether the proposed criteria are valid with the requirements from the experts. The respondents are asked to rank the importance of each element and its sub-elements and then are tabulated and examined for its consistencies. In Part B, the objective of this questionnaire is to determine the weightage of the proposed evaluation indicators of the performance evaluation index. Only result from Part B will be used in the study, in which the weightages for ranking are calculated using two MCDM approaches, AHP and PROMETHEE II, and used to evaluate the selected personnels.

Analytical Hierachy Process (AHP)

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The expert respondents are asked to do a two way assessment in order to compare the importance of each sub-element based on Satty's level of importance (Saaty, 1990).

Table 2. Saaty's scale

Scale	Meaning	Explanation
1	Equally important	Two criteria have equal important
3	Weakly important	Experience and judgment slightly favor one criteria over another
5	Strongly important	Experience and judgment strongly favor one criteria over another
7	Very strongly important	A criteria is favored very strongly ver another
9	Extremely important	The evidence favoring one criteria over another is of the highest possible affirmative
2,4,6,8	Intermediate value between adjacent scales	When there is a compromise between the judgment

A two -way assessment comparison yields a reciprocal matrix A, as follows:

$$A = \begin{pmatrix} a_{11} & a_{12} & a_{1n} \\ a_{21} & \ddots & \vdots \\ \vdots & & \\ a_{n1} & \cdots & a_{nn} \end{pmatrix}$$

Each entry of A denotes the relative importance of the decision elements. For example, a_{ij} has a relative importance in the decision element over the decision element j, and vice versa. It is satisfying $a_{ij} = 1 / a_{ji}$. In the next step, the mathematical process begins to normalize and find the relative weight for each matrix. The relative weight of the decision elements can be obtained by calculating the eigenvalue of a normal vector that satisfies the following equation:

$$A \cdot w = \lambda \cdot w \qquad (1)$$

Where λ the eigenvalue is associated with the eigenvector w. Saaty (1980) recommended using eigenvector, $w_{max} = [w_1, w_2, \ldots, w_n]^T$ corresponds to the maximum eigenvalue, λ_{max}, to represent the relative the weight of each of these criteria.

Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE)

Preference function based outranking method is a unique kind of MCDM method that can offer a rating order of the choice options. The PROMETHEE I technique can

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Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/altr

offer the partial ordering of the choice alternatives, whereas PROMETHEE II technique can derive the total rating of many alternatives.

The procedure and steps for PROMETHEE method are listed as follows:

Step 1: Normalize the decision matrix using this following equation:

$$R_{ij} = [X_{ij} - min(X_{ij})]/[max(X_{ij}) - min(X_{ij})](i = 1,2,\dots,n: j = 1,2,\dots,m) \quad (2)$$

Where X_{ij} = performance measure of i^{th} alternative with respect to j^{th} criterion.

For non-beneficial criteria, Eqn. (2) can be rewritten as follows:

$$R_{ij} = [max(X_{ij}) - X_{ij}]/[max(X_{ij}) - min(X_{ij})] \quad (3)$$

Step 2: Calculate the evaluation differences of i^{th} alternative with respect to other alternatives.

This step includes the calculation of differences in criteria value between different alternatives pairwise.

Step 3: Calculate the preference function, $P_j(i, i')$.

But those preferred capabilities require the definition of a few preferential parameters, consisting of the preferred and nonpreferred thresholds. To overcome this problem, the following simplified preference function is adopted:

$$P_j(i, i') = 0 \text{ , } if\ R_{ij} \leq R_{i'j} \quad (4)$$

$$P_j(i, i') = (R_{ij} - R_{i'j}) \text{ , } if\ R_{ij} > R_{i'j} \quad (5)$$

Step 4: Calculate the aggregated preference function considering the criteria weights.

Aggregated preference function, $\pi(i, i') = \left[\sum_{j=1}^{m} w_j \times P_j(i, i')\right] / \sum_{j=1}^{m} w_j \quad (6)$

Where w_j = relative importance of j^{th} criterion.

Step 5: Determine the leaving and entering outranking flows:

Leaving (or positive) flow for i^{th} alternative,

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http://proceedings.itltrisakti.ac.id/index.php/altr

$$\varphi^{+}(i) = \frac{1}{n-1}\sum_{i'=1}^{n} \pi(i, i') \qquad (i \neq i') \tag{7}$$

Entering (or negative) flow for i^{th} alternative,

$$\varphi^{-}(i) = \frac{1}{n-1}\sum_{i'=1}^{n} \pi(i', i) \qquad (i \neq i') \tag{8}$$

Where *n* = number of alternatives

Here, every alternative faces (*n-1*) variety of different alternatives. The leaving flow expresses the magnitude of how the alternative dominates the opposite alternatives. At the same time, the entering flow denotes the magnitude of how an alternative is dominated by the opposite alternatives.

Step 6: Calculate the net outranking flow for each alternative.

$$\varphi(i) = \varphi^{+}(i) - \varphi^{-}(i) \tag{9}$$

Step 7: Determine the ranking of all the considered alternatives depending on the value $\boldsymbol{\varphi(i)}$.

The more the value of $\varphi(i)$, the better the alternative. Thus, the one that having the highest $\varphi(i)$ is the best alternative.

Discussion and Result

The two MCDM approaches are used and tested against a set of data consisting of 7 personnels with orginally have scores on 7 items (Demirci and Kilic, 2019). The items are Education, Personality and Personal Skills, Experience, Technical Skills and Requirements, Foreign Language, Vocational Flexibility and Exam Results. The scores are adapted into 18 sub-elements used in this study as it appears in Table 3.

Table 3: Candidate Scores based on 18 items

Criteria	Sub elements	Cand1	Cand2	Cand3	Cand4	Cand5	Cand6	Cand7
JOB PERFORMANCE (V_1)	V_{111}	55	10	48	21	32	50	41
	V_{112}	37	56	23	28	30	17	17
	V_{113}	8	31	26	48	38	33	42

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Advances in Transportation and Logistics Research
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	V_{121}	65	49	17	28	42	18	46
	V_{122}	22	13	51	39	32	43	21
	V_{123}	13	38	32	33	26	39	33
WORK ABILITY (V_2)	V_{211}	22	86	58	37	54	47	22
	V_{212}	50	22	38	78	73	72	46
	V_{213}	108	52	54	60	23	37	53
	V_{221}	27	15	36	15	0	5	3
	V_{222}	34	44	31	47	8	6	6
	V_{223}	39	41	28	18	2	4	11
WORK ATTITUDE (V_3)	V_{311}	10	34	16	21	17	34	12
	V_{312}	43	34	25	41	31	18	35
	V_{313}	32	17	34	18	17	18	3
	V_{321}	34	31	25	47	44	12	40
	V_{322}	44	38	38	40	11	59	37
	V_{323}	22	31	37	13	45	29	23

Result on AHP

The weights of each sub-element are calculated and summarised in Table 4.

Table 4: Summary of weightage for each sub-element

Criteria & Sub-elements		Weightage	Criteria & Sub-elements		Weightage
JOB PERFORMANCE (V_1)	V_{111}	0.228	WORK ATTITUDE (V_3)	V_{311}	0.316
	V_{112}	0.288		V_{312}	0.429
	V_{113}	0.484		V_{313}	0.254
	V_{121}	0.508		V_{321}	0.392
	V_{122}	0.100		V_{322}	0.245
	V_{123}	0.392		V_{323}	0.363
WORK ABILITY (V_2)	V_{211}	0.305			
	V_{212}	0.379			
	V_{213}	0.316			
	V_{221}	0.159			
	V_{222}	0.175			
	V_{223}	0.665			

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http://proceedings.itltrisakti.ac.id/index.php/altr

Using the calculated weightage in Table 4, the performance of the personnels in Table 3 are ranked using decision matrix in equation 1. The ranking of the personnel is tabulated in Table 5 and it can be seen that Cand2 is the most preferred candidate.

Table 5. Priority Vector Values for Personnels based on the weightage

	(V_1)	(V_2)	(V_3)	**Priority Vector**	**Rank**
Weightage	0.298	0.142	0.560		
Cand1	0.137764	0.208326	0.14967	0.9912	2
Cand2	**0.161111**	**0.201575**	**0.156688**	**1.0384**	**1**
Cand3	0.122197	0.17712	0.144358	0.8870	4
Cand4	0.145984	0.15791	0.14799	0.9035	3
Cand5	0.146964	0.079818	0.146449	0.7462	5
Cand6	0.131985	0.089356	0.134309	0.7111	7
Cand7	0.153995	0.085894	0.120537	0.7206	6

PROMETHEE

Instead of using weightage, PROMETHEE method uses the act of giving preference to more dominant criteria. The leaving and the entering flows for all candidates are then computed using Equation (6) and (7) respectively. The net outranking flow values for every candidate and their relative ranking are given in Table 6. The best candidate that scores highest net outranking flow is Candidate 2 (C2) while the worst candidate who scores the lowest net outranking flow is Candidate 6 (C6).

Table 6. Net outranking values for every candidate

	Leaving flow	Entering flow	Net Outranking	Ranking
Cand1	0.296	0.216	0.08084487	2
Cand2	0.301	0.146	0.15517387	1
Cand3	0.198	0.205	-0.0071449	4

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Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/altr

Cand4	0.230	0.160	0.07030348	3
Cand5	0.172	0.233	-0.0606561	5
Cand6	0.161	0.295	-0.1346528	7
Cand7	0.129	0.233	-0.1038684	6

COMPARATIVE ANALYSIS

In order to check for consistencies in the results, the ranking from both methods are compared against the results in Demirci & Kilic (2019) using ELECTRE, another MCDM method. Spearman Spearman's rank-order correlation (ρ, also signified by r_s) test is used to determine the strength and direction of the **monotonic relationship** between the two data sets. Since there is not tied ranks within the data set, the Spearman's correlation is calculated as such:

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \quad (10)$$

Table 7. Comparative analysis among MCDM approaches

	Demirci & Kilic (2019)	AHP	PROMETHEE	Difference (d)	Diff^2 (d^2)
Cand 1	1	2	2	-1	1
Cand 2	3	**1**	1	2	4
Cand 3	6	4	4	2	4
Cand 4	2	3	3	-1	1
Cand 5	5	5	5	0	0
Cand 6	4	7	7	-3	9
Cand 7	7	6	6	1	1
Total				**0**	**20**

Based on the ρ value is calculated to be 0.643 compared to the critical value of 0.786 from Spearman Rho table (Ramsey, 1989). Since the table contains critical values for two-tail tests and the calculated value is less than the critical value, hence it is concluded that the null hypothesis (there is no correlation) should be rejected. Hence, it can be concluded that there is correlation between the data sets as to indicate the similarity in ranking the candidate.

Conclusion

As the marine logistics industry has become a critical component in the commercial link, the need for performed talents and manpower to support the industry is of competitive advantage to the nation. This study explores the criteria for needed talents in view of port logistics experts using the MCDM approaches, AHP and PROMETHEE II. The two approaches are selected based on its ability to consider many criteria simultaneously as well as considering the subjective judgement of importance by the participating experts.

Results show that both approaches are consistent in providing guidelines for selecting the personnels, hence can be enhanced further for more accurate analysis as well as better decision making. Hence, this calls for further research on several related issues in order to ensure the performance criteria used for evaluating the marine logistics practitioners in the South China sea operations.

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