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Analytic Evaluation of Intellectual Capital for Ship Management Companies Under a Fuzzy Environment

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Abstract

To determine the market value of a ship management company, apart from its book value, it is necessary to also know its intellectual capital. The impact of this type of capital is evident, especially for ship management companies that are service-based. If these businesses follow the intellectual capital level and managers determine the necessary strategies based on this, these companies, which compete internationally beyond ensuring the continuity of their businesses, can stay one step ahead of their competitors. The purpose of this article is to provide an analytical perspective for ship management companies to evaluate their intellectual capital. In this context, the study adopts the analytical hierarchy process in the environment of fuzzy sets to increase sensitivity. Based on the analysis results, the most important intellectual capital elements for ship management companies are "human capital" as compared to "structural capital" and "relational capital" elements. As the key performance indicators applied for evaluation may differ according to enterprises, group performance indicators to be evaluated in the measurement of the elements were determined. The indicators related to human capital were more weighted than the others. This study guides not only the evaluation of the intellectual capital of ship management companies but also the determination of new strategies by managers for the development and valuation of companies.

Keywords: Intellectual capital, Valuation, Performance measurement, Fuzzy AHP, Ship management

1. Introduction

For the first time in 1969, John Kenneth Galbraith defended a thesis stating that intellectual capital is the entirety of intellectual activities [1]. Then, in 1975, Michael Kalecki used this term in a statement: "I wonder if you realize how much those of us the world around have owed to the intellectual capital you have provided over these past decades." "I wonder how many of us are conscious of the intellectual capital we have acquired over the past few decades?" The first scientific study on the concept is the book "Mobilizing Invisible Assets," written by Japanese scientist Hiroyuki Itami [2] in 1980 and translated into English in 1987.

The concept was used for the first time in an organizational sense in the article "Brainpower," written by Fortune Magazine Editor Thomas A. Stewart in 1991, with the expression "a hidden treasure to be discovered" and "the sum of everything that employees know, giving the business a competitive advantage in the market" [3]. Stewart [4] explained the concept of intellectual capital as "obtained useful knowledge" in his work titled "Intellectual Capital: The New Wealth of Organizations" published in 1997. He stated that intellectual capital includes data on customers and suppliers, organizational processes, information technologies, brands, patents, and employee knowledge-skills.

Thomas Stewart defines it more broadly than others: "Intellectual capital is all the intellectual materials that the business puts to use to create wealth, such as knowledge, information, intellectual property, skills, and experience of employees. Intellectual capital is the sum of all the assets in a company that are known to people and that gives the company a competitive advantage" [4].

Intellectual capital is generally the difference between a company's book value and what it is willing to pay for that value. It is a phenomenon that includes assets that are

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not seen in balance sheets. To measure the unmeasured, knowledge draws attention as a concept used to determine the relationships between people and ideas with all its dimensions.

In sum, intellectual capital is the sum of invisible assets that cannot be fully obtained from a business balance sheet and is the main source of ensuring the permanence of the competitive advantage of enterprises. The management of the intellectual capital of an enterprise is an important managerial responsibility. The increase or decrease in intellectual capital can be called intellectual performance and can be measured and made visible. A systematic approach to measuring and making visible intellectual capital is becoming increasingly valuable regardless of the type, size, structure, owners, and geographic location of businesses [5].

While information-based economy measures strengthen their place in the world, the importance of intangible assets is increasing every day. The capitals related to these assets are examined under three main headings in the literature as human capital, investment (organizational) capital, and customer capital, and the resultant is intellectual capital [1,4,6,7]. Human capital includes employee competence, skills, brainpower, and tacit knowledge. Customer capital includes inputs on customer relationships, feedback, product/service, recommendation, experience, and tacit knowledge. A customer is broadly defined to include suppliers, distributors, and other players that can contribute to the value chain. Structural capital is organizational knowledge contained in databases, practices, know-hows, and cultures. It represents all organizational capabilities that enable it to respond and meet market needs and challenges.

This type of capital plays a more dominant role in the service sectors compared to enterprises operating in the production field. Maritime businesses are among service-intensive businesses when their fields of activities are taken into account, and they are in a sector where all national and international social, economic, and political variables play an active role [8].

A close relationship exists between the performance of businesses and their intellectual capital [9]. Generally, the value of intellectual capital will increase as the business performance of companies increases [10]. In the maritime industry, which is within the scope of this study, only two studies draw attention. First, Del Giudice and De Paola [11] made a performance measurement on a maritime company with the intangible assets monitor method and concluded the findings as a result of this evaluation, which has many predictive data, with a financial formulation. The company, which is under branding, has been followed up by keeping it dependent on the general/restricted variables for three periods, and some suggestions have been made to decision-makers. Second, a sectoral report on Intellectual Capital Services Ltd. was published, and a performance measurement using the "the conjoint value hierarchy" method was performed, adhering to a much more comprehensive list of variables with key performance variables compared to the work of Del Giudice and De Paola [11]. This performance measurement can be considered a preliminary study for the evaluation of the intellectual capital of the ship operating company.

The key indicators used in performance evaluations constitute the building blocks of this capital. However, key performance indicators (KPIs) may differ as a result of the companies' operating areas and the depth of their assessments. For this reason, the focus of this study is to distinguish the importance levels of intellectual capital elements in a ship operating company and to determine the group performance indicators that should be examined to measure these elements and prioritize them among themselves. Thus, the KPIs have been integrated, which differ at the enterprise level, in a certain structure. To achieve this goal, the analytical hierarchy process (AHP) was used under a fuzzy environment [12-14]. Accordingly, this paper is organized as follows: Chapter 1 reviews the motivation behind the study and the key literature on the assessment of intellectual capital of ship management companies. Chapter 2 describes the theoretical framework of Fuzzy AHP. Chapter 3 further discusses intellectual capital in shipbuilding and how the proposed approach has been applied. Chapter 4 presents a conclusion and future works.

2. Methodology

In this section, the Fuzzy AHP method is explained step by step to evaluate the intellectual capital of ship management companies.

2.1. Fuzzy AHP

As one of the best-known techniques for decision making, multicriteria decision making (MCDM) offers a systematic method for solving decision problems on the basis of multiple criteria. This method, which often focuses on simultaneously dealing with multiple and contradictory criteria, often depends on quantitative and qualitative approaches. Although it varies depending on the approaches, MCDM can increase decision quality with more effective and rational methods than traditional processes [15].

The AHP is a powerful method for solving complex decision problems. Any complex problem can be decomposed into several subproblems using the AHP in terms of hierarchical levels, where each level represents a set of criteria or attributes relative to each subproblem. The AHP method

is a multicriteria analysis method based on the additive weighting process, in which many relevant features are represented by their relative importance. The AHP has been extensively applied by academics and professionals in engineering practices, which includes financial decisions predominantly associated with non-financial qualifications [16]. Through the AHP, the importance of several attributes is derived from a pairwise comparison process in a hierarchical structure of the relevance of categories of attributes or drivers of intangibles. With the potential to speed up the MOP analysis, the AHP offers a convenient technique to derive an initial linear approximation of this unexpressed utility function. Another advantage of using the consistency metric is that it improves decision-maker learning.

However, the pure AHP model has some shortcomings [17]. The AHP method is mainly used in decision applications with almost clear information. Moreover, it creates and deals with a very unbalanced judgment scale. The AHP method does not take into account the uncertainty associated with mapping human judgments to several natural languages, and the ordering of the AHP method is rather uncertain.

Subjective judgments through perception, evaluation, improvement, and choice based on decision-makers' preferences have a great influence on AHP results. To overcome these problems, several researchers have integrated fuzzy theory with the AHP to improve uncertainty. To determine the fuzzy weights of objects from fuzzy pairwise comparison matrices, Buckley added trapezoidal fuzzy numbers to the fuzzy AHP theory and fuzzified the geometric mean approach in 1985 [18]. Cheng and Mon [19] estimated the fuzzy eigenvectors of a fuzzy pairwise comparison matrix using interval arithmetic and α-cuts. To obtain fuzzy weights from a fuzzy pairwise comparison matrix, Xu [20] proposed a fuzzy extension of the least-square priority method. Considering all the information available in a decision-making problem, Enea and Piazza [21] proposed techniques depending on the constrained fuzzy arithmetic for deriving fuzzy weights. These formulas were further developed by Krejˇcí et al. [22], who also used the restricted fuzzy arithmetic to the aggregated fuzzy priority of possible alternatives. In this study, Buckley's Fuzzy AHP method has been utilized, which has key benefits, including offering a distinct solution to the reciprocal comparison matrix and a reasonably simple calculation using the algorithm to calculate weights with trapezoidal fuzzy numbers and the criterion. The fuzzy AHP relies on the fuzzy interval arithmetic with triangular fuzzy numbers and confidence index to determine the weights of evaluation elements.

It has become necessary to weigh the group performance indicators that combine elements in a way that will facilitate the measurement and management of the intellectual capital of ship management companies. For this purpose, it would be appropriate to use the AHP method. While constructing the hierarchical structure, a weighting study was performed for the group performance indicators and intellectual capital elements. In this way, while effective indicators are compared with the indicators in their clusters, the group performance indicators are weighted according to the capital types. Nodes in each cluster are compared in pairs based on linguistic terms in Table 1.

Thirteen mariner experts, with a minimum of 11 years of experience and an average of 15 years of experience, evaluated group performance indicators and supporting elements from sources as discussed in Section 2.1. Using the answers from the experts, the following steps were followed, and the importance levels of the elements and group performance indicators were determined.

Step 1: Generate pairwise comparison matrices between all elements/criteria in the dimensions of the hierarchy system.

Assign language terms to pairwise comparisons by asking which of the two dimensions is more important, as in matrix $\widetilde{A}$ below:

$$\mu\left(\frac{x}{\widetilde{M}}\right)=\begin{cases}0, x<l\\ \frac{(x-l)}{(m-l)}, l\le x\le m\\ \frac{(u-x)}{(u-m)}, m\le x\le u\\ 0, x>u\end{cases}, \tag{1}$$

$$\widetilde{M}=\begin{pmatrix}1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n}\\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n}\\ \vdots & \vdots & \ddots & \vdots\\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1\end{pmatrix}=\begin{pmatrix}1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n}\\ 1/\tilde{a}_{12} & 1 & \cdots & \tilde{a}_{2n}\\ \vdots & \vdots & \ddots & \vdots\\ 1/\tilde{a}_{1n} & 1/\tilde{a}_{2n} & \cdots & 1\end{pmatrix}, \tag{2}$$

where

$$\tilde{a}_{ij}=\begin{cases}\tilde{1},\tilde{3},\tilde{5},\tilde{7},\tilde{9}\ \text{criterion } i \text{ has relative importance to criterion } j\\ 1.\ i=j\\ \tilde{1}^{-1},\tilde{3}^{-1},\tilde{5}^{-1},\tilde{7}^{-1},\tilde{9}^{-1}\ \text{criterion } i \text{ has less importance to criterion j}\end{cases} \tag{3}$$

Step 2: Use the geometric means method to integrate the opinions of respondents [18].

$$\tilde{a}_{ij}=\left(\tilde{a}_{ij}^{1}\otimes\tilde{a}_{ij}^{2}\otimes\ldots\otimes\tilde{a}_{ij}^{n}\right)^{\frac{1}{n}}, \tag{4}$$

where $\tilde{a}_{ij}$ is the triangular fuzzy number in the *i*th column and *j*th row of the fuzzy positive reciprocal matrix and $\tilde{a}_{ij}^{n}$ is the assessment value of respondent *N*.

Step 3: Perform the column geometric mean method

In this step, the fuzzy weights of each criterion are determined using the following equation, where i^{th} denotes the fuzzy weight of the criterion $\widetilde{w}_i$ and is denoted by $\widetilde{w}_i = (lw_i, mw_i, uw_i)$ [23].

$$\widetilde{w}_i = r_i \otimes \left[r_1 \oplus \ldots \oplus r_i \oplus \ldots \oplus r_n \right]^{-1}, \quad (5)$$

$$r_i = \left(\tilde{a}_{i1} \otimes \ldots \otimes \tilde{a}_{ij} \otimes \ldots \otimes \tilde{a}_{in} \right)^{\frac{1}{n}}, \quad (6)$$

where $\widetilde{w}_i$ is the fuzzy weight value of each column in the fuzzy positive reciprocal matrix and r_i is the geometric mean of the triangular fuzzy number.

Step 4: Obtain data consistency using Equations (7, 8, and 9). If the consistency ratio (CR) is less than or equal to 0.10, the expert opinion is considered reasonable and consistent. The CR is calculated to evaluate the consistency of the comparison matrix in the classical AHP. However, the results of the fuzzy AHP are a fuzzy number of linguistic judgments. Therefore, it is necessary to apply a defuzzification technique.

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (7)$$

$$\sum_{j=1}^{n} a_{ij} w_j = \lambda_{max} w_i \quad (8)$$

$$CR = CI / RI \quad (9)$$

Step 5: In the final step, the center of area method is utilized to determine the best non-fuzzy performance (net weight) of each criterion. For each w_i fuzzy number, defuzzified values are obtained as follows:

$$BNP\,\widetilde{w}_i = \frac{l+m+u}{3} \quad (10)$$

After the completion of these steps, eventually, the sum of the weights of the group performance indicators is equalized to the element to which they depend. Weightings are recalculated using the simple proportionality method.

3. Analytic Evaluation of Intellectual Capital for Ship Management Companies Under A Fuzzy Environment

In this section, the fuzzy AHP method is applied among the group performance indicators determined to evaluate the intellectual capital of ship management companies.

3.1.1. Intellectual capital assessment for ship management companies

Considering the fields of activities of ship management companies, they are considered part of service-intensive businesses, and they are in a sector where all national and international social, economic, and political variables play an active role. Regardless of where they are located geographically, these companies are fighting to get a share from the world market due to their international structure. Meanwhile, many variables, such as knowledge, experience, organizational culture, organizational structure, relations with national and international stakeholders, education level of employees, safety level of operations, inspection and follow-up procedures, and number and tonnage of ships in their operations, affect these enterprises positively or negatively.

These and many more factors should be evaluated to increase the intellectual assets and capital of ship management companies. Considering the literature and sectoral applications, many of these factors are used in the performance measurements of companies. For an accurate analysis to be made, the rules, regulations, and systems on which these companies have built their correct and safety management systems should be explained. For this reason, the International Safety Management Code prepared by the International Maritime Organization, which is thought to be affected by operational factors, International Ship and Port Facility Security Code, Maritime Labor Convention 2006 prepared by the International Labor Organization, Ship Inspection Report Program, and Internal Evaluation Program in Tanker and Dry Cargo Management [Tanker Management Self Assessment (TMSA)/Bulk Management Self Assessment (BMSA)] published by the International Maritime Forum of Oil Companies were examined. In addition, the Quality Management System (ISO: 9001) and Environmental Management System (ISO: 14001) offered by the International Standards Organization, which we encounter in other sectors, are included in the content, considering businesses that implement these systems, although they are not mandatory for maritime operators. The evaluation of the KPIs (shipping KPI system) designed by the Baltic and International Maritime Council (BIMCO) to examine the performance of ship operators in terminological harmony has been prioritized as it will provide ease of perception, application, and follow-up to the companies. It cannot be claimed that the performance standards of BIMCO used in the research can be accepted as an absolute performance indicator for ship owners. Companies should not only use the performance standards of the BIMCO or any other organization but also have the opportunity to analyze, manage their ships, and increase their performance by developing and using their own KPI standards and having the opportunity to measure, evaluate, and monitor their performance [24]. However, these sectorally determined performance factors will not be sufficient for the evaluation and management of intellectual capital.

In a pilot study report published by the Intellectual Capital Services Ltd. in 2005, 28 KPIs for ship management companies were agreed upon as a result of workshops held with the participation of ship managers, ship owners,

port control authorities, and major oil companies, and these KPIs were gathered in five groups. In this report, the aforementioned 28 indicators were prioritized using the "conjoint value hierarchy" method.

This study aimed to determine the other factors that play a role in the ability of ship management companies to evaluate their own intellectual capital and determine the importance of all these factors on a sectoral basis.

3.1.2. Problem definition

For calculating the full value of ship management companies, the values of ships and other immovable or material resources are not sufficient for these institutions, which are service-based businesses. While valuing a firm, its intellectual capital, which is outside of the book value, should also be measured. Again, if these companies want to increase their value, they should understand the intellectual capital indicators well, monitor their performance in this field, and create development strategies. As mentioned in the section above, the management performances of ship management companies are measured and followed up with the recommendation of the BIMCO and the benchmarking method of companies. However, to understand intellectual capital and monitoring and managing company performance in this context, the indicators that the BIMCO recommends to follow are insufficient. To measure intellectual capital and increase it with the integration of innovative strategies, the above-mentioned element and group performance indicators should be evaluated, taking into account the critical influencing factors.

3.1.3. Evaluation of intellectual capital for ship management companies under a fuzzy environment

A survey was conducted with 13 experts, including employees of a prestigious ship management company or academics compatible with their field of expertise, to measure the intellectual capital of ship management companies, identify critical performance indicators, and evaluate their management. The average experience of specialists in this field is about 15 years. These group performance indicators were then grouped (Figure 1), and each expert was asked to compare each element and the indicators according to Saaty's 1-9 scale given in Table 1.

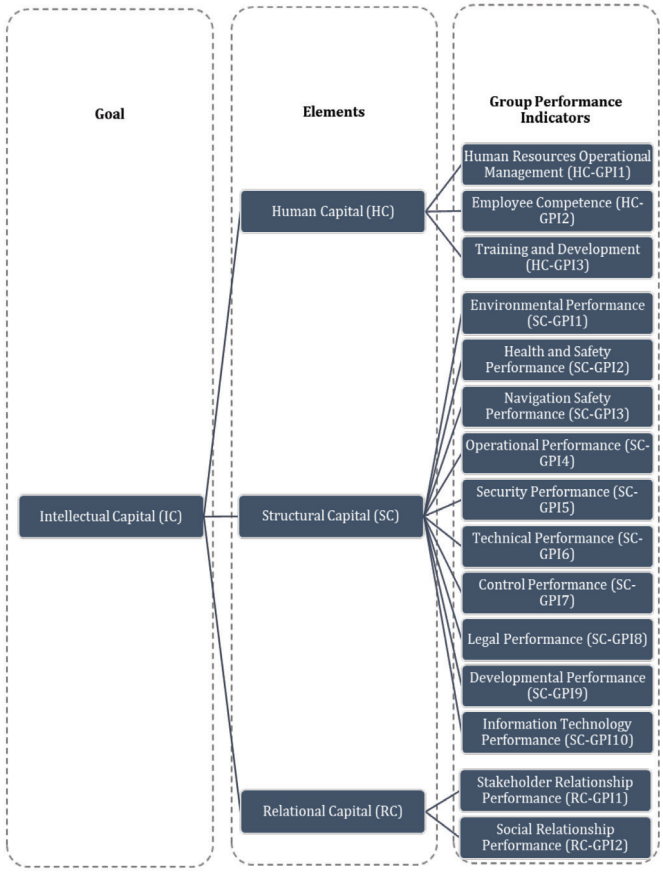

Figure 1. *Hierarchical structure of elements and group performance indicators of intellectual capital for ship management companies*

Table 1. *Triangular fuzzy scale and linguistic terms [15]*

Saaty's scale	Description	Triangular fuzzy scale	Triangle fuzzy reciprocal scale
1	Equal importance (E)	(1, 1, 1)	(1, 1, 1)
3	Moderate importance (MI)	(2, 3, 4)	(0.25, 0.333, 0.5)
5	Strong importance (SI)	(4, 5, 6)	(0.167, 0.2, 0.25)
7	Demonstrated importance (DI)	(6, 7, 8)	(0.125, 0.143, 0.167)
9	Extreme importance (EI)	(9, 9, 9)	(0.111, 0.111, 0.111)
2	Intermediate values between two adjacent judgments	(1, 2, 3)	(0.333, 0.5, 1)
4		(3, 4, 5)	(0.2, 0.25, 0.333)
6		(5, 6, 7)	(0.143, 0.167, 0.2)
8		(7, 8, 9)	(0.111, 0.125, 0.143)

According to Saaty's scale, the fuzzy and standardized matrices were obtained as a result of the evaluation of 13 experts. First, whether judgments of each expert are consistent (CR<0, 1) were examined, and the results are shown in Table 2. Group performance indicators represent the elements of intellectual capital and the weightings of the group performance indicators that should be used in the measurements of these elements (Tables 3.1, Table 3.2, Table 3.3, and Table 3.4).

After the evaluation by the 13 experts, Equations (1-9) were used to calculate the priority weight for each element and group performance indicator. In the final step, defuzzification was performed by using Equation (5) to get the exact value of each indicator. The CR was 0.0121 for the elements, 0.0246 for the human capital group performance indicators, 0.0285 for the structural capital group performance indicators, and 0.0000 for the relational capital group performance indicators, each within acceptable limits. Therefore, the maritime expert judgments included in the comparison matrices were reasonable. Accordingly, Table 4 shows the defuzzified and normalized importance weights of the intellectual capital elements and group performance indicators constituting the elements.

Table 2. *Consistency control of the judgments of each expert*

	Intellectual capital			**Human capital**			**Structural capital**			**Relational capital**		
	λmax	CI	CR	λmax	CI	CR	λmax	CI	CR	λmax	CI	CR
E1	3.040	0.020	0.035	3.040	0.020	0.034	10.707	0.079	0.053	2.00	0.00	0.00
E2	3.110	0.055	0.095	3.089	0.045	0.077	10.948	0.105	0.071	2.00	0.00	0.00
E3	3.078	0.039	0.067	3.111	0.055	0.096	10.932	0.104	0.069	2.00	0.00	0.00
E4	3.078	0.039	0.067	3.087	0.044	0.075	10.712	0.079	0.053	2.00	0.00	0.00
E5	3.077	0.039	0.067	3.007	0.004	0.006	11.119	0.124	0.083	2.00	0.00	0.00
E6	3.000	0.000	0.000	3.095	0.048	0.082	11.167	0.130	0.087	2.00	0.00	0.00
E7	3.037	0.018	0.032	3.070	0.035	0.061	11.245	0.138	0.093	2.00	0.00	0.00
E8	3.072	0.036	0.062	3.059	0.029	0.051	11.275	0.142	0.095	2.00	0.00	0.00
E9	3.038	0.019	0.033	3.098	0.049	0.085	10.578	0.064	0.043	2.00	0.00	0.00
E10	3.047	0.023	0.040	3.054	0.027	0.046	10.902	0.100	0.067	2.00	0.00	0.00
E11	3.021	0.011	0.018	3.105	0.053	0.091	10.421	0.047	0.031	2.00	0.00	0.00
E12	3.104	0.052	0.090	3.078	0.039	0.067	11.244	0.138	0.093	2.00	0.00	0.00
E13	3.091	0.045	0.078	3.050	0.025	0.043	11.168	0.130	0.087	2.00	0.00	0.00

Table 3. *Fuzzy and standardized matrices*

Table 3.1. *Intellectual capital*

Fuzzy geometric mean			**Fuzzy weights**			**BNP**	**Normalization**	**Criterion weights**	
1.614	1.805	1.997	0.429	0.538	0.673	0.547	0.537	0.537	HC
0.854	0.985	1.106	0.227	0.294	0.373	0.298	0.292	0.292	SC
0.499	0.563	0.658	0.133	0.168	0.222	0.174	0.171	0.171	RC
Consistency index (CI)			0.0064						
Consistency ratio (CR)			0.0110						

Table 3.2. *Human capital*

Fuzzy geometric mean			**Fuzzy weights**			**BNP**	**Normalization**	**Criterion weights**	
0.959	1.103	1.285	0.275	0.365	0.491	0.377	0.367	0.367	HC-GPI1
0.743	0.850	0.967	0.213	0.282	0.370	0.288	0.280	0.280	HC-GPI2
0.914	1.066	1.236	0.262	0.353	0.472	0.363	0.353	0.353	HC-GPI3
Consistency index (CI)			0.0118						
Consistency ratio (CR)			0.0203						

Table 3.3. *Structural capital*

Fuzzy geometric mean			Fuzzy weights			BNP	Normalization	Criterion weights	
0.875	1.042	1.235	0.065	0.093	0.133	0.065	0.092	0.092	SC-GPI1
1.760	2.173	2.568	0.130	0.193	0.277	0.130	0.191	0.191	SC-GPI2
1.785	2.158	2.542	0.132	0.192	0.274	0.132	0.190	0.190	SC-GPI3
0.820	0.998	1.222	0.061	0.089	0.132	0.061	0.089	0.089	SC-GPI4
0.869	1.049	1.262	0.064	0.093	0.136	0.064	0.093	0.093	SC-GPI5
1.003	1.222	1.492	0.074	0.109	0.161	0.074	0.109	0.109	SC-GPI6
0.702	0.843	1.012	0.052	0.075	0.109	0.052	0.075	0.075	SC-GPI7
0.474	0.567	0.693	0.035	0.050	0.075	0.035	0.051	0.051	SC-GPI8
0.421	0.512	0.639	0.031	0.046	0.069	0.031	0.046	0.046	SC-GPI9
0.576	0.683	0.829	0.043	0.061	0.089	0.043	0.061	0.061	SC-GPI10
Consistency index (CI)			0.0382						
Consistency ratio (CR)			0.0256						

Table 3.4. *Relational capital*

Fuzzy geometric mean			Fuzzy weights			BNP	Normalization	Criterion weights	
1.49	1.70	1.91	0.579	0.743	0.946	0.756	0.741	0.741	RC-GPI1
0.52	0.59	0.67	0.203	0.257	0.332	0.264	0.259	0.259	RC-GPI2
Consistency index (CI)			0.000						
Consistency ratio (CR)			0.000						

Table 4. *Weights of elements and group performance indicators*

Elements	w	GPI	w
HC	**0.54**	HC-GPI1	0.20
		HC-GPI2	0.15
		HC-GPI3	0.19
SC	**0.29**	SC-GPI1	0.03
		SC-GPI2	0.06
		SC-GPI3	0.06
		SC-GPI4	0.03
		SC-GPI5	0.03
		SC-GPI6	0.03
		SC-GPI7	0.02
		SC-GPI8	0.01
		SC-GPI9	0.01
		SC-GPI10	0.02
RC	**0.17**	RC-GPI1	0.13
		RC-GPI2	0.04

Considering the importance weights of the elements, the human capital element is quite important compared to the structural capital and relational capital. Although the human capital group performance indicators, human resources operational management (0.20), employee competence (0.15), and training and development (0.19) indicators are interpreted with approximately similar importance levels, when all group performance indicators are examined, they become the leading criteria.

While evaluating the relational capital element, which can be described as another leading criterion, the group performance indicator stakeholder relationship performance also comes

after the group performance indicators of the human capital element with 0.13. Ten groups of performance indicators (environmental performance, health, and safety performance, navigational safety performance, operational performance, safety performance, technical performance, control performance, legal performance, developmental performance, and information technology) used when measuring the structural capital element, which has a 0.29 degree of importance in factor weighting. Hence, the weights of the indicators examined in this section and the social relationship performance indicator, which is the second of the indicators that make up the relational capital element, have a low degree of importance.

4. Findings and Discussion

The intellectual capital elements that are considered critical in the measurement and management of the intellectual capital of ship management companies and the group performance indicators that provide the analysis of these elements and the priorities examined by applying the fuzzy AHP model are given in percentages by the 13 maritime experts.

Based on this, as presented in Figure 2.1, when evaluating the intellectual capital of ship enterprises, which is a service-based sector, the most important element is human capital with a weight of 54%, followed by structural capital with 29% and relational capital with 17%.

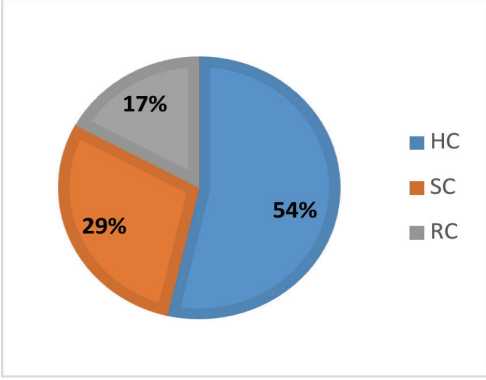

Figure 2.1. *Weights of the elements of intellectual capital*

As shown in Figure 2.2, three group performance indicators need to be considered while evaluating the human capital aspect. Accordingly, we can list them according to their importance as follows: 1. human resources operational management (37%), 2. training and development (35%), and 3. employee competence (28%). In addition, this ranking is valid for all group performance indicators, and the three indicators lead to the general situation.

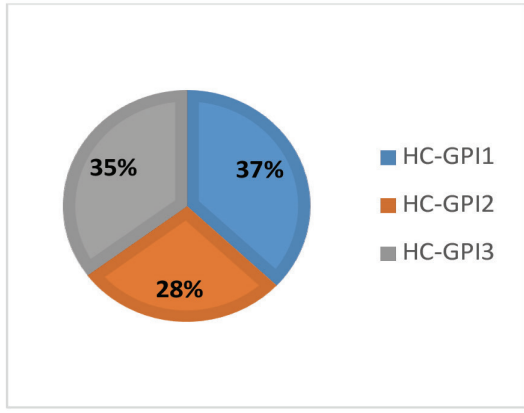

Figure 2.2. *Weights of the group performance indicators of human capital*

As shown in Figure 2.3, 10 group performance indicators make up the structural capital aspect, and when ranked according to their importance, health and safety performance and navigational safety performance (19%) share the first place. Technical performance comes in third place with 13% importance, but other groups remained below 10%. Nonetheless, evaluating intellectual capital requires a holistic perspective. The total of structural capital group performance indicators, which are divided into more groups and therefore have a little effect, constitutes 29% of intellectual capital.

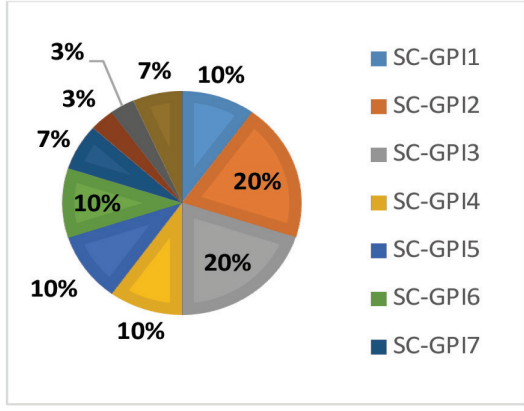

Figure 2.3. *Weights of the group performance indicators of structural capital*

Finally, from the group performance indicators that make up the relational capital element are examined closely, the stakeholder relationship performance for ship management companies dominates this element with an impact of 74%, as shown in Figure 2.4. Again, we measure 26% of relational capital, which makes up 17% of intellectual capital, with the social relationship performance.

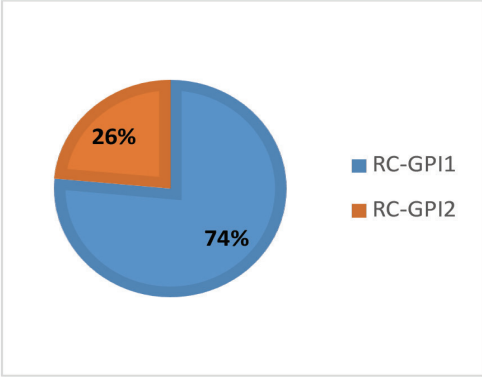

Figure 2.4. *Weights of the group performance indicators of relational capital*

To summarize the findings, 15 group performance indicators created by experts for a closer analysis of the elements of the intellectual capital of a ship management company were put forward within the scope of this study, and the importance levels of these indicators were determined. The order of these indicators is clearly shown in Figure 3, and the indicators with the highest importance are as follows: 1. human resources operational management (HC-GPI1), 2. training and development (HC-GPI3), 3. employee competence (HC-GPI2), and 4. stakeholder relationship performance (RC-GPI1).

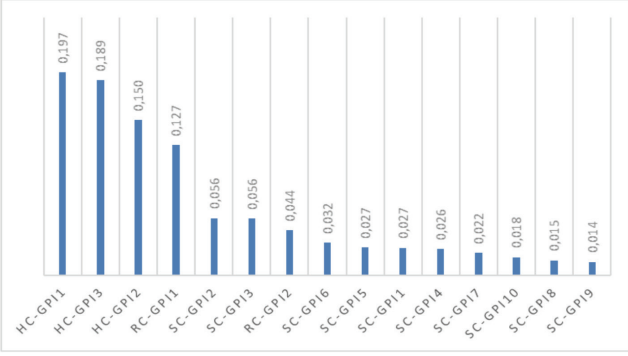

Figure 3. *Ranking of the group performance indicators of relational capital*

5. Conclusions

Measuring intellectual capital gains is important in revealing the real values of ship management companies, which are considered service-based businesses. In addition, the evaluation and management of intellectual capital will contribute to the determination of sustainable development strategies of these companies. For this reason, it is necessary to determine the elements that make up the intellectual capital for ship management companies and the important indicators that play a role in the analysis of these elements. In this study, three elements of intellectual capital, namely, human capital, structural capital, and relational capital, and group performance indicators that will enable them to follow these elements have been prioritized using the fuzzy AHP method.

Based on the analysis results, the importance of the human capital and the determined human resources operational management, employee competence, training, and development group performance indicators will play in the value acquisition strategies of a ship management company due to the nature of the business. Although the structural capital element is the second priority element, the group performance indicators lose their priority when examined individually due to the difference in the indicators that make up the element. However, the correct point of view on this issue is that, undoubtedly, none of them should be neglected about its effect on the whole. While relational capital comes as the third element, the stakeholder relationship performance, one of the related group performance indicators, is three times more important than the social relationship performance.

The results of this study will encourage ship owners and managers to focus on intellectual capital management and identify priority strategies to increase firm value. With the entry into force of the BMSA program, which is similar to the TMSA program, where tanker companies are currently subjected, companies can more effectively plan their further steps toward their targets by collecting their data to monitor their management and interpreting them periodically. The procedures and checklists that can be created in the light of this study will support these enterprises in making their own evaluations and will also be useful in increasing the company values while measuring and managing their performance.

As with most studies, the design of the present study is subject to limitations, in this case two, which could be addressed in future research. First, there are very limited resources in the literature on the evaluation of the intellectual capital of the ship management companies, which are the focus of the study, and it shows terminology differences due to the nature of the application area. Second, the parameters used to measure maritime intellectual capital were kept at the level of group performance indicators. Components to measure performance indicators in these groups were excluded due to time constraints. In further studies, KPIs compatible with sectoral terminology and their measurement methods can be determined for the measurement of this group of performance indicators.

Authorship Contributions

Concept design: G. Çevik, Ö. Arslan, Data Collection or Processing: G. Çevik, Ö. Arslan, Analysis or Interpretation: G. Çevik, Ö. Arslan, Literature Review: G. Çevik, Ö. Arslan, Writing, Reviewing and Editing: G. Çevik, Ö. Arslan.

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