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Analysis of determinants of work performance for seafarers based on fuzzy Electre model

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Abstract

Nowadays, most shipping companies are aware of the importance of analysing seafarers' work performance. Thus, improving seafarers' work performance or finding out the ways by which seafarers' work performance can be enhanced is becoming one of the decisive factors for the success of any shipping company. Any organization aims to have employees who can accomplish corporate goals and objectives using available resources efficiently and effectively. Manpower performance can be enhanced by putting more emphasis on factors that can stimulate employees' motivational level, creativity and job satisfaction. In this study, we use literature review and experts' opinions to identify determinants of workplace performance for seafarers working with Marine Services Company Limited (MSCL), a shipping company owned by the government of Tanzania. The data is collected from a random sample of 30 seafarers working for the MSCL and a Fuzzy Electre Model (FEM) is developed and applied to determine the significance of the factors and sub-factors for the work performance of seafarers. The fuzzy terms are adopted in order to integrate the uncertainty of subjective judgment when evaluating alternatives. The computational results validate the effectiveness of the developed evaluation model. This study is resourceful for the top management of MSCL, as it points out those factors that can directly affect the performance of her seafarers. Seafarers are important assets of any shipping company and thus, this study helps shipping enterprises devise efficient human resource strategies to get maximum benefit from this kind of assets. More importantly, enhanced seafarers' work performance leads to improved company's productivity and higher service quality and therefore make the shipping company competitive in the trading markets.

Keywords: Fuzzy Electre model, Analysis, Seafarers, Work performance, Shipping companies

Introduction

About 90% of international trade by volume is seaborne (ICS, [n.d.](#)). Ocean shipping is the principal mode of international freight transport, underpinning international trade (Achurra-Gonzalez et al., [2019](#)). The importance of shipping lies in the way it facilitates import/export of goods worldwide, hence contributing to availability of affordable



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food, merchandize and/or products. Without ships and the transportation services these ships provide, the world would not be as prosperous as it is today and many countries would not be able to participate in the international trade (Greencarrier, 2016). Thus, the international shipping industry contributes hundreds of billions of dollars to the global economy annually thereby increasing gross domestic product in countries throughout the world (World Shipping Council, n.d.-a). A country's access to world markets depends on its seaborne transport connectivity, especially with regards to the metrics of liner shipping services for the import and export of manufactured goods (Reza et al., 2015). Liner shipping is the foundation for global commerce, transporting about 60% of world seaborne trade by value in cost-effective and reliable manner (World Shipping Council, n.d.-b). More specifically, international liner shipping is a sophisticated network of regularly scheduled services that transports goods from anywhere in the world at low cost and with greater energy efficiency than any other form of international transportation (World Shipping Council, n.d.-a). Since a significant portion of the global seaborne trade is carried by liner shipping, effective liner shipping is important for the global seaborne trade, and, thereby, for the overall supply chain management (Pasha et al., 2020). Generally, the operational performance of a shipping company is largely dependent on the performance of its employees. However, there are a variety of factors, personal, company-based and external that affects the performance of employees at work place. Unveiling these factors can help improve recruitment, retention and organizational results.

Nowadays, the phenomenon of increased competition between firms and their need to respond effectively to rapidly changing operational conditions as well as to personnel requirements has escalated the necessity to identify those factors that affect employee performance (EP) (Diamantidis & Chatzoglou, 2019). This study focuses on the Tanzanian shipping companies to know about the factors and sub-factors affecting the performance of onboard employees. The study is based in Tanzania due to its geographic position (i.e. strategic position) in international trade of serving the landlocked countries of Malawi, Zambia, Democratic Republic of Congo, Burundi, Rwanda, and Uganda. Efficiency and effectiveness of logistics systems between Tanzanian Ports and the hinterland will decrease Port congestion and stimulate more movement of cargo at a minimum total logistics cost. Thus, improving the efficiency of the Tanzanian supply chains including shipping services is very crucial for the betterment of the Tanzania's and the region's trade potential. In particular, we use Marine Services Company Limited (MSCL) as our case study. The MSCL is a Tanzanian shipping company with 134 seafarers at the moment and the largest fleet in the country. The company is 100% -owned by the government of Tanzania and transports cargo and passengers on Lake Victoria, Lake Tanganyika and Lake Nyasa. Thus, the MSCL smoothen international trade between Tanzania, Burundi, Zambia, Malawi, Democratic Republic of Congo, Kenya and Uganda. Moreover, the poorest people in Tanzania could see their real income rise by almost 2.8% as a result of a reduction in transport and logistics costs (Gasiorek et al., 2017).

In this study, we develop and apply Fuzzy Electre Method (FEM) to appraise the determinants of seafarers' workplace performance of the shipping company. The Fuzzy Electre technique is proposed to deal with the imprecise or vague nature of linguistic assessment (Sevкли, 2010). Fuzzy Electre Model is a composite model of Electre model

and Fuzzy model. The Electre model is one of the outranking MCDM method which is widely recognized for policy analysis involving qualitative criteria (Rouyendegh & Erol, 2012). Fuzzy model, on the other hand, is applied to handle uncertainty and vagueness in the data set. More specifically, Fuzzy Electre Model is one of the fuzzy multi criteria decision making methods for resolving the ambiguity of concepts that are associated with decision maker's judgments (Komsiyah et al., 2019). The paper is organized as follows: Section 2 presents a review of the literature; Section 3 presents the Fuzzy Electre Model and Section 4 applies Fuzzy Electre Model to evaluate the determinants of work performance for seafarers. Lastly, Section 5 gives the conclusions.

Review of the literature

Numerous studies investigate the performance of employees in the workplace. This trend is based on the fact that firms have realized that they have to develop unique dynamic characteristics that empower their competitive advantages by focusing on the exploitation of their human resources (HR) as a strategic advantage (Diamantidis & Chatzoglou, 2019). Sujatha and Krishnaveni (Sujatha & Krishnaveni, 2018) explore the knowledge creation practices and how does it influence the work performance of employees among pump manufacturing firms in South India. Alefari et al. (Alefari et al., 2018) present a conceptual model through system dynamics of the factors that affect employee performance and the different improvement initiatives. Osman et al. (Osman et al., 2016) investigate the relationship between innovation and employee performance at Tenaga Nasional Berhad (TNB), a utility company in Malaysia. Pawirosumarto et al. (Pawirosumarto et al., 2008) present a study whose aims are to examine, analyse and explain the influence of leadership style, motivation and discipline to employee performance simultaneously and partially at PT. Kiyokuni Indonesia. Ibrahim et al. (Ibrahim et al., 2017) examine the direct influence of both training methodology and trainers' effectiveness on soft skills acquisition and their influence on employees' work performance. Arian et al. (Arian et al., 2018) seek to identify the factors affecting job satisfaction in nurse educators. Tengpongsthorn (Tengpongsthorn, 2017) investigates the factors affecting the effectiveness of police performance in the Thai Metropolitan Police Bureau.

On the other hand, researchers and practitioners in the shipping industry investigate the factors that may influence positively or negatively the performance of seafarers' on-board ships. Rengamani and Murugan (Rengamani & Murugan, 2012) apply one-way ANOVA to investigate the work-related stress factors, physical stress factors and psychosocial factors in the process of assessing the stress levels of the seafarers who work on-board ships. Nguyen et al. (Nguyen et al., 2014) discuss the current challenges in the recruitment and retention of seafarers in Vietnam. Fan et al. (Fan et al., 2017) investigate employers' views on the current level of Chinese seafarers' communicative competence and its correlation with their employability in the international maritime labour market. Yuen et al. (Yuen et al., 2018) apply structural equation modelling for analysis of the core determinants of job satisfaction and performance of seafarers. Othman et al. (Othman et al., 2015) apply TOPSIS method to rank the root causes for distractions and the affected areas for three groups of Malaysian seafarers, Senior deck cadets, Senior deck officers and Junior deck officers. Park (Park, 2017) reviews the trend and characteristics in the separation rate of maritime officers, and examines the

main factors affecting the separation rate through panel data models. Tsai and Liou (Tsai & Liou, 2017) apply exploratory factor analysis and multi-regression analysis to discover the problems existing in the seafarer recruitment system for shipping companies to retain skilful seafarers for their companies. Patchiappane and Rengamani (Patchiappane & Rengamani, 2018) apply One-way ANOVA to examine the factors that are influencing the seafarers' job satisfaction, the factors which impact on them while accomplishing the allocated tasks on board ships and the factors which improve the satisfaction level. Despite their usefulness in evaluating work performance for seafarers, the conventional methods cannot accurately define the relative importance of each evaluation criterion due to uncertainty of subjective judgment when evaluating alternatives.

In this study, we develop and apply Fuzzy Electre Method (FEM) to evaluate the determinants of work performance of seafarers. The FEM has been applied extensively to tackle problems involving uncertainty and vagueness. Sevkli (Sevkli, 2010) compares and contrasts crisp and fuzzy ELECTRE methods and applies the proposed methods to a manufacturing company in Turkey. Shojaie et al. (Shojaie et al., 2018) apply fuzzy ELECTRE method in green supplier selection and examine suppliers of a pharmaceutical company in Iran in order to achieve a green health supply chain. Baki (Baki, 2016) applies fuzzy ELECTRE method to select personnel for a sales engineer post of an international firm. Yücel and Görener (Yücel & Görener, 2016) apply the ELECTRE method to evaluate the investment group's local acquisition opportunities. Mohammadi et al. (Mohammadi et al., 2011) propose the ELECTRE Decision Making Method Based on Triangular Fuzzy numbers to be used for different types of rankings. Marbini et al. (Marbini et al., 2013) apply a fuzzy group Electre method to carry out safety and health assessment in hazardous waste recycling facilities.

Galo et al. (Galo et al., 2018) propose an approach to supplier categorization in the automotive industry based on the use of ELECTRE TRI combined with hesitant fuzzy. Kumar et al. (Kumar et al., 2017) apply fuzzy ELECTRE to evaluate operational performance and ranking of cellular mobile telephone service providers. Yu et al. (Yu et al., 2018) apply ELECTRE methods to prioritize criteria in the MCDM environment. Zandi and Roghanian (Zandi & Roghanian, 2013) extend ELECTRE I method based on VIKOR to rank a set of alternatives versus a set of criteria to show the decision maker's preferences. Liao et al. (Liao et al., 2018) extend the ELECTRE II method to solve the MCDM problems under the uncertain environment in terms of hesitant fuzzy linguistic term set (HFLTS). Chen and Xu (Chen & Xu, 2015) suggest hesitant fuzzy ELECTRE II approach to efficiently handle different opinions of group members that are frequently encountered when handling the MCDM problems. Petrović et al. (Petrović et al., 2018) propose an approach to enhance the accuracy of input data in the ELECTRE based stepwise benchmarking model. Mousavi et al. (Mousavi et al., 2017) present a new decision model based on modified elimination and choice translating reality (ELECTRE) under a hesitant fuzzy environment for solving the multi-attribute group decision-making (MAGDM) problems in the energy sector. Zhong and Yao (Zhong & Yao, 2017) extend the ELECTRE method using interval type-2 fuzzy numbers to ensure more effective multi-criteria group decision making in uncertain environments. Fernández et al. (Fernández et al., 2017) present a method for multiple criteria ordinal classification based on ELECTRE TRI-B. Govindan and Jepsen (Govindan & Jepsen, 2016)

investigate how ELECTRE and ELECTRE-based methods have been considered in various areas. Peng et al. (Peng et al., 2015) present a method for comparing multi-hesitant fuzzy numbers (MHFNs). Doumpos and Figueira (Doumpos & Figueira, 2019) use ELECTRE TRI-NC method to construct internal credit rating models in an expert-based judgment framework. Marbini and Tavana (Marbini & Tavana, 2011) propose an alternative fuzzy outranking method by extending the Electre I method to take into account the uncertain, imprecise and linguistic assessments provided by a group of decision-makers. Antonella et al. (Antonella et al., 2017) apply the Multi-Criteria Decision Making (MCDM) method ELECTRE TRI to assign failure modes to predefined and ordered risk classes from the highest to the lowest risky ones. Neto et al. (Neto et al., 2017) apply the ELECTRE-TRI multiple criteria decision making to assist the distribution centres of a Brazilian retail enterprise to decide on the investment to be carried out in a new technological structure to be implemented in the central data processing system of the company. Terrientes et al. (Terrientes et al., 2015) propose an ELECTRE-III-H method for ranking a set of alternatives evaluated using multiple and conflicting criteria that are organized in a hierarchical structure. Dong et al. (Dong et al., 2014) apply ELECTRE-II method to rank seven wind/solar hybrid power stations.

From the literature, it is revealed that limited MCDM studies are focussing on seafarers’ workplace performance. More specifically, Nguyen et al. (Nguyen et al., 2015) state that though there have been many studies examining the impacts of various factors on employee performance, very few examine more than three factors at one-time. Moreover, none study on seafarers’ workplace performance is investigated in the Tanzanian perspective. Thus, this study fills in the identified gap in the literature.

Fuzzy Electre model

Fuzzy Electre Methods have been applied extensively in the literature to solve Multi-Criteria Decision Making (MCDM) problems involving both qualitative and quantitative criteria. The application of Fuzzy Electre Model (FEM) involves the use of Fuzzy numbers. There are various Fuzzy numbers in use from the literature. However, most of the researchers and practitioners employ Triangular Fuzzy Numbers (TFNs). Unlike the previous studies, the current research does not apply the TFNs. More specifically, this study uses a simple procedure i.e. fuzzy membership grade to determine the weight of each evaluation criterion. The proposed Fuzzy Electre Model (FEM) is given as follows:

- **Step 1:** Formulation of Alternatives and Decision Criteria. We assume m alternatives and n decision criteria . Thus; each alternative is evaluated by a decision-maker with respect to n criteria.
- **Step 2:** Construction of Evaluation Scale of Fuzzy Numbers. We develop the evaluation scale of fuzzy numbers for the decision criteria as shown in Table 1.

Table 1 Evaluation Scale of Fuzzy Numbers

Linguistic Term n (LT_n)	C_1 (VP)	C_2 (P)	C_3 (M)	C_4 (G)	C_5 (VG)
Fuzzy Membership Grade n (FMG_n)	0.1	0.3	0.5	0.7	0.9
Weight of Criterion n (W_n)	0.04	0.12	0.20	0.28	0.36

In Table 1, the weight of each linguistic term (LT_n) is given by eq. (1).

$$W_n = \frac{FMG_n}{\sum_{n=1}^N FMG_n}, \quad n \in \{1, 2, \dots, N\} \tag{1}$$

(Where) $\sum_{n=1}^N W_n = 1$

- **Step 3:** Construction of the Decision Matrix. The data collected from Practitioner k leads to the formation of the decision matrix given by eq. (2).

$$X = [x_{mn}]; x_{mn} = \frac{1}{K} \sum_{k=1}^K x_{mn}^k \quad m \in \{1, 2, \dots, M\}, n \in \{1, 2, \dots, N\}, k \in \{1, 2, \dots, K\} \tag{2}$$

- **Step 4:** Computation of the Overall Decision Matrix X . We use the values given by eq. (2) to deduce the Overall decision matrix X as given by eq. (3).

$$X = [x_{mn}]; x_{mn} = \frac{1}{K} \sum_{k=1}^K x_{mn}^k \tag{3}$$

- **Step 5:** Computation of the Normalized Decision Matrix (R).

The normalized decision matrix is given by eq. (4).

$$R = [r_{mn}]; r_{mn} = \frac{x_{mn}}{\sum_{n=1}^N x_{mn}}, \quad m \in \{1, 2, \dots, M\}, n \in \{1, 2, \dots, N\} \tag{4}$$

- **Step 6:** Computation of the Weighted Normalized Decision Matrix (V).

We use the Normalized Decision Matrix and the Matrix for Weights of the Criteria to compute the Weighted Normalized Decision Matrix as given by eq. (5).

$$V = [v_{mn}]; v_{mn} = r_{mn} \cdot w_n, \quad m \in \{1, 2, \dots, M\}, n \in \{1, 2, \dots, N\} \tag{5}$$

Where $W = [w_{nn}]$ is a diagonal matrix with diagonal elements w_1, w_2, \dots, w_n .

- **Step 7:** Computation of Concordance and Discordance Sets. If an alternative is better than or equal to the other element of the pair it is considered under concordance set. Thus, the concordance set is composed as given by eq. (6a).

$$C(p, q) = \{n | v_{pn} \geq v_{qn}\}, \quad n \in \{1, 2, \dots, N\} \tag{6a}$$

If an alternative is worse than the other element of the pair for relevant criteria it is considered under discordance set. Thus, the discordance set is defined as given by eq. (6b).

$$D(p, q) = \{n | v_{pn} < v_{qn}\}, \quad n \in \{1, 2, \dots, N\} \tag{6b}$$

- **Step 8:** Computation of Concordance and Discordance Indices. The concordance index of (p, q) i.e. C_{pq} is obtained by adding the weights of elements in the Concordance set and is given by eq. (7a).

$$C_{pq} = \sum_{j^*} w_{j^*}, \quad j^* \in C(p, q) \tag{7a}$$

The discordance index of (p, q) i.e. D_{pq} is given by eq. (7b).

$$D_{pq} = \frac{\sum_{j^+} |v_{pj^+} - v_{qj^+}|}{\sum_{\forall j} |v_{pj} - v_{qj}|}, \quad j^+ \in D(p, q) \tag{7b}$$

- **Step 9:** Determining the Outranking. The averages of Concordance and Discordance indices are computed at this stage. In the Concordance index set, any C_{pq} greater than or equal to the mean of Concordance indices (\bar{C}) is stated as *Yes*. In the set of Discordance indices, any D_{pq} less than the mean of Discordance indices (\bar{D}) is stated as *No*. Thus, alternative P outranks alternative q when the relations given by eq. (8a) are true.

$$C_{pq} \geq \bar{C}; D_{pq} < \bar{D}, \quad p, q \in \{1, 2, \dots, M\} \tag{8a}$$

The mean values of the Concordance and Discordance indices are given by eq. (8b).

$$\bar{C} = \frac{1}{T} \sum_{t \in T} C_{pq}, \quad \bar{D} = \frac{1}{T} \sum_{t \in T} D_{pq} \tag{8b}$$

T : Number of non-repetitive pairs of alternatives p and q .

- **Step 10:** Determining Net Concordance and Discordance Indices. The net concordance and discordance indices are computed to make the ranking amongst alternatives as given by eqs. (9a) and (9b).

$$NC_p = \sum_{p \neq q} C_{pq} - \sum_{q \neq p} C_{qp}, \quad p, q \in \{1, 2, \dots, M\} \tag{9a}$$

$$ND_p = \sum_{p \neq q} D_{pq} - \sum_{q \neq p} D_{qp}, \quad p, q \in \{1, 2, \dots, M\} \quad (9b)$$

The final rank is obtained by sorting the net concordance and discordance indices from the largest to smallest for C and from the smallest to the largest for D . Not always C and D give the same rank, there is a possibility of having more than one best alternative for some cases.

- **Step 11:** Determining a Composite Ranking. In case there is no alternative with the highest value of net concordance index and the lowest value of net discordance index, the alternatives are ranked based on the concordance and discordance indices where each alternative is ranked by taking the average of the two rankings. The alternative with the highest average ranking is considered to be the best alternative (Yoon & Hwang, 1995). Alternatives with the same average ranking would be considered equally suited.

Application of fuzzy Electre model to evaluate the determinants of work performance for seafarers

Review of studies by Patchiappane and Rengamani (Patchiappane & Rengamani, 2018), Tsai and Liou (Tsai & Liou, 2017), and experts' opinions identify the following determinants of work place performance for seafarers as shown in Table 2.

Table 2 reveals the sub-divisions of Job benefits, Work environment, Ship specifics, organizational culture, and Social impacts. This section represents the perceptions of MSCL seafarers on each of these work performance determining factors.

Evaluation of determinant factors for seafarers work performance

Computation of the overall decision matrix

We use the data collected from 30 seafarers working for MSCL to form a decision matrix for a Practitioner k i.e. equation (2). We then use values from all decision matrices and eq. (3) to give the overall decision matrix as shown in Table 3.

The overall decision matrix contains competitive alternatives (i.e. determinant factors) row-wise, with their crisp scores in the fuzzy evaluation scale. These determinant factors are job benefits (D_1), work environment (D_2), ship specifics (D_3), organizational culture (D_4), and social impacts (D_5). The values in Table 3 are used to form the normalized decision matrix in next section.

Computation of the normalized decision matrix

In order to transform the values in Table 3 into standard form, we apply eq. (4) to compute the values that form the normalized decision matrix given in Table 4.

Values in the normalized decision matrix i.e. Table 4 and weights of the evaluation criteria are used for the computation of values that form the weighted normalized decision matrix which is represented in next section.

Table 2 Determinants of work place performance for seafarers

Determinant Factor (D_m)	Determinant Sub-factor (D_{mn})
D₁ : Job benefits	D₁₁ : Salary and increments
	D₁₂ : Dignity and respect
	D₁₃ : Reward as per achievement
	D₁₄ : Promotion
	D₁₅ : Pension and insurance benefits
D₂ : Work environment	D₂₁ : Weather condition/Natural calamity
	D₂₂ : Facilities and technology
	D₂₃ : Maritime regulations and rules
	D₂₄ : Existence of maritime piracy threat
D₃ : Ship specifics	D₃₁ : Condition of accommodation spaces
	D₃₂ : Equipment reliability and/or maintenance of the ship
	D₃₃ : Ship design and automation
	D₃₄ : Ship vibration, noise and ship motion
D₄ : Organizational culture	D₄₁ : Team work and management supports
	D₄₂ : Training and development
	D₄₃ : Time pressure and heavy workloads
	D₄₄ : Gap between company's policy and practice
	D₄₅ : Transparency and feedback
	D₄₆ : Role and accountability clarity
	D₄₇ : Irregular sleeping and rest hours
D₅ : Social impacts	D₅₁ : Availability of recreation activities
	D₅₂ : Long stay on-board and reduced shore leave
	D₅₃ : Port regulations and visa problem

Computation of the weighted normalized decision matrix

We multiply the normalized decision matrix and the matrix for weights of the evaluation criteria to give values that form the weighted normalized decision matrix as given in Table 5.

Table 5 i.e. the weighted normalized decision matrix gives values that are used in the construction of values in the concordance and discordance sets.

Computation of concordance and discordance sets

Using the values in Table 5, eq. (6a) and eq. (6b), we ascertain values in the concordance and discordance sets as depicted in Table 6.

Table 3 Overall decision matrix

D_m	C_1 (VP)	C_2 (P)	C_3 (M)	C_4 (G)	C_5 (VG)
D₁	0.0000	0.2000	0.3333	0.4667	0.0000
D₂	0.0000	0.0000	0.4333	0.5667	0.0000
D₃	0.0000	0.0000	0.3667	0.6000	0.0333
D₄	0.0000	0.0000	0.3333	0.6333	0.0333
D₅	0.0000	0.0000	0.3000	0.5333	0.1667

Table 4 The normalized decision matrix

D_m	C_1 (VP)	C_2 (P)	C_3 (M)	C_4 (G)	C_5 (VG)	$\sum_{n=1}^N x_{mn}$
D_1	0.0000	0.2000	0.3333	0.4667	0.0000	1.0000
D_2	0.0000	0.0000	0.4333	0.5667	0.0000	1.0000
D_3	0.0000	0.0000	0.3667	0.6000	0.0333	1.0000
D_4	0.0000	0.0000	0.3333	0.6334	0.0333	1.0000
D_5	0.0000	0.0000	0.3000	0.5333	0.1667	1.0000

Concordance values in Table 6 are used in the computation of the concordance indices. Similarly, the discordance values in Table 6 are engaged in the calculation of the discordance indices as detailed in next section.

Computation of concordance and discordance indices

We apply eq. (7a) and eq. (7b) to compute concordance and discordance indices as shown in Table 7. The same table also shows the outranking among alternatives deduced using eq. (8a) and eq. (8b).

The values of concordance indices in Table 7 are summed up for each pair of alternatives to give the net concordance index. Similarly, the values of discordance indices in Table 7 are summed up for each pair of alternatives to give the net discordance index. The net concordance and discordance indices are shown in next section.

Determination of the net concordance and discordance indices

We use the values in Table 7, eq. (9a) and eq. (9b) to determine the net concordance and discordance indices for each determinant factor as shown in Table 8.

Table 8 reveals the existence of two different ranks for alternatives (i.e. determinant factors) D_3 and D_5 . Consequently, we need to undertake a composite ranking for the determinant factors as given in next section.

Determination of a composite ranking

We use the rank deduced by the net concordance index (RC) and the rank deduced by the net discordance index (RD) to get the composite rank (CR) measure of the alternatives (i.e. determinant factors) as shown in Table 9.

The composite rank measure in Table 9 reveals that seafarers consider *ship specifics*, *organizational culture* and *social impacts* as the most determinant factors for work performance. The seafarers also perceive that *job benefits* is the least influential factor on work performance followed by the *work environment* on-board ships. Thus, the MSCL

Table 5 The weighted normalized decision matrix

D_m	C_1 (VP)	C_2 (P)	C_3 (M)	C_4 (G)	C_5 (VG)
D_1	0.0000	0.0240	0.0667	0.1307	0.0000
D_2	0.0000	0.0000	0.0867	0.1587	0.0000
D_3	0.0000	0.0000	0.0733	0.1680	0.0120
D_4	0.0000	0.0000	0.0667	0.1774	0.0120
D_5	0.0000	0.0000	0.0600	0.1493	0.0600

Table 6 Concordance and discordance sets

$C(p, q)$	$\{n v_{pn} \geq v_{qn}\}$	$D(p, q)$	$\{n v_{pn} < v_{qn}\}$
C(1, 2)	{1, 2, 5}	D(1, 2)	{3, 4}
C(1, 3)	{1, 2}	D(1, 3)	{3, 4, 5}
C(1, 4)	{1, 2, 3}	D(1, 4)	{4, 5}
C(1, 5)	{1, 2, 3}	D(1, 5)	{4, 5}
C(2, 1)	{1, 3, 4, 5}	D(2, 1)	{2}
C(2, 3)	{1, 2, 3}	D(2, 3)	{4, 5}
C(2, 4)	{1, 2, 3}	D(2, 4)	{4, 5}
C(2, 5)	{1, 2, 3, 4}	D(2, 5)	{5}
C(3, 1)	{1, 3, 4, 5}	D(3, 1)	{2}
C(3, 2)	{1, 2, 4, 5}	D(3, 2)	{3}
C(3, 4)	{1, 2, 3, 5}	D(3, 4)	{4}
C(3, 5)	{1, 2, 3, 4}	D(3, 5)	{5}
C(4, 1)	{1, 3, 4, 5}	D(4, 1)	{2}
C(4, 2)	{1, 2, 4, 5}	D(4, 2)	{3}
C(4, 3)	{1, 2, 4, 5}	D(4, 3)	{3}
C(4, 5)	{1, 2, 3, 4}	D(4, 5)	{5}
C(5, 1)	{1, 4, 5}	D(5, 1)	{2, 3}
C(5, 2)	{1, 2, 5}	D(5, 2)	{3, 4}
C(5, 3)	{1, 2, 5}	D(5, 3)	{3, 4}
C(5, 4)	{1, 2, 5}	D(5, 4)	{3, 4}

Table 7 Concordance and discordance indices

$C(p, q)$	C_{pq}	$D(p, q)$	D_{pq}	$C_{pq} \geq \bar{C}$	$D_{pq} < \bar{D}$	$A_p \rightarrow A_q$
C(1, 2)	0.52	D(1, 2)	0.6667	NO	NO	NO
C(1, 3)	0.16	D(1, 3)	0.6996	NO	NO	NO
C(1, 4)	0.36	D(1, 4)	0.7098	NO	NO	NO
C(1, 5)	0.36	D(1, 5)	0.7191	NO	NO	NO
C(2, 1)	0.88	D(2, 1)	0.3333	YES	YES	$A_2 \rightarrow A_1$
C(2, 3)	0.36	D(2, 3)	0.6138	NO	NO	NO
C(2, 4)	0.36	D(2, 4)	0.6055	NO	NO	NO
C(2, 5)	0.64	D(2, 5)	0.6243	YES	NO	NO
C(3, 1)	0.88	D(3, 1)	0.3004	YES	YES	$A_3 \rightarrow A_1$
C(3, 2)	0.80	D(3, 2)	0.3862	YES	YES	$A_3 \rightarrow A_2$
C(3, 4)	0.72	D(3, 4)	0.5875	YES	NO	NO
C(3, 5)	0.64	D(3, 5)	0.6000	YES	NO	NO
C(4, 1)	0.88	D(4, 1)	0.2902	YES	YES	$A_4 \rightarrow A_1$
C(4, 2)	0.80	D(4, 2)	0.3945	YES	YES	$A_4 \rightarrow A_2$
C(4, 3)	0.80	D(4, 3)	0.4125	YES	YES	$A_4 \rightarrow A_3$
C(4, 5)	0.64	D(4, 5)	0.5797	YES	NO	NO
C(5, 1)	0.68	D(5, 1)	0.2809	YES	YES	$A_5 \rightarrow A_1$
C(5, 2)	0.52	D(5, 2)	0.3757	NO	YES	NO
C(5, 3)	0.52	D(5, 3)	0.4000	NO	YES	NO
C(5, 4)	0.52	D(5, 4)	0.4203	NO	YES	NO
TOTAL C	12.04	TOTAL D	10.0000			
\bar{C}	0.602	\bar{D}	0.5000			

Table 8 Net concordance and discordance indices

NC_p	$\sum_{p \neq q} C_{pq} - \sum_{q \neq p} C_{qp}$	Rank	ND_p	$\sum_{p \neq q} D_{pq} - \sum_{q \neq p} D_{qp}$	Rank
NC_1	-1.92	5	ND_1	1.5904	5
NC_2	-0.40	4	ND_2	0.3538	4
NC_3	1.20	1	ND_3	-0.2518	3
NC_4	1.16	2	ND_4	-0.6462	2
NC_5	-0.04	3	ND_5	-1.0462	1

Board of Directors and Management must first modernize its aging fleet, re-engineer the corporate culture and improve the social aspect of the work-place. In the long run, the company also should improve the job benefits to its seafarers taking into account the competition in the international maritime labour market. Such a strategy would reduce and/or eliminate seafarers’ turnover and attract more qualified and competent seafarers. More specifically, the increase in demand for Tanzanian seafarers could result from the fact that the government of Tanzania on June 28, 2017, ratified two ILO conventions – the seafarers Identity Documents Convention No 185 (2003) and the Maritime Labour Convention (MLC, 2006). These instruments now enable Tanzanian seafarers to be recruited internationally and thus contribute to the increase of export of services abroad.

Evaluation of job benefit related factors for seafarers work performance

Using the first nine (9) steps of the Fuzzy Electre Model, we eventually get the values of net concordance and discordance indices as shown in next section.

Determination of the net concordance and discordance indices

We use eq. (9a) and eq. (9b) to determine the net concordance and discordance indices for each sub-determinant factor as shown in Table 10. The sub-factors for *job benefits* are salary and increments (D_{11}), dignity and respect (D_{12}), reward as per achievement (D_{13}), promotion (D_{14}), and pension and insurance benefits (D_{15}).

Table 10 reveals the existence of two different ranks for alternatives (i.e. sub-determinant factors) D_{13} and D_{14} . As a result, we need to undertake a composite ranking for the sub-determinant factors as given in next section.

Determination of a composite ranking

We use the rank deduced by the net concordance index (RC) and the rank deduced by the net discordance index (RD) to get the composite rank (CR) measure of the alternatives (i.e. sub-determinant factors) as shown in Table 11.

Table 9 A composite rank measure produced by averaging RC and RD

D_m	RC	RD	$\frac{RC+RD}{2}$	CR
D_1	5	5	5	5
D_2	4	4	4	4
D_3	1	3	2	1
D_4	2	2	2	1
D_5	3	1	2	1

Table 10 Net concordance and discordance indices

NC_p	$\sum_{p \neq q} C_{pq} - \sum_{q \neq p} C_{qp}$	Rank	ND_p	$\sum_{p \neq q} D_{pq} - \sum_{q \neq p} D_{qp}$	Rank
NC_{11}	-2.24	5	ND_{11}	1.978	5
NC_{12}	2.80	1	ND_{12}	-1.6118	1
NC_{13}	0.56	2	ND_{13}	-0.5579	3
NC_{14}	0.52	3	ND_{14}	-0.9431	2
NC_{15}	-1.64	4	ND_{15}	1.1348	4

With regards to job benefit issues, the findings in Table 11 reveal that *dignity and respect* is the most important factor valued by seafarers followed by *promotion and reward as per achievement*. In contrast, seafarers have the opinion that *salary and increments* are the least important factor in work performance followed by *pension and insurance benefits*. Thus, the MSCL should create a harmonious environment and improve the chain of command at the workplace i.e. reconsider its Management style while developing performance-based incentive policy. Nevertheless, any proposed incentive policy should meet the provisions stipulated by the Maritime Labour Convention, 2006 as amended and the Tanzania Merchant Shipping Act No. 21 of 2003 and other relevant laws of the land. Moreover, the company’s annual action plan should have a target that focuses on the seminar to its employees with regard to Retirement planning and other social security issues.

Evaluation of work environment related factors for seafarers work performance

Using the first nine (9) steps of the Fuzzy Electre Model, we eventually get the values of net concordance and discordance indices as shown in next section.

Determination of the net concordance and discordance indices

We use eq. (9a) and eq. (9b) to determine the net concordance and discordance indices for each sub-determinant factor as shown in Table 12. The sub-factors for *work environment* are weather condition/natural calamity (D_{21}), facilities and technology (D_{22}), maritime regulations and rules (D_{23}), and existence of maritime piracy threat (D_{24}).

The net concordance indices and the net discordance indices of Table 12 give the same rank. Thus, the significance in decreasing order of influential factors with regard to work environment on-board ships is *maritime regulations and rules, weather condition/natural calamity, the existence of maritime piracy threat, and facilities and technology*. Thus, the MSCL should comply with all safety, pollution, and security maritime conventions including the International Convention for the Safety of Life at Sea

Table 11 A composite rank measure produced by averaging RC and RD

D_m	RC	RD	$\frac{RC+RD}{2}$	CR
D_{11}	5	5	5	5
D_{12}	1	1	1	1
D_{13}	2	3	2.5	2
D_{14}	3	2	2.5	2
D_{15}	4	4	4	4

Table 12 Net concordance and discordance indices

NC_p	$\sum_{p \neq q} C_{pq} - \sum_{q \neq p} C_{qp}$	Rank	D_p	$\sum_{p \neq q} D_{pq} - \sum_{q \neq p} D_{qp}$	Rank
NC_{21}	0.32	2	ND_{21}	-0.1792	2
NC_{22}	-0.44	4	ND_{22}	0.8756	4
NC_{23}	0.48	1	ND_{23}	-0.5044	1
NC_{24}	-0.36	3	ND_{24}	-0.192	3

(SOLAS, 1974 as amended), International Convention for the Prevention of Pollution from Ships (MARPOL, 1973/78), United Nations Convention on the Law of the Sea (UNCLOS, 1982), and Convention for the Suppression of Unlawful Acts of Violence Against the Safety of Maritime Navigation (SUA, 1988). More specifically, the MSCL shall comply with the provisions of the Tanzania Merchant Shipping Act No. 21 of 2003. This, in turn, necessitates the company to have all necessary certificates on-board such as Manning certificate, Class certificate, Seaworthiness certificate, Certificate of registry, Safety construction certificate, Safety equipment certificate, Safety radio certificate, Loadline certificate, Crew list, Log-book, Insurance certificate etc.

Evaluation of ship specific related factors for seafarers work performance

Using the first nine (9) steps of the Fuzzy Electre Model, we eventually get the values of net concordance and discordance indices as shown in next section.

Determination of the net concordance and discordance indices

We use eq. (9a) and eq. (9b) to determine the net concordance and discordance indices for each sub-determinant factor as shown in Table 13. The sub-determinant factors for *ship specifics* are condition of accommodation spaces (D_{31}), equipment reliability and/or maintenance of the ship (D_{32}), ship design and automation (D_{33}), and ship vibration, noise and ship motion (D_{34}).

Table 13 reveals the existence of two different ranks for alternatives (i.e. sub-determinant factors) D_{31} and D_{34} . As a result, we need to undertake a composite ranking for the sub-determinant factors as given in next section.

Determination of a composite ranking

We use the rank deduced by the net concordance index (RC) and the rank deduced by the net discordance index (RD) to get the composite rank (CR) measure of the alternatives (i.e. sub-determinant factors) as shown in Table 14.

Table 13 Net concordance and discordance indices

NC_p	$\sum_{p \neq q} C_{pq} - \sum_{q \neq p} C_{qp}$	Rank	ND_p	$\sum_{p \neq q} D_{pq} - \sum_{q \neq p} D_{qp}$	Rank
NC_{31}	0.48	1	ND_{31}	-0.2904	2
NC_{32}	-0.20	3	ND_{32}	-0.073	3
NC_{33}	-0.64	4	ND_{33}	0.8494	4
NC_{34}	0.36	2	ND_{34}	-0.486	1

The composite ranking of Table 14 shows that the most influential factors on work performance of seafarers with regard to ship specifics are *condition of accommodation spaces (sleeping rooms, mess rooms, sanitary accommodation, hospital accommodation, recreation accommodation, store rooms, and catering accommodation)*, and *ship vibration, noise and ship motion*. On the other hand, *ship design and automation* is the least influential factor followed by *equipment reliability and/or maintenance of the ship*. This calls MSCL to modernize its aging fleet by new building or carrying out major rehabilitation of its fleet. Nonetheless, the MSCL has accomplished major rehabilitation for MV Victoria and MV Butiama while one new building ship with the carrying capacity of 1200 passengers and 400 tons to be deployed on Lake Victoria is under construction. Such a modernization strategy of its fleet will make the company comply with the provisions of the Maritime Labour Convention, 2006 as amended, the ILO convention that is in the process of being domesticated after being ratified by the government of the United Republic of Tanzania on June 28, 2017.

Evaluation of organization culture related factors for seafarers work performance

Using the first nine (9) steps of the Fuzzy Electre Model, we eventually get the values of net concordance and discordance indices as shown in next section.

Determination of the net concordance and discordance indices

We use eq. (9a) and eq. (9b) to determine the net concordance and discordance indices for each sub-determinant factor as shown in Table 15. The sub-determinant factors for *organization culture* are team work and management supports (D_{41}), training and development (D_{42}), time pressure and heavy workloads (D_{43}), gap between company’s policy and practice (D_{44}), transparency and feedback (D_{45}), role and accountability clarity (D_{46}), and irregular sleeping and rest hours (D_{47}).

Table 15 reveals the existence of five different ranks for alternatives (i.e. sub-determinant factors) D_{41} , D_{42} , D_{43} , D_{45} and D_{47} . As a result, we need to undertake a composite ranking for the sub-determinant factors as given in next section.

Determination of a composite ranking

We use the rank deduced by the net concordance index (RC) and the rank deduced by the net discordance index (RD) to get the composite rank (CR) measure of the alternatives (i.e. sub-determinant factors) as shown in Table 16.

With regard to organization culture, the composite ranking in Table 16 reveals in descending order the influential factors on work performance of seafarers as *irregular sleeping and rest hours, training and development, time pressure and heavy workloads, team-work and management supports, the gap between company’s policy and practice,*

Table 14 A composite rank measure produced by averaging RC and RD

D_m	RC	RD	$\frac{RC+RD}{2}$	CR
D_{31}	1	2	1.5	1
D_{32}	3	3	3	3
D_{33}	4	4	4	4
D_{34}	2	1	1.5	1

Table 15 Net concordance and discordance indices

NC_p	$\sum_{p \neq q} C_{pq} - \sum_{q \neq p} C_{qp}$	Rank	ND_p	$\sum_{p \neq q} D_{pq} - \sum_{q \neq p} D_{qp}$	Rank
NC_{41}	-1.28	6	ND_{41}	-0.564	2
NC_{42}	1.72	1	ND_{42}	-0.3528	3
NC_{43}	0.96	3	ND_{43}	-0.3296	4
NC_{44}	-0.84	5	ND_{44}	0.6994	5
NC_{45}	-0.36	4	ND_{45}	0.8168	6
NC_{46}	-1.28	7	ND_{46}	1.1068	7
NC_{47}	1.08	2	ND_{47}	-1.3766	1

transparency and feedback, and *role and accountability clarity*. The MSCL is called to ensure that it has sound staff policies e.g. updated staff rules and regulations taking into account inputs from seafarers i.e. collective bargaining, maritime transport regulator and other interested parties. Moreover, effective implementation of such rigorous staff rules and regulations will be in harmony with the recently ratified Maritime Labour Convention, 2006 which provides rights for seafarers to decent work and living conditions on-board ship and rights to social protection including health, medical care, and welfare issues.

Evaluation of social related factors for seafarers work performance

Using the first nine (9) steps of the Fuzzy Electre Model, we eventually get values of the net concordance and discordance indices as shown in next section.

Determination of the net concordance and discordance indices

We use eq. (9a) and eq. (9b) to determine the net concordance and discordance indices for each sub-determinant factor as shown in Table 17. The sub-factors for *social impacts* are availability of recreation activities (D_{51}), long stay on-board and reduced shore leave (D_{52}), and port regulations and visa problem (D_{53}).

Table 17 reveals that the net concordance index and the net discordance index give the same rank. Consequently, *port regulations and visa problem* is the most influential factor on work performance for seafarers with regard to social issues whereas the *availability of recreation activities* is the least factor affecting the performance of seafarers

Table 16 A composite rank measure produced by averaging RC and RD

D_m	RC	RD	$\frac{RC+RD}{2}$	CR
D_{41}	6	2	4	4
D_{42}	1	3	2	2
D_{43}	3	4	3.5	3
D_{44}	5	5	5	5
D_{45}	4	6	5	5
D_{46}	7	7	7	7
D_{47}	2	1	1.5	1

Table 17 Net concordance and discordance indices

NC_p	$\sum_{p \neq q} C_{pq} - \sum_{q \neq p} C_{qp}$	Rank	ND_p	$\sum_{p \neq q} D_{pq} - \sum_{q \neq p} D_{qp}$	Rank
NC_{5_1}	-1.16	3	ND_{5_1}	1.2336	3
NC_{5_2}	0.32	2	ND_{5_2}	-0.5754	2
NC_{5_3}	0.84	1	ND_{5_3}	-0.6582	1

while on-board ship. Thus, the company is strongly advised to comply with the flag state control i.e. abide to the Tanzania Merchant shipping Act No. 21 of 2003 and Tanzania’s immigration laws. Besides, the company need to observe also the Port state and Coastal state regulatory regimes of states whose waters the company’s vessels are trading. Adherence of the company to relevant regulations will reduce the ships’ turn-around times while in Port and increase the freight revenue provided there is the demand for shipping services.

Conclusions

The operational performance of a shipping company is largely dependent on the performance of its employees. Nonetheless, there are a variety of factors, personal, company-based and external that affect the performance of seafarers while on-board ship. Identifying these factors and their impact can help shipping companies improve recruitment, retention and organizational results. To analyse the determinants of work performance for seafarers, we take a random sample of 30 seafarers working for Marine Services Company Limited (MSCL) – a Tanzanian shipping company trading on Lake Victoria, Lake Tanganyika and Lake Nyasa. We develop and apply Fuzzy Electre Model (FEM) to rank the determinants and sub-determinants of seafarers’ work performance. The computational results reveal that at the first level of the evaluation model, *ship specifics, organizational culture, and social impacts* are the most determining factors for seafarers’ work performance followed by *work environment* and *job benefits*. On the other hand, at the second level of the evaluation model, *dignity and respect* are the most determining factors concerning job benefit issues; while *maritime regulations and rules* are the most determining factors regarding working environment on-board ships. Also, *condition of accommodation spaces and ship vibration, noise and ship motion* are the most determining factors with regard to ship specifics whereas *irregular sleeping and rest hours* are the most determining factors with regard to organization culture. Lastly, *port regulations and visa problem* are the most determining factors regarding social issues. The evaluation results also validate the effectiveness of the FEM for handling problems with vagueness and uncertainty.

The findings of this study therefore call for all relevant parties to determine solutions for the challenges that hinder seafarers’ work performance. Such a strategy would attract more young Tanzanians to join the seafarers’ profession which in turn would reduce the shortage of seafarers in both the local and international labour market. The increase in supply of competent and qualified seafarers in the local market implies improving the efficiency and effectiveness of on-board ship operations and increase in the country’s exports through seafarers which in turn impacts positively on the country’s balance of trade. A potential limitation of this study is that it focuses only on one

shipping company (i.e. MSCL) which poses limitation to generalize the results to other shipping companies whose ships fly a Tanzanian flag. The future direction of this study could be the analysis of the impact of the shortage of Tanzanian ocean-going vessels on the country's balance of payments.

Abbreviations

MSCL: Marine Services Company Limited; FEM: Fuzzy Electre Model; MCDM: Multi-Criteria Decision Making; TFN: Triangular Fuzzy Number; RC: Net Concordance Index; RD: Net Discordance Index; CR: Composite Rank; ILO: International Labour Organization; MLC: Maritime Labour Convention; SOLAS: International Convention for the Safety of Life at Sea; MARPOL: International Convention for the Prevention of Pollution from Ships; UNCLOS: United Nations Convention on the Law of the Sea; SUA: International Convention for the Suppression of Unlawful Acts of Violence Against the Safety of Maritime Navigation.

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Authors' contributions

Dr. Erick P. Massami was extensively involved in the problem formulation and data analysis whereas Mr. Malima M. Manyasi was extensively involved in the data collection exercise. The authors read and approved the final manuscript.

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'The authors declare that they have no competing interests'.

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