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Computer-based systematic execution model on human resources management in maritime transportation industry: The case of master selection for embarking on board merchant ships

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Abstract

Human resources management (HRM) have been increased its functionality and popularity in the shipping business, due to the expeditiously changes in technology, market strategies, risks and challenges in transportation industry. Despite the requirements of International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), held by International Maritime Organization (IMO), especially the quality and competency of personnel who are being employed on board ships are primarily issue of shore-based ship management organizations. This paper proposes an extendable and applicable model based on Analytic Network Process to support the personnel selection facilities of crewing departments in ship management companies. The priorities of evaluation factors are outlined for employing the Master, the most significant and key personnel on board merchant ships, as a case application in this study. Consequently, the results are elaborated to construct a scheme on evaluating of job applications for embarking Master on board ships. The model can be achieved to modify for carrying out to evaluate the employment criteria for other ranks on board ships as a further study.

Keywords: Human resources management; Seafarers employment; Information technology; STCW requirements; Analytic Network Process

1. Introduction

The influences of rapid changes in various parameters such as technology, risks, policies, and strategies in competitive market conditions have been caused to seek new approaches in terms of management processes at shipping companies to accomplish the sustainable development in maritime transportation industry. It is one of the expected results of this phenomena that modifying and extending of the roles and responsibilities of organizations in a professional manner parallel to the requirements of additional needs and expectations of maritime industry. Hence, it is addressed in contents of the recent studies, cited by Hork (2004), Panayides (2006), Engelen, Meersman, and Voorde (2006), Jensses and Randoy (2006) on maritime policy and management to integrate new approaches into the organizations and to utilize practical tools in order to support managerial activities. Although information technology (IT) based management tools (Lyridis et al., 2005; Roumboutsos, Nikitakos, & Gritzalis, 2005) are taking a part within maritime organizations to satisfy the needs properly on several processes such as risk evaluation, finance, communication, and so on, there are still many needs about decision support mechanisms for divisional activities and various ongoing problems. Therefore, additional approaches should be investigated on these issues and they ought to be adopted to the existing procedures of organizations to extent the decision support mechanisms towards whole process. Since the human-based errors and risks are the dominant factor on maritime incidents (Baker & McCafferty, 2005; Er & Celik, 2005), executing of the

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relevant issues on human resources such as labor planning, labor quality, training of personnel, competency of crew, safety-related precautions, crew performance monitoring, crew insurance policy, and payment of wages can be recognized as the critical management processes for ship management companies. All of these issues are executed in both operational level and implementation process under the responsibilities of managers who have positions in shore-based management organization of the ship management companies (Celik & Er, 2006).

This paper mainly concentrates on structuring of an innovative managerial tool in order to the personnel embarkation facilities of human resources management (HRM) and crewing department in ship management companies. Among divisional facilities, HRM is one of the principal concerns for ship management companies as an international perspective within dynamic boundary conditions. However, the role and systematic of the HRM in shipping business are required different procedures when it is benchmarked with the other disciplines due to various expectations and constraints on operational processes in maritime industry. Especially, critical decisions on various facilities regarding with the crew manning process such as planning, evaluation, training, embarkation, and disembarkation have been performed with the control and execution of professional managers with the statistical and experimental approaches. Performing of evaluation process on the selection of the most suitable personnel is the most highlight and critical issue in the activities of HRM department. It is the common sense for many of the shipping companies on this issue to perform the facilities under the execution of crewing department instead of professional HRM department in organizations. However, the firms which have a more professional organization, are performed the various activities under the department of HRM as well. Nevertheless, it is still an urgent necessity to perform an IT based systematic employment and evaluation approaches for both kinds of organizations to ensure the personnel competency on board ships. On the other hand, the additional requirements of International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), held by International Maritime Organization (IMO), should be recognized as another constraint during the manning process in ship management. The rules and regulations are enforcing the shore-based management organizations for employing the well-trained and competent personnel on board ships by supporting a wide range of certification procedure. Hence, the additional standardization and certification processes apart from other business disciplines increase the complexity of problem for maritime transportation industry. The main objectives of the IMO are the promotion of maritime safety and the protection of the marine environment (Dijxhoorn, 1996). On the other hand, the requirements of STCW, one of the global conventions of IMO, prescribe minimum standards relating to training, certification and watchkeeping for seafarers taking into account of shipboard hierarchical organization. So, it is recognized as another expectation in international level to ensure the qualifications of shipboard personnel in technical manner. The STCW convention defines standards of competence and identifies the roles and responsibilities of ship management companies on this issue (McCarter, 1999). All of these requirements, expectations, and constraints create external pressures on maritime society especially on ship management companies for employing high competency of personnel on board ships (Dinwoodie, 2000).

The urgent needs on systematic tools for managing human resources planning under the various constraints and complexity of personnel recruitment problem for shipping business are outlined in this section. It is argue that maritime community has been already discussing the significance of the HRM to ensure the consistency of decisions on personnel selection and assessment processes in ship management companies. However the needs on effective tools clearly appeared for executing this process after the wide range of industry and market based survey is completed in this section. The remaining parts of the paper are organized as follows: Section 2 investigates the existing personnel evaluation and assignment models for different business disciplines in literature. Additional requirements and different points of crewing issue for maritime business are outlined as well. For managing the personnel embarkation process in shipping firms as a complex issue, a systematic personnel evaluation and assignments model based on analytical network process (ANP) are considered to construct, therefore, the fundamental concept and recent popular applications of ANP are introduced widely in Section 3. The framework of the proposed model for personnel selection is represented in Section 4, and the model is tested with a case application on embarkation process of master, the most significant and key personnel on board, to be able to obtain illustrative results in Section 5. The paper is concluded with gathering the outcomes of case application for practical usage and expressing the further research directions.

2. Literature survey on manpower planning and personnel evaluation models

Understanding of the maritime manpower system is focused theme as force major events in shipping industry during last decade. The on-going researches are generally concerned with both manpower availability and the quality of seafarers. Despite all considerable and profound changes in the industry, labor is the primary factor of maritime sector (McConville, 1999) and it is still organized on board ship on the basis of a hierarchical structure of officers and ratings. Obando-Rojas, Gardner, and Naim (1999) investigated a system dynamic methodology to utilize some aspects of the officer supply-chain in the merchant marine. Forecasting the future demand of maritime manpower is another critical point for investigating the pressure on ship-

ping firms in terms of shortage problem. Chin-Tsai, Wang, and Chiang (2001) applied the grey theory to forecast the annual demand of deck officers, and they utilized cross analysis to investigate the manpower supply and demand of ocean deck officers in Taiwan as a case application. Contributory factors of the present employment trends and emphasizes issues such as recruitment, maritime education outlined by Sambracos and Tsiaparikou (2001) for the Greek owned fleet. Li and Wonham (1999) analyzed the comprehensive survey reports of Baltic and International Maritime Council (BIMCO) and the International Shipping Federation (ISF) and they determined that numbers of seafarers were enough for world fleet, but the quality issues were clearly underlined. Wu, Lai, and Cheng (2006) investigates the performance levels and skills of Chinese seafarers in the global labor market by considering the relevant criterion on obedience, teamwork ability, attitudes, technical qualifications and navigational skills. The factors within the cited paper are expected to make valuable contributions to this study for structuring the criterion.

On the other hand, existing studies on labor planning, worker performance evaluation, personnel selection, and personnel assignment in different kinds of business disciplines are also investigated to make a deeply analysis on proposed methodologies in literature. Theoretical papers on personnel selection and employment (Borman, Hanson, & Hedge, 1997; Hough & Oswald, 2000; Lievens, Van Dam, & Anderson, 2002; Robertson & Smith, 2001) have been continued to be published in literature. The existing papers are much more concentrates on measuring knowledge, ability, technical proficiency, and personality, structuring interview procedures, evaluation of job performance in advance to enhance the personnel selection process systematically. The researches of famous psychologists like Schmidt and Hunter (1981, 1998) outlined that general cognitive ability and personality traits and success influence approximately 20–30% of the variance in job performance. Therefore, they underline the requirements of the systematic evaluation methodology to measure these factors during personnel assessment. Recent years, many of the methodologies such as meta-analytic studies, five factor model (FFM), forced-choice personality test, internet and paper-and-pencil administrations of personality tests were performed by Salgado and Moscoso (2003), Ployhart, Lim, and Chan (2003), Naglieri et al. (2004), Hsu (2004), Hoel (2004), Erickson (2004), Faulder (2005), Handler (2005), Heller (2005), and Roberts, Chernyshenko, Stark, and Goldberg (2005) on personality measures for being utilized during job applications. As more advanced approaches on employee evaluations, utilization of decision support systems (DSS) are proposed by Niehaus (1995), Bellone, Merlino, and Pesenti (1995), Mohanty and Deshmukh (1997), Dessler (2000), Bali (2001), Vitolo and Vance (2002), Brice and Waung (2002) in literature. Chien and Chen (2008) argue that it is the primarily expectations from the proposed models to find the right people for the right jobs and positions. Therefore, the structuring process of the model is so critical to manage the utility of the model in practice. For enhancing the model utility, advanced techniques on personnel employment such as IT (Beckers & Bsat, 1995; Kovach & Cathcart, 1999; Liao, 2003) and expert systems (Hooper, Galvin, Kilmer, & Liebowitz, 1998; Nussbaum et al., 1999) have been utilized.

The outcomes of the literature survey indicate that the relevant papers on human resources and employment trends in maritime industry are available; however, analytical studies on crew recruitment as well as personnel selection for crew embarkation on board are almost rare in literature. Therefore, the urgent needs on systematic evaluation and quantitative personnel assignment models have been appeared both in academic field and in practice. This paper investigates the satisfactory solution on crew and officer assignment problem of the ship management companies. Many factors, constraints, and concerns have influenced the crewing process as it is observed in literature review. Due to the interdependencies and outer dependencies between factors, ANP is found as a suitable methodology to identify the relative importance of the relevant factors.

3. Overview on Analytic Network Process

When the nature of the problem on hand is complicated and the problem can only be modeled as a hierarchy or network, most of the multi-criteria decision aid methods fail for analysis (Eddie & Cheng, 2007). Saaty (1980, 1996) proposed the Analytic Hierarchy Process (AHP) and ANP approaches those can be utilized for examining hierarchy and network model representations.

The power of AHP/ANP lies in their use of special ratio scales Saaty (1980, 1996) to capture all kinds of interactions between tangible and intangible criteria for making accurate predictions and better decisions. Both methods are claimed to possess qualitative and quantitative components. They not only employ the procedure for assigning importance to the criteria (factors) but also assess the global preferences to the alternatives. These characteristics are other advantages of AHP/ANP approaches.

However, AHP is restrictive to solve problems having a linear unidirectional hierarchical relationship among factors. The ANP, the general form of AHP, does not require this strictly hierarchical structure and therefore can treat problems having complex interrelationships among factors (dependencies and feedbacks) so that it can handle the complexities of real-world problems for making societal, governmental, and corporate decisions (Bayazit & Karpak, 2007; Jharkharia & Shankar, 2007; Saaty, 2003; Salo & Hamalainen, 1997; Shyur & Shih, 2006). Unfortunately, ANP applications have been noticeably limited when compared with AHP, due to its complexity and time consuming nature.

So far, the ANP approach has proven itself to be successful when expert knowledge is used within business by Lee and Kim (2001), Meade and Sarkis (1998), Lee and Kim (2000), Partovi (2001), Sarkis and Sundarraj (2002), Agarwal and Shankar (2002), Sarkis and Talluri (2002), social themes by Erdogmus, Aras, and Koc (2006), Sarkis (1998), Sarkis (1999), Sarkis (2003), and manufacturing Meade and Sarkis (1999), Karsak, Sozer, and Alptekin (2003) decision contexts or used to predict sports outcomes (Partovi & Corredoira, 2002) and economic turns (Blair, Nachtmann, Saaty, & Whitaker, 2002).

In order to assess judgments of the decision makers, they are asked to make pairwise comparisons of the factors of the network using a nine-point scale suggested by Saaty (1996). Saaty's scale asks "of the dependent factors, which one influences the common factor more and how much more?". In this scale, a value of 1 between two factors indicates that both equally influence the affected node, whereas a value of 9 indicates that the influence of one factor is extremely more than that of the other. Monitor team computes the geometric means of all paired-comparison judgments of different decision makers for each question in order to reveal the aggregated group judgments. Group judgments then are arranged in pairwise-comparison matrices, which will be input for Super Decisions (2007) software. In the aggregated pairwise-comparison matrix, the value for an (i,j)-pair is in the range 1–9 if the influence of factor i is more than that of factor j, while the value of that pair is in the range 1–1/9 if the influence of factor i is less than that of factor j. Regardless, the value of an (i,i) pair is 1, and given the (i,j)-value, the corresponding (j,i)-value will be the reciprocal of the (i,j)-value.

The relative importance of the factors is computed as a further step. The importance can be regarded as the influence of the factors on the goal of the decision problem. For this purpose, necessary calculations to synthesize aggregated judgments are done by super decisions software. These calculations include the computation of the eigenvector for each pairwise-comparison matrix, the formation of a supermatrix and a weighted supermatrix (if necessary), and the computation of the convergence of the supermatrix (limit matrix).

The eigenvector consists of priorities of the affecting nodes with respect to affected node (Saaty, 1980, 1996). The easiest way to compute the eigenvector is to start with the normalization of the pairwise-comparison matrix – dividing each element by its column sum – so that each column adds to 1. The arithmetic mean (average) of the values of each row is an element of the eigenvector.

In a supermatrix, each node is represented in one row and one respective column (i.e. the goal is in the first row and first column). The computed eigenvector is placed in the column representing the affected node and the rows representing the affecting nodes. If any column sum in the composed supermatrix is greater than 1 (there is more than one eigenvector), that column will be normalized. Such a supermatrix is called a weighted supermatrix.

The weighted supermatrix then is raised to a significantly large power to have converged or stable values. The values of this limit matrix are the desired priorities of the elements of the decision network with respect to the goal.

4. Framework of proposed evaluation model on shipboard personnel selection

The model is constructed on the philosophy of interfacing the quantified methodology and technical know-how about ship operations and personnel qualifications. The variety of personnel duties and responsibilities on board ships requires systematic evaluation for embarkation process each personnel group. Name of the positions and average number of the crew in shipboard organization are illustrated in Table 1.

Master, Chief Officer, Junior Deck Officers, Chief Engineer, Second Engineer, Junior Engineers, and Electrical Officer can be listed under the category of officers. Crewmembers are regarded as the ratings for both deck and engine departments, provisional personnel, and cadets. Variety of the personnel and the duties of them for routine and emergency conditions seek many of the qualifications for each of the rank correspondingly. The problem is getting more complex when the preference of shipping company is employing multinational crew. In this case, another difficulty is appeared on managing ship operations with harmony of personnel from different cultures termed as diversity. Personality characteristics and professionals ethics are playing a significant role on succeeding of multinational crew situations. On the other hand, definitions of responsibilities with respect to related position, certification requirements, and expectations of the company can be considered as referred factors for structuring the model on personnel assignment. When it is considered as a decision support mechanism, Fig. 1 illustrates the general framework of the proposed model.

The framework of the model consists of four main components: database, model, user interface, and user. When candidates applied for a position, they are faced with computer-based testing system and human-based interview.

Table 1
Personnel organization on board merchant ships

Personnel	Average number
Master	1
Chief officer	1
Junior deck officers	1–2
Chief engineer	1
Second engineer	1
Junior engineers	1–2
Electrical officer	1
Ratings (deck)	4–8
Ratings (engine)	4–8
Provisional personnel	2–4
Cadets	0–4

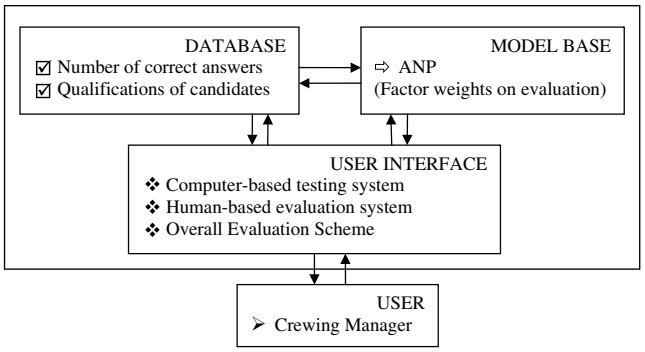


Fig. 1. General framework of the proposed model.

The results of the both evaluation is collected in database unit as the number of correct answers for testing, and assigned scores for interview. The ANP based model provides support for weighting of evaluation factors and examining the performance of candidates with respect to each factor. Total performances of the candidates are determined to give final decisions about candidates. Personnel manager controls and performs the all processes as the user of the decision support mechanism. The model let the personnel manager make both subjective and objective evaluation during personnel assignment for a position.

5. Utilization of proposed model on master embarkation process

In this section, the proposed model in the previous section on supporting personnel embarkation process in ship management companies is utilized on a case to be able to obtain illustrative results. The case of employing the Master who is the most significant and key personnel on board, is examined as a sample application of the proposed model in practice.

5.1. Identifying relevant factors and evaluation units on master selection

For multiple criteria decision-making models, it is the most critical issue to structure the criteria hierarchy. In broad sense, the outcomes of the existing studies in literature are taken into account while structuring the relevant criteria. Due to the lacking of analytical models on ship personnel selection in literature, it is determined to design an original model by referring the main responsibilities of positions and related expectations. Table 2 illustrates the main responsibilities of master on board while Table 3 identifies the expectations of ship management companies on qualifications of master.

The main responsibilities of the position generally require technical knowledge and capability of candidates in desired level. However, the expectations of the ship management companies are related to additional qualifications and personality characteristics such as motivation, discipline, congeniality, tenderness, endurance to sea conditions, and so on. On the other hand, certification is another constraint for seafarers. The content of the certification requirements indicates the expectations on technical knowledge and competency as well. Table 4 exhibits the required certificates for being embarked on board merchant ships. The training requirements of the related certificates are considered for structuring criterion hierarchy. The evaluation for measuring occupational capability of candidates generally requires usage of knowledge-based assessment usually applied with multiple choices testing system. This paper originally proposes computer- based testing system for evaluation the occupational knowledge of candidates in an efficient manner.

The fundamental structure of the evaluation factors is determined to be categorized into five main clusters: occupational information, professional discipline and responsibilities, leadership and coaching, and personality characteristics, denoted with Cluster A, Cluster B, Cluster C, Cluster D respectively. Table 5 illustrates the clusters of evaluation factors.

ANP requires identifying the interdependencies and outer-dependencies as relations between relevant factors

Table 2
Main responsibilities of master on board

No.	Responsibilities
1	Acting as personnel executive for the company for required situations
2	Ensuring safety of the ship, crew, and cargo
3	Monitoring of cargo plans of operations
4	Planning shipboard training facilities
5	Reporting accidents, failures, and damages
6	Monitoring the measurements of stability, trim, and stress
7	Accounting of voyage expenditures and post-fixtures
8	Apprising the performance of the personnel on board
9	Keeping contact with the manning divisions on embarking/disembarking process
10	Monitoring the outcomes of repair and maintenance facilities on board

Table 3
Main expectations of ship management companies on qualifications for master

No.	Qualifications
1	Having all valid documents regarding with the certifications producers
2	Having desired level of English ability for managing commutation process
3	Having good skills of leadership and command
4	Having an adequate knowledge of safety management system (SMS)
5	Having an adequate disciplinary to perform responsibilities
6	Referring good reputation from his previous experiences
7	Having a good health with psychologically and physically
8	Motivating ability on crew members in terms of educating and training facilities
9	Having a professional knowledge on information technologies (IT)
10	Keeping commercial and social relations with the related stakeholders

Table 4
Certifications requirements for embarkation of master on board ship

Certificate	
Valid seaman's book	√
Valid passport	√
Certificate of competency	√
Valid medical examination	√
Special medical examination of company	√
Personal survival techniques training cert	√
Advanced fire fighting certificate	√
Fire prevention and fire fighting training certificate	√
Elementary first aid training certificate	√
Personal safety and social responsibility training certificate	√
Proficiency in survival craft and rescue boat certificate	√
Medical first aid and training certificate	√
Medical care training certificate	√
The operational use of ARPA training certificate	√
Radar observation and plotting training certificate	√
VHF communication certificate	√
SSO certificate	√
Oil tanker familiarization certificate	√
Advanced trainings program on oil tanker operations certificate	√
Chemical tanker familiarization certificate for chemical tankers	√
Advanced training program on chemical tanker operations certificate	√
COW training certificate	√
Bridge resource management certificate	√
Ship handling course certificate	√

Table 5
Clustering of evaluation factors

Cluster A: Occupational information	
A.1	Competency in navigation and meteorology
A.2	Authority, initiate, reliability in cargo and ballast operations
A.3	Precision and accuracy in ballast and bilge water operations
A.4	Circumspection in maintenance of hull, hardware, and deck
A.5	Utilization and management o material ration and suppliers
A.6	Knowledge in implantation of mandatory rules and regulations
A.7	Capability in necessary documents prior to completion of voyage
A.8	Providing to vessel is prepared for voyage and cargo without any shortage
A.9	Competency in emergency preparedness
A.10	Knowledge in complying the requirements of international standards
Cluster B: Professional discipline and responsibilities	
B.1	Professionals ethics
B.2	Allocation of responsibilities
B.3	Working in self sacrifice
B.4	Establishment of communication
B.5	Working out of the vessel' hierarchical order
Cluster C: Leadership and coaching	
C.1	Comportment in regards of maritime practice and habits
C.2	Behavior in terms of vessel's organization and disciplines
C.3	Capacity to command and reliability
C.4	Motivation
C.5	Resoluteness
C.6	Capacity to train and teach
C.7	Consistency in manners
Cluster D: Personality characteristics	
D.1	Endurance to sea (psychology)
D.2	Endurance to sea (physically)
D.3	Frankness
D.4	Uprightness
D.5	Tenderness
D.6	Congeniality

within clusters. So, the professionals from human resources department and technical departments of several ship management companies are contacted to identify the pairwise relations among the factors. Fig. 2 illustrates these pairwise relations.

As a further step, the judgments on each of the pairwise comparisons are determined by the same expert group in group consensus. Then, the geometric means of the judgments are performed on the software package of Super Decisions (2007). The framework of the model structure on the software package is illustrated in Fig. 3.

The software package of super decisions represents the priorities of factors both in text and graphic mode. After completing the computation process, Fig. 4 illustrates the weight the each of the factors within clusters.

5.2. Testing of evaluation scheme on master embarkation process

After determining the weights of the relevant factors, the evaluation scheme is structured. The characteristics of the clusters are required to design an evaluation system both subjective and objective manners. Therefore, the combination of human-based interview unit and computer-based testing system are determined to perform for evaluating of the candidates who are applied the position to be designated as a shipboard employee. Tables 6 and 7 illustrate the evaluation scale and scores in a correspondence manner.

The threshold levels are identified to be able to perform final decisions on candidates. Table 8 illustrates the intervals of total score levels for decision making on the employment process.

Finally, the illustrative application is performed on three candidates denoted as Candidate I, Candidate II, and Candidate III within evaluation scheme. The evaluation scheme is consisting of following units: relevant factors, evaluation types, interfaces, factor weights, performances of candidates, total score of candidates, factors in success of candidates, and final decisions. The candidates initially start with answering the question set for each of the criterion via computer-based testing system. Then, the scores are automatically assigned by the system by considering number of correct answers and factor weights. The system also calculates the factor-based performance scores of the each candidate. Considering the score levels, final decisions on candidates are executed. Table 9 illustrates the overall evaluation scheme with the illustrative example.

5.3. Extended discussions on illustrative results

In this section, the extended discussions on the findings are performed for utilizing the outcomes of systematic

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5	C6	C7	D1	D2	D3	D4	D5	D6
A1		*		*		*			*	*		*	*	*		*	*	*		*	*		*	*				
A2	*			*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*		*				*		
A3		*			*	*	*		*	*	*	*	*	*	*			*	*	*	*	*			*	*		
A4	*	*	*		*	*		*			*	*	*	*			*	*	*		*	*			*	*		
A5		*		*							*		*	*		*	*	*	*		*	*			*	*		
A6	*	*	*	*			*	*	*		*	*	*	*	*	*	*	*	*	*	*	*			*	*	*	
A7		*		*	*	*		*		*	*	*	*	*	*	*		*	*	*	*	*			*	*		
A8	*	*		*	*		*			*						*		*	*	*	*		*		*	*		
A9	*	*	*		*	*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
A10	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*	*	*	*	*	*			*	*		
B1	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*	*	*	*		*			*	*		
B2	*	*	*	*	*	*		*	*	*	*			*	*		*	*				*			*	*	*	
B3	*	*	*	*	*	*		*	*	*	*			*			*				*		*	*				
B4	*	*	*	*	*	*	*		*	*		*			*	*	*	*	*	*	*				*	*	*	*
B5	*	*	*	*	*	*			*	*	*	*		*		*	*		*			*			*	*		
C1	*	*		*	*							*		*	*		*	*	*			*			*	*	*	
C2	*	*	*	*	*			*			*	*		*	*			*		*		*			*		*	
C3	*	*	*	*	*	*	*		*	*		*		*	*		*		*	*	*				*	*	*	*
C4	*	*	*		*	*	*	*	*	*		*	*	*	*		*	*		*	*	*	*	*	*	*	*	*
C5	*	*	*	*	*	*	*		*	*		*	*	*	*		*	*	*		*	*			*	*	*	
C6	*	*	*	*	*	*	*	*		*		*	*	*	*		*	*	*	*		*			*		*	*
C7	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*		*	*		*		*	*		
D1		*	*	*		*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*		*		*	*
D2	*		*	*	*	*		*	*	*		*	*	*	*		*	*	*	*	*	*	*	*				
D3		*	*	*	*			*	*	*	*		*	*			*	*		*		*				*		
D4		*	*								*		*	*			*					*			*			
D5														*				*	*	*	*							*
D6														*					*								*	

Fig. 2. The pairwise relationships matrix.

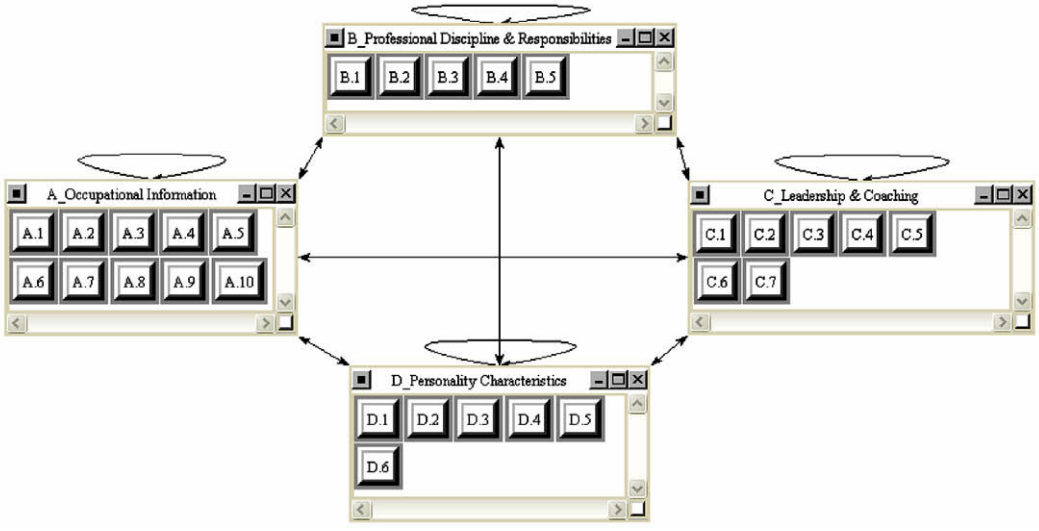


Fig. 3. Framework of the ANP-based model on software package.

approach for effective human resources planning in shipping business. First of all, the distribution priority weights on relevant factors within each of the clusters, illustrated in Figs. 5–8, can be synthesized respectively.

According to the illustrative results, competency in emergency management and endurance to sea both physiologically and physically are the primarily expectations of the shipping firms from the candidates who apply to be employed as master on board ships. The normalized priority weights of these factors are 38%, 44%, and 32% in percentage correspondingly. For maritime operations, these factors have been playing crucial role for enhancing safety aspects on board ships. However, the evaluations of the candidates with respect to these factors are so critical. In the proposed evaluation scheme, the emergency management capabilities of the candidates are evaluating with the computer based testing system via the technical questions on emergency planning and preparedness and related issues. On the other hand, the physiologic and physically characteristic of the candidates are determined during interview with the professionals. Moreover, working in self sacrifice, managing of communication, and hierarchical working principles are the other critical factors within cluster B with the priorities of 24%, 22%, and 20% in

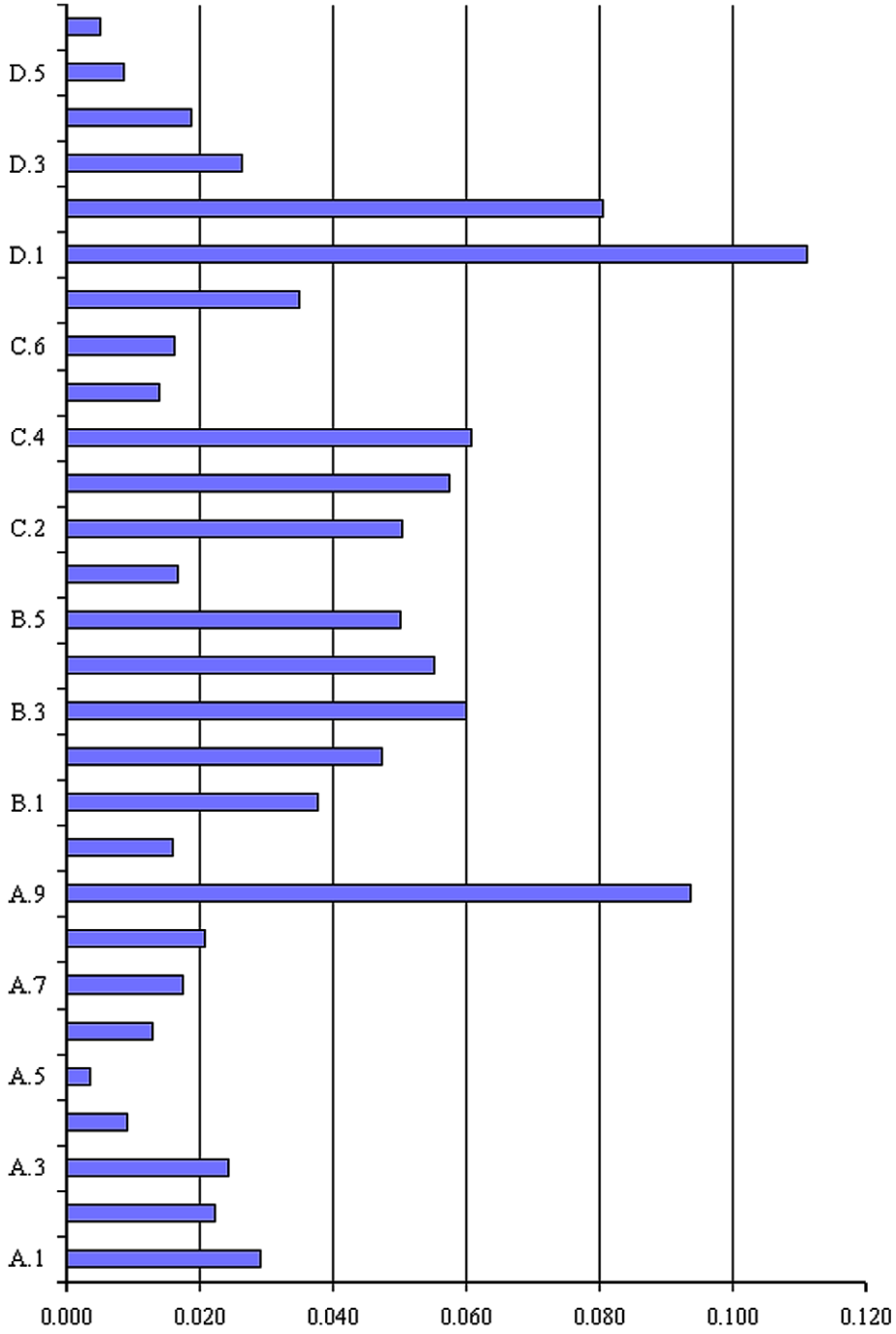


Fig. 4. Factor weights on evaluating of Master employment process.

percentage respectively. Within Cluster C; managing the organizational disciplines, commanding capacity, and motivation are the other focusing factors with the priorities of 20%, 23%, and 24% correspondingly.

Table 6
Testing-based evaluation scale and scores for objective evaluation criterion

Number of correct answers	1	2	3	4	5	6	7	8	9	10
Assigned score	10	20	30	40	50	60	70	80	90	100

Monitoring the factor-based performances of the each candidate gives the additional opportunities for executing problem-based assignment. Considering the taxonomies on shipboard problems, the existing ships in merchant fleet can be categorized into groups such as personnel-related problems, performance-related problems, and so on. The relationships can be established between the factor-based performances of the candidates and the

Table 7
Interview-based evaluation scale and scores for subjective evaluation criterion

	Symbol	Assigned score
Poor	P	20
Fair	F	40
Good	G	60
Very good	VG	80
Excellent	E	100

Table 8
Score levels for final decisions on employment

Total score	Final decision
0–50	Not embarking on board ship
50–60	Replaying of evaluation process
60–100	Embarking on board ship

problems of the ship operations. This approach led the personnel manager to assign the candidates who can manage the exceed threshold level to the suitable ship. Figs. 9–12 illustrate the performance comparison of the candidates graphically based on relevant factors in each clusters respectively.

Considering the performance comparisons graphics of the candidates, the evaluations on candidates can be performed. Based on the illustrative results of case application, the performance of the candidate I is reach in satisfactory level for A2, A6, A7, C1, D2, and D5 within Cluster A, Cluster C, and Cluster D respectively. On the other hand, Candidate II is managing to have best scores in the factors of A2, B2, B3, B4, B5, C1, D1, and D2 while the Candidate III has the best scores in A1, A3, A4, A5, A6, A8, A9, A10, B1, B2, B3, C2, C3, C4, C5, C6, C7, D1, D3, D4, D5, and D6 respectively. Identification the factor based performances of each candidates can be utilized as a decision support for assigning the personnel to the most suitable ship considering the ongoing problems. cluster-based total performance scores of the each candidate, illustrated in Fig. 13, can be utilized for the same purpose as supporting the final decision as well. According to the performance graphics in Fig. 13, the performance of the Candidate III is higher in Cluster A, Cluster C, and Cluster D with the scores of 21.84, 21.84, and 15.52 respectively. The Candidate II manages to be the best alternative in Cluster B with the total performance scores of 18.2 while the Candidate I cannot manage to obtain best scores for any of the clusters dramatically.

Finally, it is decided to employ the Candidate III on the shipping fleet while the performance scores of Candidate I cannot manage to exceed the threshold level for employing. On the other hand, the evaluation process is determined to replay for the Candidate II.

Table 9
Evaluation scheme on master selection process

Criterion	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5	C6	C7	D1	D2	D3	D4	D5	D6
Evaluation type	Testing	Testing	Testing	Testing	Testing	Testing	Testing	Testing	Testing	Testing	Interview	Interview	Interview	Interview	Interview	Interview	Interview	Interview	Interview	Interview	Interview	Interview	Interview	Interview	Interview	Interview	Interview	Interview
Interface	Computer-based testing system										Human-based evaluation system																	
Factor weights	0.029	0.022	0.024	0.009	0.003	0.013	0.017	0.021	0.094	0.016	0.038	0.047	0.060	0.055	0.050	0.017	0.050	0.057	0.061	0.014	0.016	0.035	0.111	0.081	0.026	0.019	0.009	0.005
Candidate I	50	70	50	40	70	70	90	20	40	40	P	F	G	F	G	VG	G	F	F	F	P	F	F	G	P	F	VG	F
Candidate II	80	70	60	30	40	50	30	60	30	30	G	G	VG	G	E	VG	G	G	F	P	F	P	G	G	F	P	G	P
Candidate III	90	60	100	90	90	70	80	100	90	100	VG	G	VG	F	VG	G	E	VG	E	E	G	VG	G	F	E	E	VG	VG
Factor-based performance scores																												
Candidate I	1.45	1.54	1.20	0.36	0.21	0.91	1.53	0.42	3.76	0.64	0.76	1.88	3.60	2.20	3.00	1.36	3.00	2.28	2.44	0.56	0.32	1.40	4.44	4.86	0.52	0.76	0.72	0.20
Candidate II	2.32	1.54	1.44	0.27	0.12	0.65	0.51	1.26	2.82	0.48	2.28	2.82	4.80	3.30	5.00	1.36	3.00	3.42	2.44	0.28	0.64	0.70	6.66	4.86	1.04	0.38	0.54	0.10
Candidate III	2.61	1.32	2.40	0.81	0.27	0.91	1.36	2.10	8.46	1.60	3.04	2.82	4.80	2.20	4.00	1.02	5.00	4.56	6.10	1.40	0.96	2.80	6.66	3.24	2.60	1.90	0.72	0.40

	Total score	Factors in success of candidates	Final decision
Candidate I	46.32	A2–A6–A7–C1–D2–D5	Not embarking on board ship
Candidate II	55.03	A2–B2–B3–B4–B5–C1–D1–D2	Replaying of evaluation process
Candidate III	76.06	A1–A3–A4–A5–A6–A8–A9–A10–B1–B2–B3–C2–C3–C4–C5–C6–C7–D1–D3–D4–D5–D6	Embarking on board ship

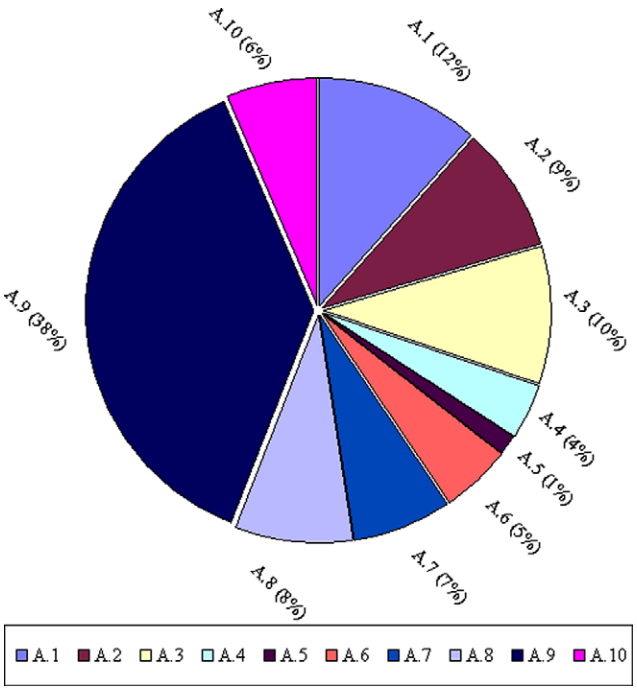


Fig. 5. Distribution of weights on factors in Cluster A.

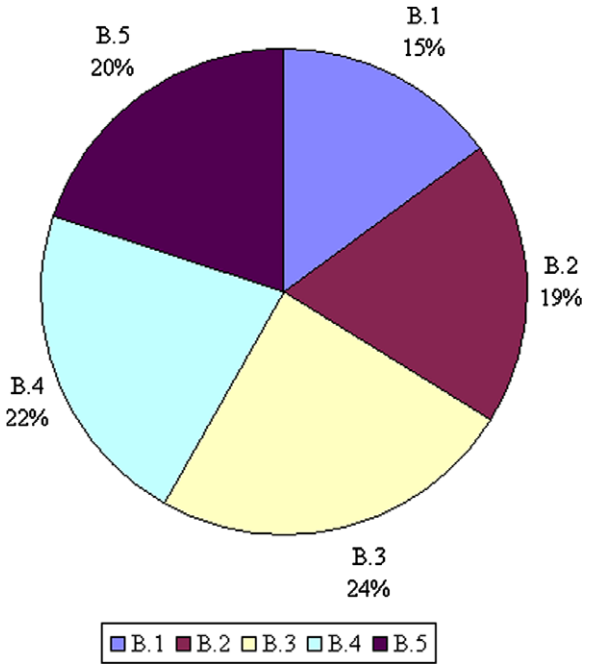


Fig. 6. Distribution of weights on factors in Cluster B.

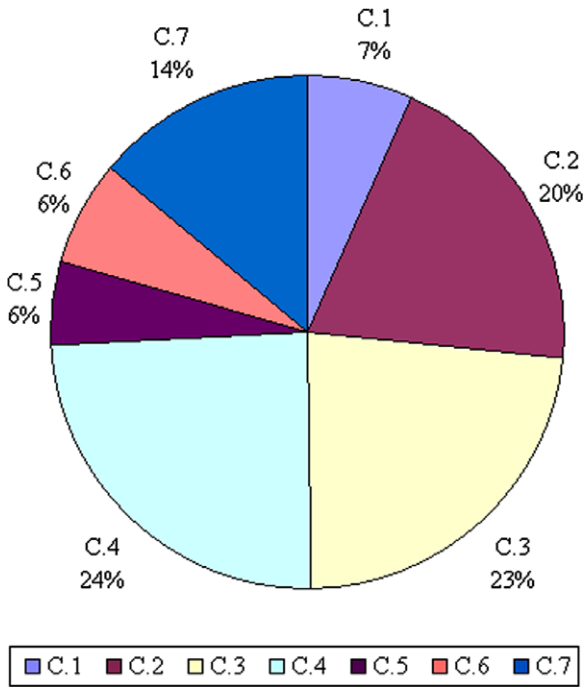


Fig. 7. Distribution of weights on factors in Cluster C.

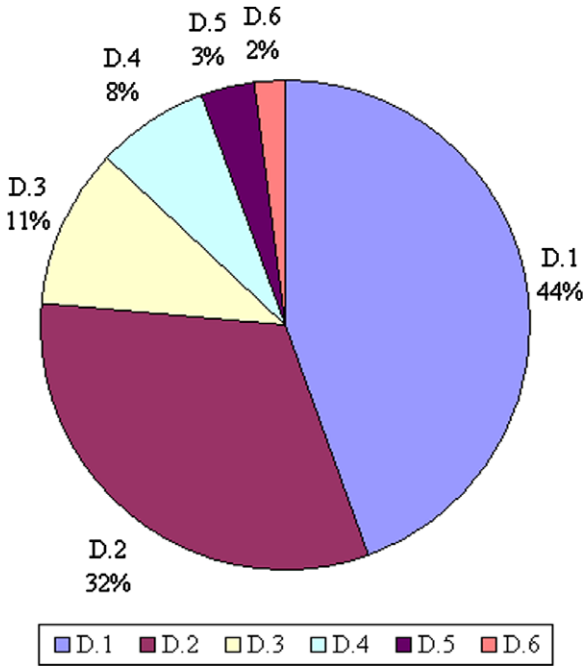


Fig. 8. Distribution of weights on factors in Cluster D.

6. Conclusion and further studies

This paper proposes an extendable and practical model based on ANP to support the decision process regarding with the personnel selection facilities in ship management companies. Due to the varieties of constraints on human resources in maritime transportation industry, complexity level of HRM in ship management is higher when it is benchmarked with the other business disciplines. Therefore, the model structure requires integrating series of factors on personnel evaluation and assignment. The certification procedures in international manner, duties and responsibilities on board ships, and the additional expectations of the shipping firms are referred to structure the criterion hierarchy. The proposed model is performed on the selection of Master as the most critical personnel

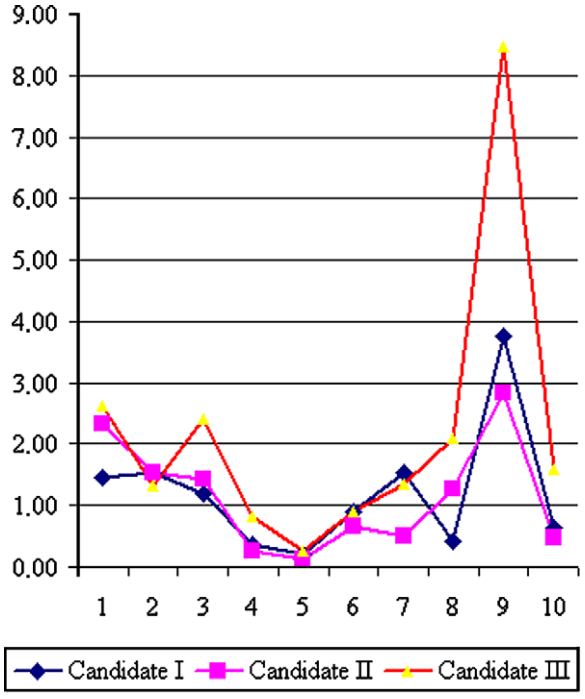


Fig. 9. Performance comparison of candidates based on factors in Cluster A.

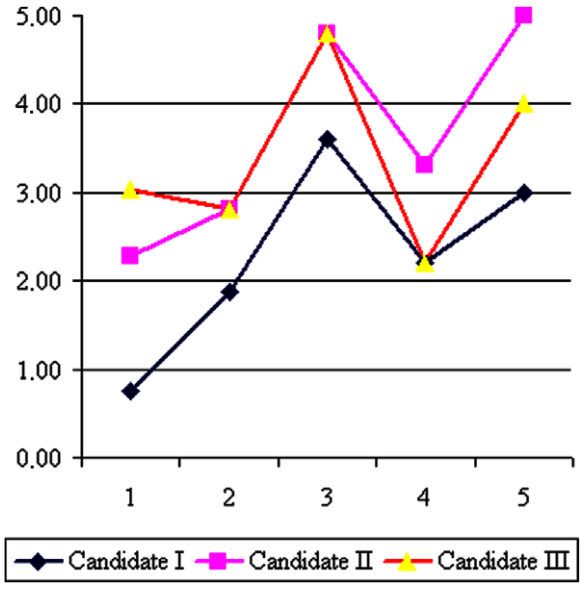


Fig. 10. Performance comparison of candidates based on factors in Cluster B.

of the shipboard organization. Managing of the interfaces such as computer-based testing system and human-based interview system are discussed in advance. The computer-based evaluation scheme which is proposed in this paper as Table 9 is utilized in practice as a pilot project in Turkish ship management companies. So, the outcomes of the case application ensure the utility of the model without any defect in real life application.

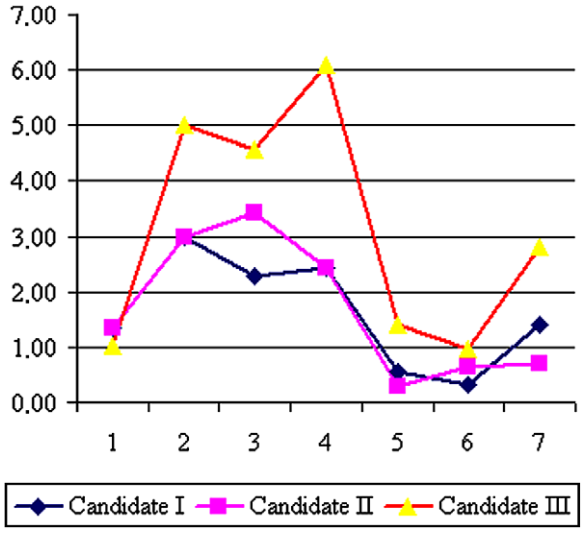


Fig. 11. Performance comparison of candidates based on factors in Cluster C.

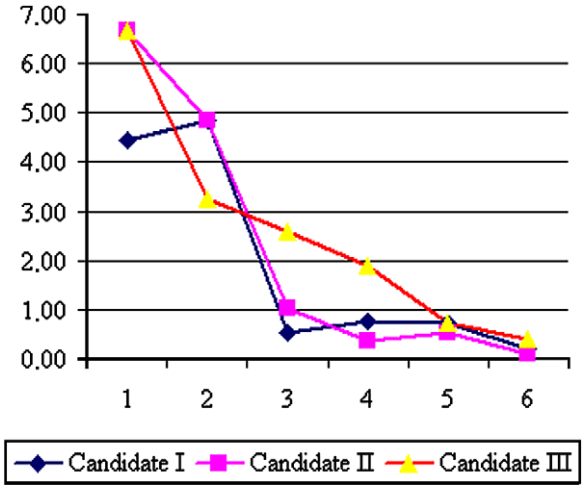
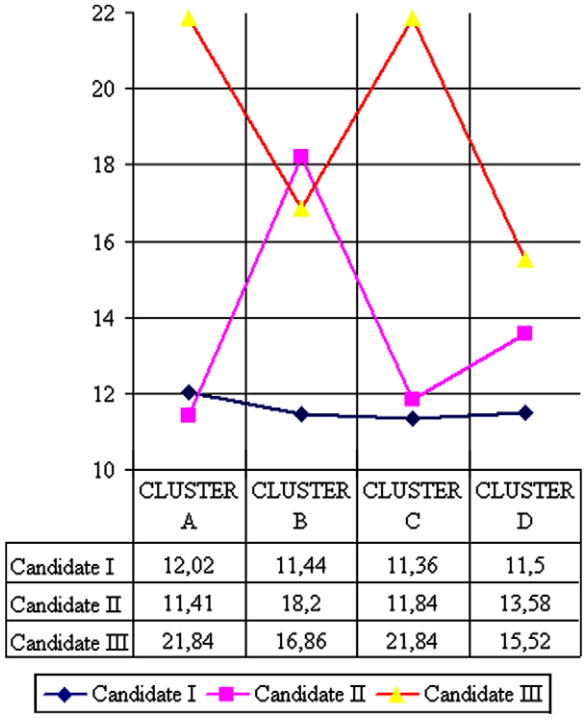


Fig. 12. Performance comparison of candidates based on factors in Cluster D.

While the theory of ANP is providing valuable contributions to the model for ensuring the dependencies between relevant factors, the computer-based support for both theoretical frame and application phases increase the consistency of the proposed system in practice. However, the different methodologies can be applied to the same case to satisfy with the robust of the proposed mechanism. Moreover, the scope of the model can be extended to cover other related personnel such as Chief Engineer, Chief Officer, Junior Deck Officers, Second Engineer, Junior Engineers, Electrical Officer, and other crewmembers. On the other hand, utilization of the evaluation results for establishing problem based personnel assignment system can be performed as further research issue.



	CLUSTER A	CLUSTER B	CLUSTER C	CLUSTER D
Candidate I	12,02	11,44	11,36	11,5
Candidate II	11,41	18,2	11,84	13,58
Candidate III	21,84	16,86	21,84	15,52

Fig. 13. Cluster-based distribution of total performance values on candidates.

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