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A SURVEY on MCDM APPROACHES for MARITIME PROBLEMS

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ABSTRACT

The maritime industry is a worldwide area of work where critical decisions are made in critical situations. The fact that decision-making is based on a scientific and mathematical basis has been in academic authorities' attendance area for the last five decades. In this study, a literature review has been conducted on the use of decision-making techniques in maritime practices. In the literature survey, Multi-Criteria Decision-Making (MCDM) methods have been examined, studies in Turkey and the International area carded; weights, distributions, usage reasons, advantages, and disadvantages of methods determined based on studies have been comparatively studied. The main aim of this paper is to statistically compare the quality and quantity of the papers published on the decision-making techniques used in maritime in Turkey and the International area. In addition to MCDM techniques, other mathematical methods used in shipping are also included in the study. The evaluation of other mathematical methods and their comparison with the commonly used methods have been made under a subtitle in this paper.

Anahtar Kelimeler: *MCDM, MADM, Fuzzy, Maritime Decision-Making, Mathematical Decision-Making Methods*

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1. INTRODUCTION

Decision analysis is a process that provides a systematic order to explain decision-making situations better. During this period, many authors made different opinions. But systematic decision analysis is lying down to Benjamin Franklin (1706-1790). Writing positive effects of decisions on one side of a white paper and writing adverse effects of decisions on the other side of the paper is fundamental of Benjamin's procedure.

On the other hand, the multi-criteria decision-making method examines more than one criterion and tries to reveal the issue solution most transparently with many concrete and abstract factors. Also, it is accepted that the academic field of Multi-Criteria Decision Making (MCDM) started with a paper which belongs to Stan Ziont named 'MCDM- If Not a Roman Numeral, then What?' (Zionts, 1979). Definitely, some papers such as ELECTRE Method (Roy, 1968), Choquet Integral (Choquet, 1954), AHP Method (Saaty, 1972), and Fuzzy Set (Zadeh, 1965), underpin the MCDM by providing it to be grown but the paper of Stan Zionts can be defined as a touchstone which is accepted MCDM compilation by most of the academists. Multi-Criteria Decision-Making (MCDM) method has been preferred in the maritime industry in recent years. MCDM was chosen because it is a massive factor in the transparent handling of events in the maritime sector. Besides, while the MCDM method is preferred in the maritime sector, it has also made significant progress in the last 45-50 years (Koksalan et al., 2011). In this case, it caused the organizations affiliated with the maritime sector to make fast and correct decisions. If it is necessary to give some examples of the use of MCDM applications in the maritime sector, these can be given as follows; MCDM (Multi-Criteria Decision-Making) procedure on cargo type selection (Ozdemir and Guneroglu, 2018), the Hybrid MCDM method to determine service quality factors in a port (Tsai et al., 2018), MCDM approach to decide dry port location (Nguyen et al., 2016), etc. Many studies focused on MCDM methods in maritime, and they will be considered in this working, detail. From a general perspective; port performance evaluation and related topics have been focused recent years and mostly used techniques can be given as AHP (Analytic Hierarchy Process), TOPSIS (Technique for Order Preference by Similarity to Ideal Solution), PROMETHEE (The Preference Ranking Organization Method for Enrichment Evaluation) and their combinations with their fuzzy versions. However, studies that have been done after the year 2016 are analyzed in this research. This work aims to compare up to date MCDM workings on maritime in Turkey with international workings.

For the literature survey, 19 national papers and 73 international papers have been investigated and analyzed carefully. It is aimed to look at the event globally through both national and international literature research. According to analyses, workings have been classified into eight categories for clear understanding and comparison, which are human resources, ship machine, and equipment selection, port/facility location decision, route selection, port performance/efficiency/risk analysis, ship selection, port/facility, and management selection and others. This classifying was created carefully for workings to be non-grouped as much as possible. In this way, it provided the opportunity to make understandable, simple, and wide-ranging research without getting things too complicated. This study comprehensive compared the quality and quantity of the papers published on the decision-making techniques used in maritime in Turkey and the International area. Often a lot of research is done to create a general perspective on a topic. These are, respectively, obtaining data from the internet, scanning current articles on the subject, reports, books, encyclopedias, etc. use of resources. However, presenting that subject in a scientific form and, most simply, examining a lot of data about that subject in an article will enable a more objective look at the events. Therefore, this study is to serve as a resource to create an overview of the topic.

2. METHODOLOGY

The introduction to a topic is vital in the subject, as much as the topic be fluent. The national and international papers discussed in this article can be a reference for the author. However, a start must demonstrate how understandable and fluent this work is. This paper is a point for the past, but a reference for the years to come. First of all, the study on the mathematical methods used in Turkey's maritime activities are correct, precise, concrete evidence and our systematic approach to the subject effective decision-making situations are investigated. Taking the events after 2016, it should obtain information with the available data, develop ideas effectively, and evaluate the research results by minimizing the margin of error. Therefore, decision analysis of mathematical methods applied in maritime, taken up separately for Turkey and the international arena, all the literature published after 2016 were screened. After the incident's findings were handled meticulously, they were noted independently, and the subject was continued with interpretation.

Subsequently, the studies were divided into eight subgroups determined by us, and the articles published were classified according to these groups. With this grouping, when the events were gathered under eight subtitles, it was possible to view the events from specific to general. Thus, the findings were fed with enough evidence. Studies that stand out in the specified subgroups are briefly explained, and the studies are presented not only in terms of quantity but also in terms of quality. The reason for this criterion is to add comments to the subject and to conclude with opinions. Studies using similar methods have been analyzed in this paper. However, the advantages, disadvantages and superior aspects of these studies over other studies have been emphasized. Subsequently, sub-fields that have been studied more in national and international publications were determined. Compared with Turkey's efforts focus on the issues to which the global study. Turkey's position in comparison with the results it has been detected. Then, the usage weights of the methods were determined, and the method usage orientations of the Turkish researchers were compared with the average orientation of the international studies. This comparison with researchers in other countries who have researched Turkey's pros and cons gave rise to reveal aspects. In this context, this study has been created an environment critically. Also, the number of studies is weighted by years, and the performance of mathematical decision-making techniques in maritime studies is compared. Then, it looks for an answer to 'how should be mathematical decision performances which are exhibited?' Then, studies other than MCDM used in maritime were examined, featured studies were mentioned and the reasons for using MCDM techniques more than other methods were interpreted based on the studies. Finally, the methods used were compared based on studies, and their advantages and disadvantages were revealed in the quotations from the publications that were examined.

3. NATIONAL STUDIES

According to research, 19 papers have been published on MCDM applications in maritime since 2016 in Turkey. The most focused subject is seen as port performance and risk analysis. Ozdemir, (2016) has studied the causes of work accidents in ports. In this study, fuzzy DEMATEL (The Decision-Making Trial and Evaluation Laboratory), and fuzzy TOPSIS (Technique for Order Performance by Similarity to Ideal Solution) approaches were used to prevent or reduce accidents. According to the study results, the causes of the accident are listed as follows; Accidents due to human error, accidents due to administrative reasons, accidents due to defective equipment and improper use of equipment, and accidents due to working environment and conditions

(Ozdemir, 2016). Acer and Yangınlar, (2017) investigated the performance of container ports in Turkey. Their work included 20 ports and they have examined selected ports according to 7 criteria with the TOPSIS method. Mersin port appeared as the most performance port (Acer and Yangınlar, 2017). In another study that belongs to Temiz et al. (2018) Samsun Port has analyzed for gaining a point of view about the future performance and opportunities of Samsun Port in the Transcaucasia project. According to analyses, the dock length and port depth's current situation is not enough to respond to the future demands of the industry. They have used a hybrid method that included the DEMATEL technique for their work (Temiz et al., 2018). Another study for port performance and risk analysis has been published by Senel et al. (2018), who worked on risk and accident analysis of ports. Accident risks have been prioritized, and recommendations have been proposed to reduce ports' accidents (Senel et al., 2018). Ship collision has caused the loss of life and property. Besides, marine pollution can occur because of ship accidents. For this, TCPA (Time to Closest Point of Approach) and DCPA (Distance to Closest Point of Approach) values were applied most appropriately according to COLREGs rules. This study tried to be concluded by using AHP and TOPSIS (Inan and Baba, 2020).

The second most focused topic in national studies is human resources. Four papers have been published since 2016. Situations that make shipmen must be taken administrative penalty have carried by Ozdemir. These situations have prioritized the FAHP method to foresee the problems and to increase efficiency in the maritime industry (Ozdemir, 2018). Another study by Efe and Kurt (2018), on human resources is selecting personnel for a port facility. Criteria that should exist in the port personnel have been prioritized with a hybrid AHP-FTOPIS method, and recommendations have been proposed. The study has done with 8 criteria and ten candidates (Efe, and Kurt, 2018). The third most focused topic is ship selection. Three papers focused on ship selection which is, decision analyzing determining ship type that will be built in the shipyard by Balbas and Turan (2019), criteria determination on ship selection in sea transport by Sener (2016), and criteria determination on cargo type selection by Ozdemir and Guneroglu, (2018).

Other study subject weights are port/facility location decision, route selection, ship machine and equipment selection, and port/facility and management selection. In the port/facility selection topic, a port selection analysis for the Western Black Sea was carried out by Pekkaya and Bucak in 2018. They have used PROMETHEE, TOPSIS, and VIKOR techniques to select the best local port location (Pekkaya and Bucak, 2018). Another study on this subject is fishery facility location selection with the AHP method has been published by Arslan et al. (2019). They have investigated the location of Mauritania's fishery facilities and found that the best option is Nauadhibu. Outputs have been matched up with the real data (Arslan et al., 2019).

2 studies have been completed since 2016 for ship machine and equipment selection. Some studies can be summarized as:

Uzun and Kazan (2016) have proposed a decision-making system to select primary machine selection in shipbuilding. 7 machines have been evaluated according to 12 criteria with separately AHP, TOPSIS, and PROMETHEE. An exact conclusion cannot be taken in this study, every method showed differences. Uzun and Kazan, remark that approximate selection can be done with this system because the system is created only for one case (Uzun and Kazan, 2016). Last of all, one studies per other subjects are determining route selection criteria by (Polat and Merdivenci, 2019), evaluating criteria for selectin of broker in sea transportation by (Ozturkoglu and Calıskan, 2016), and a study on future of the maritime education in Turkey by (Ozdemir et al., 2017).

3.1. Evaluation Frequencies of Classified Topics of National Studies

As explained before, studying has been classified into 8 sub-topics. These are human resources, ship machine, and equipment selection, port/facility location decision, route selection, port performance/efficiency/risk analysis, ship selection, port/facility, and management selection and others. There are 4 studies for human resources, 2 studies for ship machine and equipment selection, 2 studies for port/facility location decision, 5 studies for port performance/efficiency/risk analysis, 3 studies for ship selection, 1 study for route selection, 1 study for ship selection, and 1 study for other subject topics out of the 19 studies. The distribution of papers can be seen in Figure 1. And the percentage of the topics can be seen in Table 1.

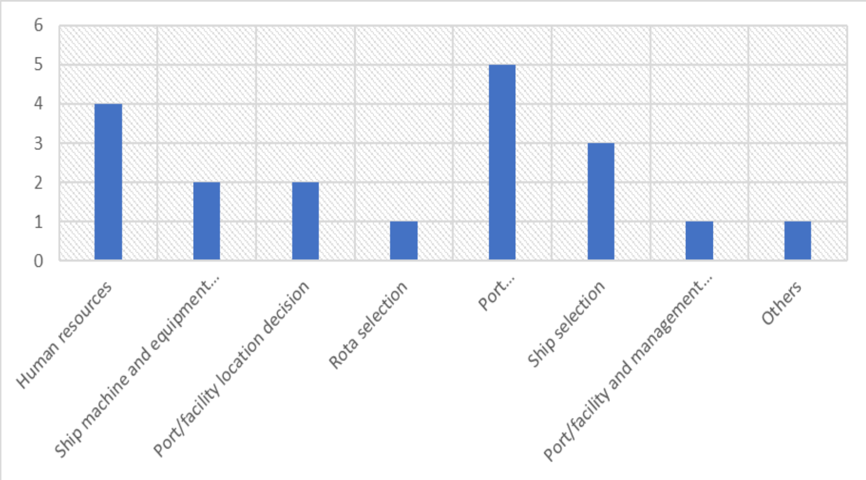

Figure 1. Distribution of national papers by organised sub-areas.

The numerical expressions and percentage rates of organized sub-areas in national studies are given in Table 1.

Table 1. Percentages of organized sub-areas.

	Number of Study	Percentage (%)
Human resources	4	21,05
Ship machine and equipment selection	2	10,53
Port/facility location decision	2	10,53
Route selection	1	5,26
Port performance/efficiency/risk analysis	5	26,32
Ship selection	3	15,79
Port/facility and management selection	1	5,26
Others	1	5,26

3.2. Evaluation of Exercised Techniques

According to analyses, the most used method was TOPSIS in Maritime MCDM studies in Turkey as 12 times (Sigle usage 5, hybrid usage 7). AHP follows TOPSIS with the number of 10 times (Sigle usage 5, hybrid usage 5) and the third one is VIKOR with the number of 4 (Sigle usage 3, hybrid usage 1). The general distribution can be seen in Figure 2. And the percentage of the methods can be seen in Table 2.

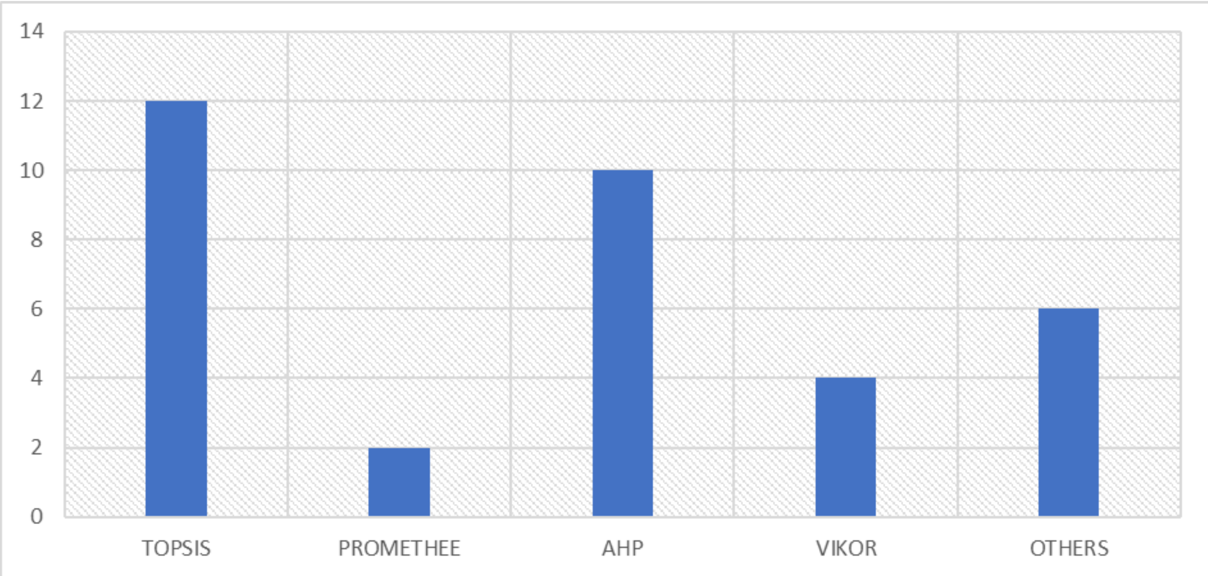

Figure 2. Distribution of MCDM methods in national studies.

The numerical expressions and percentage rates of methods in national studies are given in Table 2.

Table 2. Percentages of methods in national studies.

	Number of Usage	**Percentage (%)**
TOPSIS	12	35,30
PROMETHEE	2	5,88
AHP	10	29,41
VIKOR	4	11,76
OTHERS	6	17,65

3.3. Number of Paper Evaluation by Years

Another investigation has been done to determine studying numbers according to years. As explained before, papers that were only published after the 2016 year have considered to make up to date comparison. 2018 was the most efficient year for MCDM studies on maritime in Turkey with a study number of 7. The year 2016 is following 2018 with the paper number of 5. Other paper scores, according to years, can be seen in Figure 3.

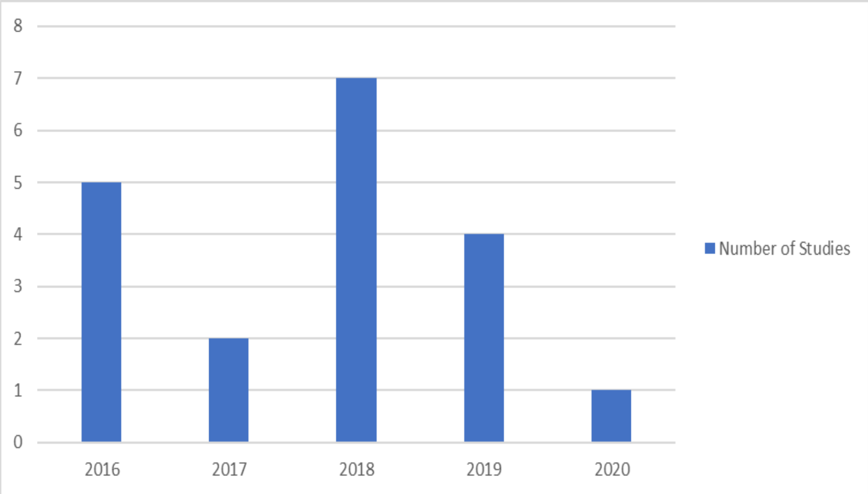

Figure 3. Distribution of national studies by years.

4. INTERNATIOANAL STUDIES

For the international investigation, 73 papers have been determined according to the literature survey criteria. These workings are based on MCDM techniques because MCDM methods are generally not used in the maritime field. The usage of MCDM techniques is rare for the maritime industry. However, selected studies have been analyzed carefully, and a general comparison between national and international studies will be executed according to outputs. Determined 8 sub-areas are used in this part of the work, too.

From a general perspective, the most focused sub-area in international studies is port performance/efficiency/risk analysis. Global logistics hub port evaluation criteria can be compared with the AHP method (Yang and Chen, 2016). In another article about security, MCDM, AHP, and

FTOPSIS models were used to conclude. This article has also modeled what can be done in the selection of operational security strategies and risk assessment at container terminals (Yami et al., 2017). Moreover, FTOPSIS and AHP methods were used to prioritize port performance improvement strategies (Ha et al., 2017). Kim has made a port competition analysis on Korea and China ports with entropy weighed TOPSIS method and tested it with real data. He has seen that outputs are matched up with accurate data (Kim, 2016). In another study, Mladineo et al. (2017) have created a decision support system using the PROMETHEE method in the case of maritime accidents. They have indicated that the system can be developed with AI and can be strongly supportive of the maritime industry (Mladineo et al., 2017). Tsai et al. (2018) have analyzed solutions for increasing port service quality with a hybrid method, a combination of AHP-ANP-DEMATEL methods (Tsai et al., 2018). On the other hand, Gao et al. (2018) have made a competition analysis for Quanzhou Port with the ELECTRE III-FAHP hybrid method and have seen that Quanzhou Port is weaker than other ports (Gao et al., 2018).

AHP model was used instead of VFT and AFT models. With the continuous expansion of the ports, the ships' location should be dispatched may confuse recently. For this, the pilotage dispatch operation is required in the port. However, there is little international study on how to use or evaluate effectively for a port. Therefore, the AHP model should be established to evaluate and effectively use port pilotage dispatch operations (Du et al., 2017). In another similar article, there are many ports around the world. With the development of technology, the capacity of these ports is also increasing. Icaza and Parnell (2018) have wanted to evaluate the region's economic potential due to the expansion of port capacity, especially in West Africa, using multi-criteria decision analysis. With this analysis, they have analyzed the strengths, weaknesses, and aspects of the ports in West Africa with VFT (Value-focused thinking) and AFT (Alternative-focused thinking) models (Icaza and Parnell, 2018). Globalization has led to the effective use of ports. There has been an increase in containers, especially at ports. In this case, Alyami et al. (2019) have used the FRBN (Fuzzy Based Bayes Network) method instead of the AHP method to evaluate the security performance of the Container Operating System (CTOS) and improve its functionality (Alyami et al., 2019).

Maritime transport has increased in recent years with the development of technology. In this case, it has triggered congestion in the river, strait, and canals. Moreover, maritime transport has caused the deterioration of marine ecology and an increase in greenhouse gas emissions. TOS (Terminal Operating Systems) operating the terminals is used to reduce this greenhouse gas emission and marine ecology degradation. However, Terminal Operating Systems should be developed based on technological development. Therefore, the AHP method can be used to improve TOS functions and make them hierarchical (Hervás-Peralta et al., 2019). After the 2015 Tianjin Port explosion, international measures were taken against port disasters. Together with these measures, the TOPSIS method was used to measure the ex-post port vulnerability (Cao and Lam, 2019). In another TOPSIS method, Kim and Lu (2016) compared the port competitiveness of Busan and Shanghai ports (Kim and Lu, 2016). Othman et al. (2020) have used the FAHP method to find the causes of the imbalance in cargo flows in Malaysian ports. Thanks to this modeling, factors that cause cargo flow imbalance have emerged. As a result, it is understood that economic factors are the leading cause of cargo flow imbalance (Othman et al., 2020). For the port/facility and management selection, some studies can be summarized as; shipping registry selection decision-making system with the ANP method (Chou, 2018), selecting a ship management company with a hybrid AHP-FTOPSIS method (Seo et al., 2018). Sumner and Rudan have tried to choose a transshipment port in pairwise compassion with Best Worst Method. They have preferred BWS instead of AHP (Sumner and Rudan, 2018). These and similar papers tried to decide the most efficient management or company in the maritime industry. TOPSIS method was used instead of the AHP method to measure the service quality of container terminal operators. It is understood that the proposed method is consistent with the results obtained (Hemalatha et al., 2018). In another similar article, the Consistent Fuzzy Preference Relation (CFPR) method was used to create an idea about competitive factors and risk factors and their overall service quality for container terminals (Pham and Yeo, 2019).

AHP, CFPR MCDM techniques can facilitate hub port selection by a feeder port (Wang and Yeo, 2019). The MCDM technique was used to select a mid-level manager with managerial competency and capabilities. This technique, it has enabled international shipping service providers to effectively select the best middle manager (Ding et al., 2019). Another article examines the key competencies that influence mid-level managers' selection for global transport logistics service providers (GSLSPs). Besides, middle-level managers' capabilities were investigated experimentally using the AHP method (Ding et al., 2019). Using the Kano model, one can create a different perspective on Port selection factors (Min and Park, 2019). Port performance and Port selections are considered separately as research topics. This situation will affect the port performance when there are any changes in the ports in the coming years, and the performance of the selected port will change. A solution can be found for this complex situation using the MCDM technique (Rezai et al., 2018). An evaluation can be made in another article on the Port selection of linear carriers for ship calls with the MCDM technique. Besides, a model based on the MCDM technique can be suggested to improve ort management of port companies. Moreover, MCDM can provide theoretical information and reference for methodological research (Hsu et al., 2020).

People are always planning to achieve success, goals, and ideals in professional life. This planning is a valid concept for people working in the maritime industry. Also, when seafarers are planning, they look at the ship type, salary status, occupational health, and work intensity criteria. The AHP can be used to correlate seafarers taking these criteria. Besides, a solution can be found with the most preferred Fuzzy TOPSIS methodology (Kaya et al., 2018). The F-AHP method can be used to compare the human factor affecting the management of container terminals, the facility's strengths and weaknesses, and the systems used in the port (Adenso-Diaz et al., 2019). Various services are provided to the ships by the ports. These services are essential for the operation between the ship and the port. Besides, the port service should be economical, high quality, reliable and with them the operation should be fast. F-AHP is also preferred in these port services (Longaray et al., 2019). Fan et al. (2020) have proposed the maritime accident prevention strategy formulation from a human factor perspective using Bayesian Networks (BN) and TOPSIS. They also showed the characteristics of multiple criteria and the relationships between strategies. As a result, they emphasized what should be done to minimize the accident rates at sea and to minimize human errors (Fan et al., 2020). The human factor has always been the most effective in ship collisions. Also, analyzing the human factor is hard to understand because it has a complex socio-technical structure. Yildiz et al. (2020) have demonstrated the feasibility of the modified Human Factor Analysis and Classification System for Passenger Vessel Ship collisions (HFACS-PV) for other types of accidents. Based on the results of this study, it can be said that the HFACS-PV structure is compatible with collisions as well as contact, grounding and sinking accidents (Yildiz et al., 2020). Song et al., (2020) have proposed the Dynamic hesitant fuzzy Bayesian network and its application in the optimal investment port decision making problem of “twenty-first-century maritime silk road” using BN (Bayesian Network), DHFBN (Dynamic Hesitant Fuzzy Bayesian Network), EM (Expectation-

Maximization) and PSO (Particle Swarm Optimization). They have also had the opportunity to compare the validity and positive aspects of the method with an experiment by using these techniques together. Moreover, with their research, they have offered opportunities to examine humanity's new trade initiatives, socio-cultural interactions, and exchange opportunities that may occur in the 21st century. Finally, they have sought an answer to the question of how economically countries are affected by this (Song et al.,2020).

Pressing and receiving ballast water on the ship is important for the stability of the ship. However, IMO has made the ballast water treatment system mandatory due to the increase in environmental problems. Therefore, it is important to predict the malfunction of the ballast water treatment system or make an effective repair. The MCDM method was used for this fault solution (Bakalar and Beatriz Baggini, 2016). In the ship machine and equipment selection sub-area, Agarwal, and Chand a made decision analysis system is based on the AHP method for selecting IT tools in shipping. It was revealed that the Internet is the most critical IT tool (Agarwal and Chand, 2018). In another study, Jiang et al. (2019), proposed a 'fuzzy MCDM if than rule' system to select a submarine power cable (Jiang et al., 2019). Also, Sahin and Yip (2017) have offered a Gaussian FAHP method for selecting shipping technology and found that energy efficiency systems are more suitable in the long term (Sahin and Yip, 2017). The Fuzzy TOPSIS model was used to find the root cause of the engines' failure in the ships using the opinions of experts. Thanks to this model, it has been observed that although engine fault detection is difficult, faults can be diagnosed (Aikhuele et al., 2017). Again, the Fuzzy TOPSIS model was used in another article. In this article, expert opinions were taken to find the root cause of offshore boat engine malfunctions. Besides, it was seen that the Fuzzy TOPSIS model was used in the solution (Aikhuele et al., 2017). When looking at both articles briefly, it is clearly seen that the Fuzzy TOPSIS model can be used in the solution of ship engine malfunctions.

There are adverse environmental problems associated with high sulfur dioxide emissions from ship machinery. Besides, health problems have occurred. IMO has established rules following regulation 14 of MARPOL Annex VI. However, it has been observed that the ship operators around the Gulf of Guinea have difficulty in complying with the IMO regulation. To identify these main obstacles, MCDM, AHP, TOPSIS, and FAHP methods were used together. The findings have proved to be the most effective obstacles to the lack of infrastructure, lack of maritime air pollution laws and the need for high capital to reduce sulfur (Animah et al., 2018). In another article, the engine rooms of ships are critical for sudden maneuvers and operations. Therefore, a model has been created about how the ship's main engine rooms should be maintained. AHP and PROMETHEE were used in this model, and a cost-benefit analysis was made (Animah and Shafiee, 2019). Nowadays, choosing the appropriate location for transshipment has become very important. Therefore, Zabihi et al. (2016) have used the MCDM model to evaluate and select the marine container transfer port. This model has been used in Iran's main ports to offer a practical solution together with the technical solution. As a result, it is understood that the MCDM model can be used in the assessment and selection of the marine container hub location selection (Zabihi et al., 2016).

In the developing world, people have started to turn to sea tourism in recent years. In this case, it has caused countries to choose and plan suitable places for sea tourism. The most convenient location can be selected with the MCDM technique and VISUAL PROMETHEE (Badurina Tomic et al., 2016). In another article, the AHP model was used to determine the potential of RO-RO Short Sea Transport operations (Arof, 2018). The tugboat to be used in the ports is selected according to the procedures to be performed. Besides, many criteria are evaluated for the tugboat required in the port and a conclusion is reached. However, there are technical knowledge, experience, and many other issues that need to be evaluated for tugboat selection in this process. Therefore, Cakıroglu et al. (2018) for selecting tugs have made a numerical analysis with the fuzzy AHP method within the framework of design, operational and financial criteria (Cakıroglu et al., 2018). Suhario and Suharyo (2019) have made the port evaluation by looking at the ports' technical, political, and economic conditions using the Fuzzy MCDM technique. In this way, they have provided ease of selection between ports by looking at the current port or the various characteristics of the important ports to be built (Suhario and Suharyo, 2019). As in other ports, it is vital to choose an ideal location for the dry port. However, choosing a location for a dry harbor is a complex decision. Because evaluating more than one criterion creates decision problems in location selection. The fuzzy-AHP method is used to minimize these uncertainties (Goncalves et al., 2019). Another study is the CFPR method of LNG selection by Lu et al. (2019). According to calculations, the Busan port has been stood as the best option for LNG (Lu et al., 2019).

One of the most focused other sub-area in the MCDM maritime applications is route selection applications. Bellsolà Olba et al. (2019) executed a SAW method on vessel traffic determination for Rotterdam

Port. They provide a selection of scenarios according to five important criteria (Bellsolà Olba et al., 2019). Another study was carried out on determining suitable routes that have environmentally friendly behavior. Jugovic et al. (2017) have evaluated Croatia ports according to decided criteria with PROMETHEE and found that none of the ports in Croatia are suitable for environmental development (Jugovic et al., 2017). The PROMETHEE method was used to direct an alternative route to cargo transportation over the Adriatic Sea. With this model, issues that need to be discussed in a new route are tested and evaluated (Vilke et al., 2017). Due to the increase in trade in Asian countries, it is imperative to have an efficient intermodal route for cargo transportation. FUZZY DELPHI and ELECTRE I models were used for this intermodal route. As a result, it is understood that the most important factor in route selection for logistics companies is the total cost (Wang and Yeo, 2018). The fuel consumption of the ships disrupts the ecological order. Therefore, studies have been started in the maritime sector to protect the ecological balance of nature. Accordingly, a different field has emerged in the maritime sector where the MCDM method is used. For example, new low-fuel ship designs can be given as examples. Within this, the Ship Energy Efficiency Management Plan (SEEMP) adopted by IMO is of great importance for the ecological balance (Besikci et al., 2016). MCA, PROMETHEE and GAIA models can be used for the type of vessel and size that will connect the mainland and island and island each other connections (Kovacic and Mrvica, 2017). In another article, it was reported that various factors affect ship maneuvering decisions. Xue et al. (2019) focused on factors affecting decision-making in autonomous ship maneuvering. As a result, the ship maneuver has allowed evaluating the factors affecting decision making theoretically and practically. It has also demonstrated that autonomous ship maneuvers can be used to make better maritime safety decisions and that transportation can be safer (Xue et al., 2019). Recently, ship selection has become a very complex affair. Because determining the most suitable ship for maritime trade means having a say in the maritime market. Therefore, the investor and the shipowner need to compare the ships to solve this problem. For example, the EVAMIX (EVAluation of MIXed Data) method was used for the first time in the articles of Yazir et al. (2020), for comparison and the solution was tried to be reached (Yazir et al., 2020). Safety at sea is paramount. Because if security is provided at sea, the risk of collision of ships is reduced. Besides, the work that needs to be done and delivered is done on time. For this, Wu et al. (2016) have decided to use the TOPSIS technique to facilitate ship safety control on uncontrolled ships. As a result of this decision, they have revealed that ship security control can provide uncontrolled ships' practical decisions (Wu et al., 2016).

Another issue where the MCDM technique is discussed in the maritime sector is the design of the holds of bulk carriers. Hatch cover design selection is very important to prevent water ingress in bulk carriers' structure and protect the transported cargo from damage caused by external factors. For this design, a solution was tried to be found by using AHP and VIKOR methods. In this way, a practical contribution has been made to ship engineers, class societies and ship owners to facilitate the selection of hatch covers (Soner et al., 2017). Celik and Akyuz (2018) have proposed a hybrid FAHP-TOPSIS method for deciding ship loader. They have recommended a parallel (traveling) ship loader for bulk material loadings (Celik, and Akyuz, 2018). There are many reasons for marine pollution. A few of them can be listed as follows; there may be spills from ship collisions and oil spills during oil extraction and oil tanker activities. Within the scope of this subject, Zafirakou et al. (2018), what can be done to prevent oil spills with the PROMETHEE method was theoretically evaluated (Zafirakou et al., 2018). Emergency response is vital in the onshore sector as well as in the maritime sector. Wu et al. (2018) have proposed the TOPSIS technique for managing ships without command. As a result of the use of this technique, it is useful in handling ships that are not under control (Wu et al., 2018). The maritime sector has an impact on the development of world trade and the growth of the logistics network. This growth has enormous implications for marine safety, human health, and marine ecology. To reduce ship accidents, which are the primary source of these factors, a solution can be made with the TOPSIS technique (Chen et al., 2019). Maritime safety policy is affected by many things. These are respectively: technological developments, new political arrangements, infrastructure, socio-cultural and the like. Hozairi et al. (2019) have tried to find solutions to what needs to be done to develop the Indonesian maritime security policy using AHP and TOPSIS techniques (Hozairi et al., 2019).

4.1. Evaluation Frequencies of Classified Topics of International Studies

Studies have been analyzed according to created sub-areas. Eight studies can be classified into our sub-areas. The reason for this situation is being considered studies much more than national studies with the number of 73. However, port performance/efficiency/risk analysis is the most focused topic in international studies with a number of 18. It means nearly a quarter of all studies. Port/ facility and management selection follow the first rank with the study number of 13 and the third rank are ship machine and equipment selection and port/facility location decision topics with 8 studies. Other distributions of their percentage can be seen in Figure 4 and Table 3.

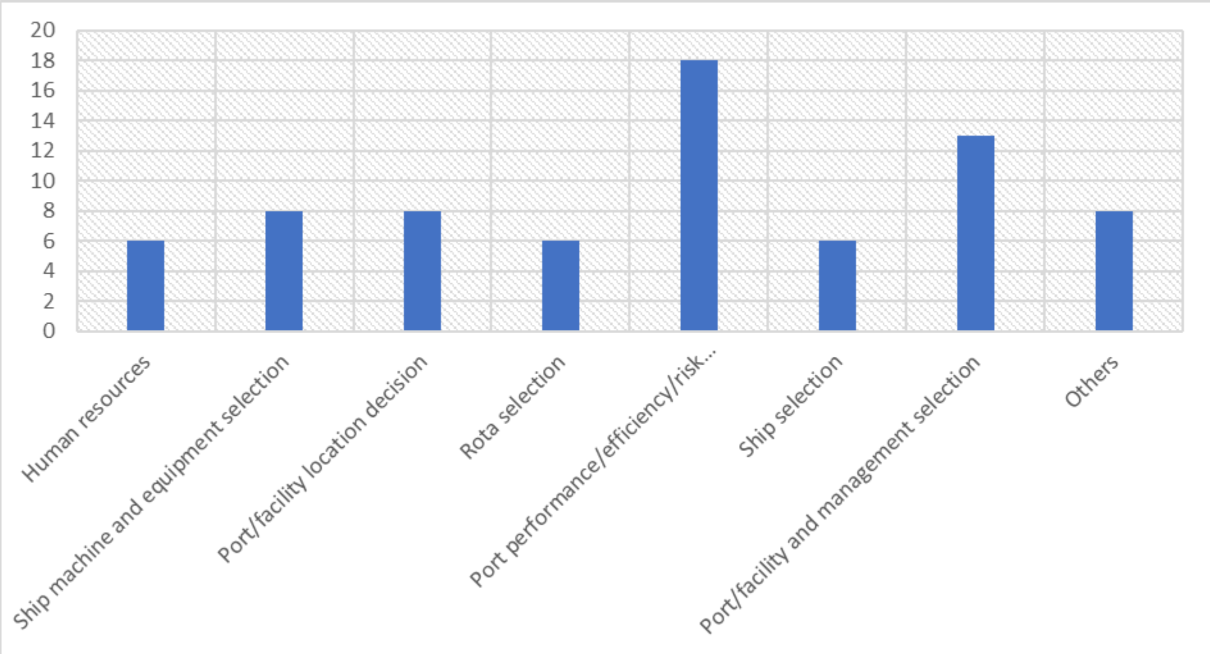

Figure 4. Distribution of international papers by organized sub-areas.

The numerical expressions and percentage rates of organized sub-areas in international studies are given in Table 3.

Table 3. Percentages of organized sub-areas in international studies.

	Number of Study	Percentage (%)
Human resources	6	8.22
Ship machine and equipment selection	8	10,96
Port/facility location decision	8	10,96
Route selection	6	8,22
Port performance/efficiency/risk analysis	18	24,66
Ship selection	6	8,22
Port/facility and management selection	13	17,80
Others	8	10,96

4.2. Evaluation of Exercised Techniques

In the studies, the AHP method was the most used. AHP is used 34 times and takes place as the first rank. In 20 studies AHP was used alone and in 14 studies it was used hybrid type. The second rank is the TOPSIS method, which was used 19 times in the distribution of 11 single, 8 hybrid ways. At third rank, there is PROMETHEE with the number of 7, which separated as 5 single and 2 hybrid types. A however interesting thing in the international studies is that there is 35 MCDM method usage in others' class. Almost all the 23 methods are different, and they have used some hybrid types. Some of these methods are: Saw Method, ANP, BN, GRP, ER, ELECTRE, DEMATEL, and DELPHI. Totally, MCDM techniques were used 96 times and 33 of them were the hybrid type. Distributions and their percentages can be seen in Figure 5 and Table 4.

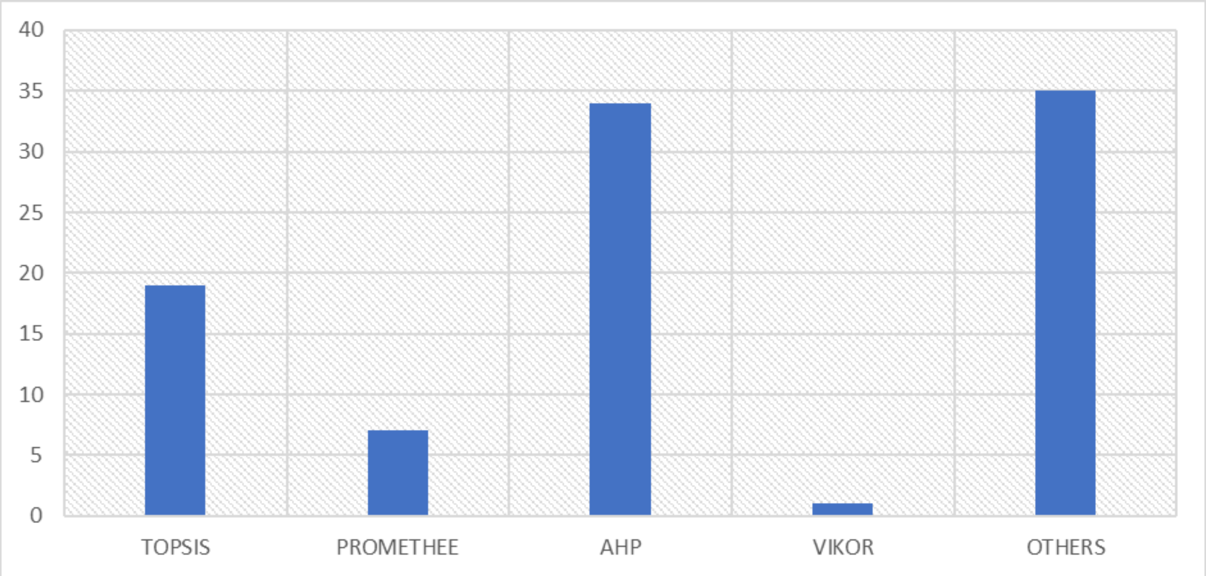

Figure 5. Distribution of MCDM methods in international studies.

The numerical expressions and percentage rates of methods international studies are given in Table 4.

Table 4. Percentages of methods in international studies.

	Number of Usage	Percentage (%)
TOPSIS	19	19,79
PROMETHEE	7	7,29
AHP	34	35,42
VIKOR	1	1,04
OTHERS	35	36,46

4.3. Number of Paper Evaluation by Years

After the year 2016, 73 papers have published in the international area for MCDM techniques in maritime. 2018 and 2019 were the most effective year for the MCDM workings in maritime with a study number of 20. And 2017 is following the years 2018 and 2019 with a study number of 17. In 2016 and 2020, the number of papers is 9 and 7, respectively. The number of articles in 2018 and 2019 exceeded half of the total articles written. That is why 2018 and 2019 are milestones for MCDM techniques in maritime. The distribution of the number of published papers per year can be seen in Figure 6.

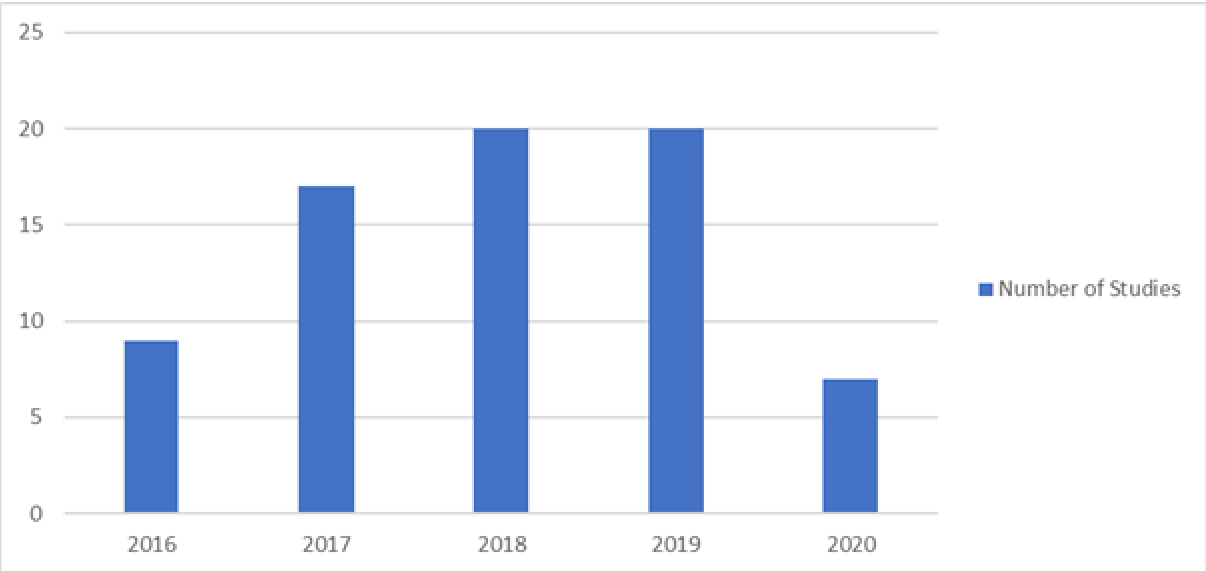

Figure 6. Distribution of national studies by years.

5. OTHER METHODS AND MATHEMATICAL MODELS USED IN THE MARITIME INDUSTRY

Besides MCDM methods, there are other decision making or analysis methods used in the shipping Industry. These methods can be grouped generally as regression and forecasting. The regression methods used frequently in shipping are as follows:

- Support Vector Regression (SVR)
- Linear Regression
- Vector Autoregression (VAR)

Forecasting methods do not have a general classification, but prediction methods such as ARIMA and Markov Chain are used in maritime studies. Wang et al. (2018) in the Target Direction of Arrival Estimation paper, have evaluated possible routes to estimate arrival time using the Support Vector Regression (SVR) method (Wang et al., 2018). Also, Kawan et al. (2007) have done a ship motion prediction study with the SVR method (Kawan et al., 2017).

Mobbing Examination in Maritime Sector article can be given as an example for linear regression studies in recent years. In that work, factors affected the mobbing were determined with Multiple Linear Regression Analysis (MLRA) (Tavacioglu et al., 2018). Weng et al. (2018) made a predicting shipping accident mortality study with MLRA, too. Twenty-three thousand twenty-nine accidents between 2001 and 2011 were examined, and a damage prediction method was created in ship accidents (Weng et al., 2018). On the other hand, there are maritime studies where forecasting methods have been used in recent years. Articles such as De Girolamo et al. (2017), Stavroulakis and Papadimitriou, (2017), and Xiao et al., (2017); have completed studies on such as Maritime activities, Maritime traffic prediction, European cluster prediction.

During the investigations, it was seen that regression, forecasting, or any type of decision supportive method have used much less than MCDM techniques in the maritime industry. In MCDM techniques, dispersed and multifarious data, criteria or alternatives are worked but in regression or forecasting studies definite data is used to compare MCDM studies. To be clearer, forecasting and regression analyses can be applied when their previous data reservoir has a single or limited dimension. However, in the

MCDM studies, much more data with infinite dimensions can be analyzed according to the method's strength.

6. COMPARISON OF NATIONAL AND INTERNATIONAL STUDIES

In national studies, port performance/efficiency/risk analysis is the most studied subject with 26.32%. The second most focused subject is human resources, with 21.4%, and the third rank is ship selection with a nearly equal percentage of 16%.

In international studies, port performance/efficiency/risk analysis is the most studied subject with a percentage of 24.66%, too. The second rank is port/facility and management selection with 17.8% and the third rank is shared by port/facility location decision and ship machine and equipment selection with 10.96%. Port performance/efficiency/risk analysis is the most studied sub-area according to our analyses. The reason for this situation can be included other sub-areas such as human resources, port/facility location decision, and route selection by port performance/efficiency/risk analysis. It can be said that other sub-areas are criteria for port performance/efficiency/risk analysis field. On the other hand, AHP was the most used MADM technique in international studies with 35.42%. Also, the second rank is TOPSIS, with 19.79% for international studies. For national studies, this percentage is the opposite. So, TOPSIS was the most used in national studies with 35.30%. Moreover, the second rank is AHP, with 29.41% for national studies. The third ranks are different, the VIKOR method is the third one for national studies and the PROMETHEE method is for the international area. All in all, it can be said that percentage of methods used in the studies in the national area is matched up with the international area. Another analysis is the usage of fuzzy methods. 38.24% of the methods are hybrid in national papers and this percentage for the international area is 34.38%. It is seen that hybrid method usage is better than the international level in Turkey. Also, it shows that Turkey is willing to consider fuzzy and uncertain data more than international colleagues. In other respects, MCDM studies for maritime in Turkey have been rising and falling from 2016 to 2018. However, MCDM papers have been decreasing since 2018. This situation, it can be problematic for future developments. And while it can be said that MCDM studies have increased in the international arena from 2016 to 2018, it is clearly seen that it has decreased since 2019. Additionally, in the next few years, especially for 2020, the number of studies might be decreased because of the coronavirus epidemic.

7. Advantages and Disadvantages of Methods

There are so many studies for different cases that are done with different methods. Every method has advantages and disadvantages. Every researcher finds some methods good or bad for their workings. Some inferences have been determined due to evaluated papers for both national and international studies. In national studies, it is seen that hybrid methods will become more common in future works. 38.24% of the papers included hybrid methods in the national area. Efe and Kurt (2018), claim in their personnel selection for a port facility analysis that hybrid methods are more beneficial for the maritime area (Efe and Kurt, 2018). Also, Gul (2019), supports this remark in the determination of health and occupation risk analysis in the maritime industry (Gul, 2019). In another remark, when a decision analysis system is created for only one project, it can weaken performance. In Uzun and Kazan's study, general evidence cannot be taken with AHP, TOPSIS, and PROMETHEE methods for equipment selection in shipbuilding (Uzun and Kazan, 2016). Uzun and Yıldırım also support this proposition with another paper (Uzun and Yıldırım, 2016). In the international area, the AHP method is the most commented on and criticized one in the MADM methods. It makes sense because it is the most common method with a 35.42% percentage. Othman et al. (2019), present AHP as complex but net output given method in their Dry Bulk Cargo Application Analysis (Othman et al., 2019). Also, Sahin and Yip remark that they chose the AHP method because it is the most consistent method (Sahin and Yip, 2017). Sahin et al. (2020) also made another suggestion that AHP should be used in purchase analyses in maritime (Sahin et al., 2020). AHP also be used as a hybrid form with other methods and gives satisfactory outputs in limited criteria and alternatives tried on Ballast Water System Decision Analysis (Karahalios, 2017). On the other hand, the AHP method has some disadvantages, according to some studies. Lu et al. (2019) have not preferred to use the AHP method in their Location Decision Analysis for LNG. They found the AHP method is less consistent while increasing the number of criteria. Also, it is not possible to do a pairwise comparison with the analytical hierarchy process (Lu et al., 2019). Sumner and Rudan (2018) support this remark in the Transshipment Port Selection study and defends that the Best Worst Method is much better than AHP in a pairwise comparison (Sumner and Rudan, 2018). Tsai et al. (2018) propose that the AHP method has low performance in the analyses in which dependent variables and feedback mechanisms are used. ANP method would be more useful for this type of analysis (Tsai et al., 2018). In several situations, PROMETHEE could be more effective in the comparison of the AHP method. Gagatsi et al. (2017) remark this inference in the Port Policy Comparison study and claims that AHP has not performed well although the number of criteria was limited (Gagatsi et al., 2017). The PROMETHEE method is another MADM method that is favored in maritime studies internationally. Mladineo et al. (2017) indicate that especially for the PROMETHEE II that the PROMETHEE method is simple and can be understood by non-professionals (Mladineo et al., 2017). PROMETHEE II also has accepted better than PROMETHEE I for the studies that worked with fuzzy data. This type of problem is generally solved by developing current methods or has adopted them with fuzzy data. However, another common technique to overcome this problem is working with hybrid methods. Chen and Zheng (2018), state that hybrid methods give more objective results in the Ship Targeting Method Analysis study (Chen and Zheng, 2018).

8. Results and Discussion

Looking at the national field studies, human resources, and port performance/ efficiency/risk analysis studies are almost half of the total studies as a ratio. From this result, the importance of human resources, and port performance studies in national studies is clearly seen. When looking at international studies, it is seen that port performance/efficiency/risk analysis and port/ facility and management studies have the highest two rates of comprehensive studies. Also, when compared to national and international studies, a common point of them is port performance. In both studies, the Port performance stands out as the most common paper. The weights of the methods used in the analyzes differ except for AHP. The reason for this may be differences in periodic needs or maritime policies.

If other methods are excluded from the research, when national and international studies are examined, it has been determined that AHP constitutes the basis of approximately half of the studies. This is because AHP is a building block in determining criteria, and it can quickly adapt to hybrid methods. On the other hand, when looking at international studies, it is seen that the ‘others’ part in the method distribution is high in MCDM techniques. It seems that the international arena is one step ahead in trying different techniques and looking for new solutions to problems.

Among the techniques used by adapting to common MCDM techniques, there are methods such as ANP, BN, GRP, ER, ELECTRE, DEMATEL, and DELPHI. To give an example, BN is a useful and indefinite causal inference model in the field of uncertain reasoning. Unlike other decision-making models, the BN model, which graphically visualizes multiple information, is ideal for predicting probabilistic situations in any study. Further, BN more conveniently includes causation and a conditional correlation between network node variables. In this case, even if the BN method is not used as much as the AHP method, it may be the method that will stand out in the coming years. The use of hybrid methods is quite common because the problems are wide and comprehensive, and the methods are relatively limited in singlev use. Analysis and hybrid usage rates show that hybrid methods are much more efficient than using single methods. It is understood from the course of studies that these methods and combinations should be improved and will be so for the future position of decision-making techniques, especially for maritime applications. An example of this is developing the AHP method as ANP and the PROMETHEE method as PROMETHEE II, III. From a general perspective, the AHP method loses its consistency when the number of criteria increases and methods such as VIKOR and TOPSIS are better than AHP in this regard. According to the literature search, especially the TOPSIS method performs well in complex analyzes. Although some shortcomings, the studies in Turkey and the international arena continue apace and will be concluded in a decision given in a purely mathematical base of the not too distant future of most of both management and application areas. For this study to be better, the studies should be examined in a broader time range, and the methods should be scanned in a broader range. In other words, the limitations of this paper are that the studies didn't be examined in a wider range of time and methods didn't be scanned in a wider range.

REFERENCES

Acer, A. and Yangınlar, G. (2017). The Determination of Turkish Container Ports Performance with Topsis Multiple Criteria Decision-Making Method. *Journal of Management Marketing and Logistics* 4(2): 67-75. doi.org/10.17261/Pressacademia.2017.452

Adenso-Díaz, B., Álvarez, N. G., and Alba, J. A. L. (2019). A Fuzzy AHP Classification of Container Terminals. *Maritime Economics and Logistics* 22(2): 218-238. doi:10.1057/s41278-019-00144-4.

Agarwal, A. and Chand, V. K. (2018). Selection of It Tools in Shipping." *Industrial Engineering Journal* 11. doi: 10.26488/IEJ.11.2.1037.

Aikhuele, D. O., Sorooshian, S., Ansah, R. H. and Mohd Turan, F. (2017). Application of Intuitionistic Fuzzy Topsis Model for Troubleshooting an Offshore Patrol Boat Engine. *Polish Maritime Research* 24(2): 68-76. doi: 10.1515/pomr-2017-0051.

Aikhuele, D. O., Mohd Turan, F., Odofin, S. and Ansah, R.H. (2017). Interval-Valued Intuitionistic Fuzzy TOPSIS-Based Model for Troubleshooting Marine Diesel Engine Auxiliary System. *Trans. R. Instit. Nav. Arch. Part A: Int. J. Marit. Eng* 159: 107-114. doi: 10.3940/rina.ijme.2016.al.402.

Alyami, H., Yang, Z., Riahi, R., Bonsall, S. and Wang, J. (2019). Advanced Uncertainty Modelling for Container Port Risk Analysis. *Accident Analysis and Prevention* 123: 411-421. doi.org/10.1016/j.aap.2016.08.007.

Animah, I., Addy Lamptey, A., Korsah, F. and Sackey, J. S. (2018). Compliance with MARPOL Annex VI regulation 14 by ships in the Gulf of Guinea sub-region: Issues, challenges and opportunities. *Transportation Research Part D: Transport and Environment* 62: 441-455. doi: 10.1016/j.trd.2018.03.020.

Animah, I. and Shafiee, M. (2019). Maintenance Strategy Selection for Critical Shipboard Machinery Systems Using A Hybrid AHP-PROMETHEE and Cost Benefit Analysis: A Case Study. *Journal of Marine Engineering and Technology* 1-12. doi: 10.1080/20464177.2019.1572705.

Arof, A.Md. (2018). Decision Making Model for Ro-Ro Short Sea Shipping Operations in Archipelagic Southeast Asia. *The Asian Journal of Shipping and Logistics* 34(1): 33-42. doi: 10.1016/j.ajsl.2018.03.005.

Arslan, H. M., Ozcan, S. and Abdellahi A. (2019). Çok Kriterli Karar Analizi Yöntemleri ile Balıkçılık İşletmeleri için En Uygun Tesis Yeri Seçimi. *Dicle Üniversitesi Sosyal Bilimler Enstitüsü Dergisi* 22: 403-413.

Badurina Tomic, P., Dundovic, C. and Grubisic, N. (2016). Selection of Suitable Locations for Nautical Tourism Ports in The Ličko-Senjska County. *Journal of Maritime & Transportation Science* 52(1): 133-149. doi: 10.18048/2016.52.11.

Bakalar, G. and Beatriz Baggini, M. (2016). Automatic Communication System Ship to Shipping Terminal, for Reporting Potential Malfunctions of A Ballast Water Treatment System Operation. *In: 2016 39th International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO). IEEE* 725-729. doi: 10.1109/MIPRO.2016.7522236.

Balbas, O. and Turan. E. (2019). Application of Fuzzy AHP and Fuzzy TOPSIS Methods in Selection of Ship Type to be Built in Shipyards. *Gmo Shipmar* 25(215): 93-111.

Bellsolà Olba, X., Daamen, W., Vellinga, T. and Hoogendoorn, S. P. (2019). Multi-Criteria Evaluation of Vessel Traffic for Port Assessment: A Case Study of The Port of Rotterdam. *Case Studies* *on Transport Policy*, 7(4): 871-881. doi: 10.1016/j.cstp.2019.07.005.

Besikci, E.B., Kececi, T., Arslan, O. and Turan, O. (2016). An Application of Fuzzy-AHP to Ship Operational Energy Efficiency Measures. *Ocean Engineering* 121: 392-402. doi: 10.1016/j.oceaneng.2016.05.031.

Cakıroglu, G., Sener, B. and Balin, A. (2018). Applying a fuzzy-AHP for The Selection of a Suitable Tugboat Based on Propulsion System Type. *Brodogradnja: Teorija i Praksa Brodogradnje i Pomorske Tehnike* 69(4): 1-13. doi: 10.21278/brod69401.

Cao, X. and Lam, J. S. L. (2019) A Fast Reaction-Based Port Vulnerability Assessment: Case of Tianjin Port Explosion. *Transportation Research Part A: Policy and Practice* 128: 11-33. doi: 10.1016/j.tra.2019.05.019.

Celik, E. and Akyuz, E. (2018). An interval type-2 fuzzy AHP and TOPSIS Methods for Decision-Making Problems in Maritime Transportation Engineering: The Case of Ship Loader. *Ocean Engineering* 155: 371-381. doi: 10.1016/j.oceaneng.2018.01.039.

Chen, A. and Zheng, P. (2018). A New Ship-Targeting Model for Ship Supervision Based on AHP-DEA Method. *In: 2018 7th International Conference on Energy, Environment and Sustainable Development (ICEESD 2018)* doi: 10.2991/iceesd-18.2018.167.

Chen, J., Bian, W., Wan, Z., Yang, Z., Zheng, H. and Wang, P. (2019). Identifying Factors Influencing Total-Loss Marine Accidents in The World: Analysis and Evaluation Based on Ship Types and Sea Regions. *Ocean Engineering* 191: 106495. doi: 10.1016/j.oceaneng.2019.106495.

Choquet, G. (1954). Theory of Capacities. *In: Annales de l'institut Fourier* 5: 131-295.

Chou, C. (2018). Application of ANP to the Selection of Shipping Registry: The Case of Taiwanese Maritime Industry. *International*

Journal of Industrial Ergonomics 67: 89-97. doi: 10.1016/j.ergon.2018.04.009.

De-Girolamo, P., Di Risio, M., Beltrami, G. M., Bellotti, G. and Pasquali, D. (2017). The Use of Wave Forecasts for Maritime Activities Safety Assessment. *Applied Ocean Research* 62: 18-26. doi.org/10.1016/j.apor.2016.11.006.

Ding, J.F., Kuo, J. F. and Tai, W.H. (2019). A Fuzzy Evaluation Model of Choosing A Middle Manager for An International Shipping Service Provider. *Brodogradnja: Teorija I Praksa Brodogradnje I Pomorske Tehnike* 70(1): 93-107. doi.org/10.21278/brod70107.

Ding, J.F., Kuo, J.F. and Tai, W.H. (2019). Using Fuzzy AHP Method to Evaluate Key Competency and Capabilities of Selecting Middle Managers for Global Shipping Logistics Service Providers. *Pomorstvo* 33(1): 3-10.doi: 10.31217/p.33.1.1.

Du, J., Jiang, Y., Wang, K., Song, G., Wu, J., Song, L., Wu, J., Tian, J. and Ma, Z. (2017). Evaluation of Pilotage Dispatching Operation for Dalian Port in China based on FCE–AHP Method. *Journal of International Maritime Safety, Environmental Affairs, and Shipping* 1(1): 11-18. doi: 10.1080/25725084.2017.1419786.

Efe, B. and Kurt, M. (2018). Bir Liman Işletmesinde Personel Seçimi Uygulaması. *Karaelmas Science and Engineering Journal* 8(2): 417-427. http://dx.doi.org/10.7212%2Fzkufbd.v8i2.750.

Fan, S., Zhang, J., Blanco-Davis, E., Yang, Z. and Yan, X. (2020). Maritime Accident Prevention Strategy Formulation from A Human Factor Perspective Using Bayesian Networks and TOPSIS. *Ocean Engineering* 210: 1-12. doi: 10.1016/j.oceaneng.2020.107544.

Gagatsi, E., Giannopoulos, G., Aifantopoulou, G. and Charalampous, G. (2017). Stakeholders-Based Multi-Criteria Policy Analysis İn Maritime Transport: from Theory to Practice. *Transportation Research Procedia* 22: 655-664. doi.org/10.1016/j.trpro.2017.03.062.

Gao, T., Na, S., Dang, X. and Zhang, Y. (2018). Study of the Competitiveness of Quanzhou Port on the Belt and Road in China Based on a Fuzzy-AHP and ELECTRE III Model. *Sustainability* 10(4) :1253. doi: 10.3390/su10041253.

Goncalves, W., Freitas, R. R. D., Chiquieri, J., Jr. Rigo, L.O., Mattos, A.L. and Zatta, F.N. (2019). Regional Development and Organization of Space: An Approach to the Dry Port location using the Hybrid Method Fuzzy-AHP. *International Journal of Advanced Engineering Research and Science (IJAERS)* 6(5): 521-530. doi: 10.22161/ijaers.6.5.68.

Gul, M. (2019). A Fuzzy-Based Occupational Health and Safety Risk Assessment Framework and A Case Study in An International Port Authority. *Journal of Marine Engineering and Technology* 1-15. doi: 10.1080/20464177.2019.1670994.

Ha, M. H., Yang, Z. and Heo, M.W. (2017). A New Hybrid Decision Making Framework for Prioritising Port Performance Improvement Strategies. *The Asian Journal of Shipping and Logistics* 33(3): 105-116. doi.org/10.1016/j.ajsl.2017.09.001.

Hemalatha, S., Dumpala, L. and Balakrishna, B. (2018). Service Quality Evaluation and Ranking of Container Terminal Operators Through Hybrid Multi-Criteria Decision Making Methods. *The Asian Journal of Shipping and Logistics* 34(2): 137-144. doi: 10.1016/j.ajsl.2018.06.010.

Hervás-Peralta, M., Poveda-Reyes, S., Molero, G., Santarremigia, F. and Pastor-Ferrando, J. P. (2019). Improving the Performance of Dry and Maritime Ports by Increasing Knowledge about the Most Relevant Functionalities of the Terminal Operating System (TOS). *Sustainability* 11(6): 1648. doi: 10.3390/su11061648.

Hozairi, H., Buhari, B., Lumaksono, H. and Tukan, M. (2019). Selection of Marine Security Policy using Fuzzy-AHP TOPSIS Hybrid Approach. *Knowledge Engineering and Data Science* 2(1): 19-30. doi: 10.17977/um018v2i12019p19-30.

Hsu, W. K. K., Lian, S.-J. and Huang, S. H. S. (2020). An Assessment Model Based on A Hybrid MCDM Approach for The Port Choice of Liner Carriers. *Research in Transportation Business and Management* 34: 100426. doi: 10.1016/j.rtbm.2019.100426.

Icaza, R. R. D. and Parnell, G. S. (2018). Container Port Selection in West Africa: A Multi-Criteria Decision Analysis. *Engineering Management Research* 7(1): 68-87. doi: 10.5539/emr.v7n1p68.

Inan, T. and Baba, A. F. (2020). Gemi Çarpışmalarının Önlenmesi için Hibrit Algoritma Tabanlı Bir Karar Destek Sisteminin Oluşturulması. *Journal of the Faculty of Engineering and Architecture of Gazi University* 35(3): 1213-1230. doi: 10.17341/gazimmfd.603464.

Jiang, D., Wu, B., Yang, X. and Van Gelder, P. H. A. J. M. (2019). A Fuzzy Evidential Reasoning-Based Approach for Submarine Power Cable Routing Selection for Offshore Wind Farms. *Ocean Engineering* 193:106616. doi.org/10.1016/j.oceaneng.2019.106616.

Jugović, A., Cukrov, M. and Poletan Jugović, T. (2017). Multi-criteria Optimization of Motorways of the Sea in the Function of the Environment Protection: Case Study of Croatia. *Promet-Trafficand Transportation* 29(4): 463-468. doi: 10.7307/ptt.v29i4.2416.

Karahalios, H. (2017). The Application of the AHP-TOPSIS for Evaluating Ballast Water Treatment Systems by Ship Operators. *Transportation Research Part D: Transport and Environment* 52: 172-184. doi: 10.1016/j.trd.2017.03.001.

Kawan, B., Wang, H., Li, G. and Chhantyal, K. (2017). Data-Driven Modeling of Ship Motion Prediction Based on Support Vector Regression. *Proceedings of the 58th Conference on Simulation and Modelling (SIMS 58) Reykjavik, Iceland, September 25th – 27th* 138(46): 350-354. doi: 10.3384/ecp17138350.

Kaya, A.Y., Asyalı, E. and Ozdagoglu, A. (2018). Career Decision Making in The Maritime Industry: Research of Merchant Marine

Officers Using Fuzzy AHP And Fuzzy TOPSIS Methods. *Zeszyty Naukowe Akademii Morskiejw Szczecinie* doi: 10.17402/306.

Kim, A. R. (2016). A Study on Competitiveness Analysis of Ports in Korea and China by Entropy Weight TOPSIS. *The Asian Journal of Shipping and Logistics* 3(4): 187-194. doi.org/10.1016/j.ajsl.2016.12.001.

Kim, A. R. and Lu, J. (2016). A Study on the Evaluation of Port Competitiveness in Busan Port and Shanghai Port. *Open Access Library Journal* 3(4): 1-8. doi: 10.4236/oalib.1102623.

Koksalan, M., Wallenius, J. and Zionts, S. (2011). Multiple Criteria Decision Making: From Early History to the 21st Century. *World Scientific* 212. doi.org/10.1142/8042.

Kovacic, M. and Mrvica, A. (2017). Selecting the size and Type of a Vessel for the Purpose of Maritime Connection of Mainland and Islands and Between the Islands in Croatia. *In: Simpozijum O Operacionim Istraživanjima SYM-OP-IS 2017.*

Longaray, A. A., Gomes, C. F. S., Gomes, S., Elacoste, T., Maria, C. and Machado, S. (2019). Efficiency Indicators to Evaluate Services in Port Services: A Proposal Using Fuzzy-AHP Approach. *Pesquisa Operacional* 39(3): 437-456. doi: 10.1590/0101-7438.2019.039.03.0437.

Lu, W., Seo, J. and Yeo, G. (2019). Location Selection of an LNG Bunkering Port in Korea. *Journal of Korea Trade* 23(2): 59-75. https://ssrn.com/abstract=3424501.

Min, H. and Park, B.I. (2019). A Two-Dimensional Approach to Assessing the Impact of Port Selection Factors on Port Competitiveness using the Kano Model. *Maritime Economics and Logistics* 22(2): 1-30. doi: 10.1057/s41278-019-00117-7.

Mladineo, N., Mladineo, M. and Knezic, S. (2016). Web MCA-based Decision Support System for Incident Situations in Maritime Traffic: Case Study of Adriatic Sea. *The Journal of Navigation* 70(6): 1312-1334. doi: 10.1017/S0373463317000388.

Nguyen, L. C. and Notteboom, T. (2016). A Multi-Criteria Approach to Dry Port Location in Developing Economies with Application to Vietnam. *The Asian Journal of Shipping and Logistics* 32(1): 23-32. doi.org/10.1016/j.ajsl.2016.03.003.

Othman, M. K., Abdul Rahman, N.S.F., Md-Arof, A., Ismail, A. and Sanusi, I. A. (2019). Evaluation of Delay Factors on Dry Bulk Cargo Operation in Malaysia: A Case Study of Kemaman Port. *The Asian Journal of Shipping and Logistics* 35(3): 127-137. doi: 10.1016/j.ajsl.2019.09.001.

Othman, M. K. Abdul Rahman, N.S.F., Ismail, A. and Saharuddin, A.H. (2020). Factors Contributing to the Imbalances of Cargo Flows in Malaysia Large-Scale Minor Ports Using a Fuzzy Analytical Hierarchy Process (FAHP) Approach. *The Asian Journal of Shipping and Logistics* 36(3). doi: 10.1016/j.ajsl.2019.12.012.

Ozdemir, U., Ece, N.J. and Gedik, N. (2017). Türkiye'de Denizcilik Eğitiminin Geleceğine Yönelik Nicel Bir Çalışma Örneği. *Journal of Eta Maritime Science* 5(2): 154-170. *doi.org/10.5505/jems.2017.83703.*

Ozdemir, U. and Guneroglu, A. (2018). Cargo Type Selection Procedure Using Fuzzy AHP and Fuzzy TOPSIS Techniques: 'The Case of Dry Bulk Cargo Ships'. *International Journal of Shipping and Transport Logistics* 10(3): 259-280. doi: 10.1504/IJSTL.2018.091673.

Ozdemir, U. (2018). Gemiadamlarının İdari Ceza Almalarnı Gerektiren Mesleki Hata ve Uygunsuzlukların Bahp Yöntemi İle Değerlendirilmesi. *Dokuz Eylül Üniversitesi Denizcilik Fakültesi Dergisi* 10(1): 19-39. doi.org/10.18613/deudfd.428155.

Ozdemir, U. (2016). Bulanık DEMATEL ve Bulanık TOPSIS Yöntemleri Kullanılarak Limanlarda Yaşanan İş Kazalarının İncelenmesi. *Journal of ETA Maritime Science* 4(3): 235-247. doi: 10.5505/jems.2016.74936.

Ozturkoglu, Y. and Calıskan, A. (2016). Deniz Taşımacılığında Broker Seçimi Kararını Etkileyen Kriter Skorlarının Belirlenmesi Ve Alternatiflerin Değerlendirilmesi. *Dokuz Eylül Üniversitesi Denizcilik Fakültesi Dergisi* 8(1): 31-61. doi: 10.18613/deudfd.97173.

Pekkaya, M. and Bucak, U. (2018). Çok Kriterli Karar Verme Yöntemleriyle Bölgesel Liman Kuruluş Yeri Seçimi: Batı Karadeniz'de Bir Uygulama. *Uluslararası İktisadi ve İdari İncelemeler Dergisi* 253-268. doi.org/10.18092/ulikidince.353653.

Pham, Y. and Yeo, G. T. (2019). Evaluation of Transshipment Container Terminals' Service Quality in Vietnam: From the Shipping Companies' Perspective. *Sustainability* 11(5): 1503. doi: 10.3390/su11051503.

Polat, C. and Merdivenci, F. (2019). Evaluation of Line Selection Criteria of Freight Forwarders in Container Transportation. *Türk Denizcilik ve Deniz Bilimleri Dergisi* 5(2): 112-126. https://www.researchgate.net/deref/https%3A%2F%2Forcid.org%2F0000-0003-1031-1593.

Rezaei, J., van Wulfften Palthe, L., Tavasszy, L., Wiegmans, B. and van der Laan, F. (2018). Port Performance Measurement in the Context of Port Choice: an MCDA Approach. *Management Decision* 57(2). Doi: 10.1108/MD-04-2018-0482.

Roy, B. (1968). Classement Et Choix En Présence De Points De Vue Multiples. *Revue Française D'informatique et de Recherche Opérationnelle* 2(8): 57-75. doi.org/10.1051/ro/196802V100571.

Saaty, T. L. (1972). An Eigenvalue Allocation Model for Prioritization and Planning. *Energy Management and Policy Center, University of Pennsylvania* 28-31.

Sahin, B. and Yip, T. L. (2017). Shipping Technology Selection for Dynamic Capability Based on Improved Gaussian Fuzzy AHP Model. *Ocean Engineering* 136: 233-242. doi: 10.1016/j.oceaneng.2017.03.032.

Sahin, B., Yip, T. L., Tseng, P., Soylu, A. and Kabak, M. (2020). An Application of a Fuzzy TOPSIS Multi-Criteria Decision Analysis Algorithm for Dry Bulk Carrier Selection. *Information* 11(5): 251. doi: 10.3390/info11050251.

Senel, M., Senel, B. and Havle, C.A. (2018). Risk Analysis of Ports in Maritime Industry in Turkey using FMEA Based Intuitionistic Fuzzy TOPSIS Approach. *ITM Web of Conferences* 22(8): 01018. doi: 10.1051/itmconf/20182201018.

Sener, Z. (2016). Evaluating Ship Selection Criteria for Maritime Transportation. *Journal of Advanced Management Science* 4(4): 325-328. doi: 10.12720/joams.4.4.325-328.

Seo, Y. J., Ha, M. H., Yang, Z. and Bhattacharya, S. (2018). The Ship Management Firm Selection: The Case of South Korea. *The Asian Journal of Shipping and Logistics* 34(3): 258–268. doi: 10.1016/j.ajsl.2018.09.008.

Soner, O., Celik, E. and Akyuz, E. (2017). Application of AHP and VIKOR Methods Under Interval Type 2 Fuzzy Environment in Maritime Transportation. *Ocean Engineering* 129: 107-116. doi.org/10.1016/j.oceaneng.2016.11.010.

Song, C., Xu, Z., Zhang, Y. and Wang, X. (2020). Dynamic Hesitant Fuzzy Bayesian Network and Its Application in The Optimal Investment Port Decision Making Problem of "Twenty-First Century Maritime Silk Road. *Applied Intelligence* 50(2): 1846-1858. doi: 10.1007/s10489-020-01647-x.

Stavroulakis, P. J. and Papadimitriou, S. (2017). Situation Analysis Forecasting: The Case of European Maritime Clusters. *Maritime Policy and Management* 44(6): 779-789. doi: 10.1080/03088839.2017.1330560.

Suharjo, B. and Suharyo, O. S. (2019). The Naval Harbours Priority Development using Zero-One Matrix Decision Variable (Zomdv) and Fuzzy MCDM Methods; A Case Study. *International Journal* *of Civil Engineering and Technology (IJCIET)* 10(2): 623-634. http://www.iaeme.com/IJCIET/index.asp.

Sumner, M. and Rudan, I. (2018). A Hybrid MCDM Approach to Transshipment Port Selection. *Pomorstvo* 32(2): 258-267. doi: 10.31217/p.32.2.11.

Tavacioglu, L., Gokmen, N., Eski, O., Sarı, V. and Yılmaz, A. C. (2018). A Research as Mobbing Examination in Maritime Sector. *Bilge International Journal of Science and Technology Research* 2: 32-39. doi: 10.30516/bilgesci.489095.

Temiz, I., Ozdemir, U. and Ece, N. J. (2018). Efficiency Analysis of Samsun Port Which Is Located on the Europe-Caucasia-Asia Transportation Corridor. *Turkish Journal of Maritime and Marine Sciences* 4(2).

Tsai, J. Y., Ding, J. F., Liang, G. S. and Ye, K. D. (2018). Use of a hybrid MCDM Method to Evaluate Key Solutions Influencing Service Quality at A Port Logistics Center in Taiwan. *Brodogradnja: Teorija i praksa brodogradnje i pomorske tehnike* 69(1): 89-105. doi.org/10.21278/brod69106.

Uzun, S. and Kazan, H. (2016). Çok Kriterli Karar Verme Yöntemlerinden AHP TOPSIS ve PROMETHEE Karşılaştırılması: Gemi İnşada Ana Makine Seçimi Uygulaması. *Journal of Transportation and Logistics* 1(1): 99-113. doi.org/10.22532/jtl.237889.

Uzun, S. and Yıldırım, B. F. (2016). Equipment Selection in Ship Building Process: TOPSIS, MOORA, VIKOR Application. *Eurasian Academy of Sciences Eurasian Business and Economics Journal* 2: 113-124. doi: 10.17740/eas.econ.2016-MSEMP-57.

Vilke, S., Bricic, D. and Kos, S. (2017). Northern and Southern European Traffic Flow Land Segment Analysis as Part of the Redirection Justification. *TransNav, the International Journal on Marine*

Navigation and Safety of Sea Transportation 11(4): 673-679. doi: 10.12716/1001.11.04.14.

Wang, R., Wen, B. and Huang, W. (2018). A Support Vector Regression-Based Method for Target Direction of Arrival Estimation from HF Radar Data. *IEEE Geoscience and Remote Sensing Letters* 15(5): 674–678. doi: 10.1109/LGRS.2018.2807405.

Wang, Y. and Yeo, G. T. (2018). Intermodal Route Selection for Cargo Transportation from Korea to Central Asia by Adopting Fuzzy Delphi and Fuzzy ELECTRE I Methods. *Maritime Policy and Management* 45(1): 3-18. doi: 10.1080/03088839.2017.1319581.

Wang, Y. and Yeo, G. T. (2019). Transshipment Hub Port Selection for Shipping Carriers in a Dual Hub-Port System. *Maritime Policy and Management* 46(6): 701-714. doi.org/10.1080/03088839.2019.1627012.

Weng, J., Yang, D., Qian, T. and Huang, Z. (2018). Combining Zero-Inflated Negative Binomial Regression with MLRT Techniques: An approach to evaluating shipping accident casualties. *Ocean Engineering* 166: 135-144. doi: 10.1016/j.oceaneng.2018.08.011.

Wu, B., Yan, X., Wang, Y. and Guedes Soares, C. (2016). Selection of Maritime Safety Control Options for NUC Ships using a Hybrid Group Decision-Making Approach. *Safety Science* 88: 108-122. doi.org/10.1016/j.ssci.2016.04.026.

Wu, B., Zong, L., Yan, X. and Guedes, S. C. (2018). Incorporating Evidential Reasoning and TOPSIS into Group Decision-Making Under Uncertainty for Handling Ship without Command. *Ocean Engineering* 164: 590-603. doi.org/10.1016/j.oceaneng.2018.06.054.

Xiao, Z., Ponnambalam, L., Fu, X. and Zhang, W. (2017). Maritime Traffic Probabilistic Forecasting Based on Vessels' Waterway Patterns and Motion Behaviors. *IEEE Transactions on Intelligent Transportation Systems* 18(11): 3122-3134. doi: 10.1109/TITS.2017.2681810.

Xue, J., Van Gelder, P. H. A. J. M., Reniers, G., Papadimitriou, E. and Wu, C. (2019). Multi-Attribute Decision-Making Method for Prioritizing Maritime Traffic Safety Influencing Factors of Autonomous Ships' Maneuvering Decisions using Grey and Fuzzy Theories. *Safety Science* 120: 323-340. doi.org/10.1016/j.ssci.2019.07.019.

Yami, H. A., Yang, Z., Riahi, R., Bonsall, S., Wang, J., Wan, C. and Qu, Z. (2017). Analytical Strategic Safety Management in Container Ports. *In: 2017 4th International Conference on Transportation Information and Safety (ICTIS).* 184-191. doi: 10.1109/ICTIS.2017.8047764.

Yang, Y. C. and Chen, S. L. (2016). Determinants of Global Logistics Hub Ports: Comparison of the Port Development Policies of Taiwan, Korea, And Japan. *Transport Policy* 45: 179-189. doi:10.1016/j.tranpol.2015.10.005.

Yazir, D., Sahin, B. and Yip, T. L. (2020). Selection of New Design Gas Carriers by Using Fuzzy EVAMIX Method. *The Asian Journal of Shipping and Logistics* 37(1): 91-104. doi.org/10.1016/j.ajsl.2020.10.001.

Yildiz, S., Uğurlu, O., Wang, J. and Loughney, S. (2020). Application of the HFACS-PV approach for identification of human and organizational factors (HOFs) influencing marine accidents. *Reliability Engineering and System Safety* 208: 1-13. doi.org/10.1016/j.ress.2020.107395.

Zabihi, A., Gharakhani, M. and Afshinfar, A. (2016). A Multi Criteria Decision-Making Model for Selecting Hub Port for Iranian Marine Industry. *Uncertain Supply Chain Managemen*t 4(3): 195-206. doi: 10.5267/j.uscm.2016.2.001.

Zadeh, L. A. (1965). Fuzzy sets. *Information and control* 8(3): 338-353. doi.org/10.1016/S0019-9958(65)90241-X.

Zafirakou, A., Themeli, S., Tsami, E. and Aretoulis, G. (2018). Multi-Criteria Analysis of Different Approaches to Protect the Marine and Coastal Environment from Oil Spills. *Journal of Marine Science and Engineering* 6(4): 125. doi: 10.3390/jmse6040125.

Zionts, S. (1979). MCDM-If Not a Roman Numeral, Then What? *Interfaces* 9(4): 94-101. https://www.jstor.org/stable/25059779.

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BİR KUŞAK BİR YOL PROJESİ'NİN TÜRKİYE VE TÜRK CUMHURİYETLERİ AÇISINDAN ÖNEMİ

Nur Jale ECE[1]

ÖZ

Orta Asya ve Güney Asya, tarihi İpek Yolu'nun birleştirdiği iki bölge olup, Orta Asya cumhuriyetlerinin bağımsızlığına kavuşmasından sonra İpek Yolu yeniden canlanmıştır. "Bir Kuşak Bir Yol (OBOR) Projesi" Asya, Avrupa ve Afrika'yı kara ve deniz yoluyla birbirine bağlayarak Orta Asya ülkelerinin ulaşım ve enerji ağları ile ekonomilerinin yeniden canlandırılmasını, barış ilkesini desteklemeyi ve Çin ile Avrupa arasındaki ticareti geliştirerek uluslararası entegrasyonu sağlamayı hedeflemektedir. "OBOR Projesi" ile Çin büyük miktarlarda birçok yatırım yaptığı ve yakın ticari ilişkiler sürdürdüğü bölgeler ile tesis ettiği ulaşım ağlarıyla ticari ve ekonomik ilişkilerini geliştirmeyi planlamaktadır. "OBOR Projesi" güzergâhında yer alan ülkelerin ortak çıkarlarına dayanmakta olup, Çin, Türkiye ve Türk Cumhuriyetleri ile güzergah üzerindeki diğer ülkeler için ekonomi, ticaret, istihdam ve kültürel açıdan birçok fayda sağlayacağı beklenmektedir. Çalışmada "OBOR Projesi" ile ilgili literatür araştırması yapılmış, Projenin kapsamı ve rotaları, Projeye ilişkin sorunlar, Proje'nin Türkiye ve Türk Cumhuriyetleri ilişkilerine potansiyel etkileri incelenmiştir. Çalışmada, "OBOR Projesi"nin güçlü ve zayıf yönleri ile fırsatlar ve tehditlerin ortaya konulması amacıyla "Güçlü ve Zayıf Yönler, Fırsatlar ve Tehditler (SWOT) Analiz Yöntemi kullanılmıştır. "OBOR Projesi"nin Türkiye ve Türk Cumhuriyetleri ile Çin ve güzergahı üzerindeki ülkelere sağlayacağı faydalar açısından genel bir değerlendirme yapılmıştır.

Anahtar Kelimeler: *Bir Kuşak Bir Yol Projesi, Uluslararası Ticaret, Ulaşım Koridorları, TRACECA, Türk Cumhuriyetleri*

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THE IMPORTANCE OF THE ONE BELT ONE ROAD PROJECT FOR TÜRKİYE AND THE TURKIC REPUBLICS

ABSTRACT

Central Asia and South Asia are two regions united by the historical Silk Road, and the Silk Road was revived after the Central Asian republics gained independence. "The "One Belt One Road (OBOR) Project" aims to revitalize the transportation and energy networks and economies of Central Asian countries by connecting Asia, Europe, and Africa by land and sea, to support the principle of peace, and to ensure international integration by developing trade between China and Europe. With the "OBOR Project", China plans to develop its commercial and economic relations through its transportation networks with the regions where it has made large investments and maintains close commercial relations. The "OBOR Project" is based on the common interests of the countries on its route and is expected to provide many benefits in terms of economy, trade, employment, and culture for China, Türkiye, the Turkic Republics, and the other countries on the route. In the study, the literature research on the "OBOR Project" was conducted, and the scope and routes of the Project, the problems related to the Project, and the potential effects of the Project on the relations between Türkiye and the Turkic Republics were examined. In the study, the "Strengths and Weaknesses, Opportunities and Threats (SWOT) Analysis Method" was used to reveal the strengths and weaknesses, opportunities and threats of the "OBOR) Project". A general evaluation has been made in terms of the benefits that the "OBOR Project" will provide to Türkiye, the Turkic Republics, China, and the countries on its route.

Keywords: *The "One Belt One Road Project", International Trade, Transport Corridors, TRACECA, Turkic Republics*

1. GİRİŞ

Çin Halk Cumhuriyeti, 1978-1979 yıllarında liberalleşme politikalarını benimsemeye başlamış olup, 1978 yılından itibaren yılda ortalama %10 oranında büyümektedir (Okur, 2017: 45-55; Ticaret Bakanlığı, 2019). Çin Halk Cumhuriyeti 2001'de Dünya Ticaret Örgütü'ne (WTO) üye olduktan sonra piyasa ekonomisine geçiş yapmış, dışa açılmanın neticesinde dünya ülkeleri için cazip hale gelmiştir. Dünya Bankası, Çin'in, 2020 yılında dünyanın ikinci büyük ticaret hacmine sahip ekonomisi haline geleceğini öngörmüştür (Yıldızoğlu, 2020). Türkiye ile Çin arasındaki ticari ve ekonomik ilişkiler tarihi ipek yolu ile başlamıştır. Türk Cumhuriyetleri Azerbaycan, Özbekistan ve Kazakistan zengin doğal kaynaklara sahip olup, gelecekte dünya ticaretinde önemli rol oynacak olup, diğer Türk Cumhuriyetlerinin ise küçük oyuncular olarak kalacağı tahmin edilmektedir. Türk Cumhuriyetleri en fazla Çin, Rusya ve AB ülkeleri ile ticaret yapmaktadır (Beşel, 2012:33-35).

"Bir Kuşak Bir Yol (OBOR) Projesi" Asya, Avrupa ve Afrika'yı kara ve deniz yoluyla birbirine bağlayarak Orta Asya ülkelerinin ulaşım ve enerji ağları ile ekonomilerinin yeniden canlandırmayı, barış ilkesini desteklemeyi, Çin ile Avrupa arasındaki ticareti geliştirerek uluslararası entegrasyonu sağlamayı hedeflemektedir. OBOR Projesi ile Çin yaklaşık 65 ülkede büyük miktarlarda birçok yatırım yapmış olup, yakın ticari ilişkiler sürdürdüğü bölgelerde tesis ettiği ulaşım ağları vasıtasıyla ticari ve ekonomik ilişkilerini geliştirmeyi planlamaktadır (Okur, 2017:45). Sermaye transferini kolaylaştırarak üretimi artırmak, ekonomik büyümeyi ve Çin'in üretim açısından rekabetini arttırmak, sanayileşme ve küreselleşmeyi artırmak, ülkeler arasındaki işbirliğini arttırmak, uzmanlaşma sağlamak OBOR Proje'sinin diğer ekonomik hedefleri arasındadır (Kopuk ve Bayraç, 2021: 1355-1356).

Türkiye OBOR Projesi'nin Çin ve Londra güzergâhları arasında alternatif güzergâh olarak yer almakta olup, Bakü-Tiflis-Kars hattı, Asya'dan gelen trenler Türkiye'ye Kafkasya üzerinden giriş yapmakta ve Marmaray Hattı'nın diğer demiryolu hatlarının bağlantılarını sağlayarak Avrupa'daki demiryollarına ulaşmaktadır (Özkan ve Ay: 2020: 355-356). OBOR Projesi'nin Çin, Türkiye ve Türk Cumhuriyetleri ile güzergahındaki diğer ülkeler arasında ulaştırma, enerji, ticaret, kültür ve turizm alanlarında işbirliğini geliştireceği ve yabancı sermayeyi çekeceği değerlendirilmektedir (Tuerdi, 2018: 4-7).

Çalışmada, "Bir Kuşak Bir Yol (OBOR) Projesi" ile ilgili literatür araştırması yapılmış, kapsamı ve rotaları, OBOR Projesi'nin Türkiye ve Türk Cumhuriyetleri ilişkilerine potansiyel etkileri, Projeye ilişkin sorunlar incelenmiş, OBOR Projesi"nin güçlü ve zayıf yönleri ile fırsatlar ve tehditlerin ortaya konulması amacıyla "Güçlü ve Zayıf Yönler, Fırsatlar ve Tehditler (SWOT) Analiz Yöntemi kullanılmış olup, Proje'nin Türkiye ve Türk Cumhuriyetleri'ne sağlayacağı faydalar açısından genel bir değerlendirme yapılmıştır.

2. LİTERATÜR ARAŞTIRMASI

Türkiye ile Türk Cumhuriyetleri arasındaki dış ticaret ilişkilerinin incelenmesi ile ilgili literatürde birçok çalışma yapılmıştır (Okur, 2017: 52). OBOR Projesi'nin Çin'i Avrupa ve Ortadoğu'ya karadan taşıyacak en güvenli güzergahın, Türk ve Müslüman nüfusun yoğun olduğu "Orta Koridor" olduğunu, bu kapsamda Çin'in Türkiye yoluyla Avrupa ve Ortadoğu'ya güvenle ulaştıracak bir uzun vadeli bir Uygur politikasına ihtiyaç olduğu belirtilmektedir. OBOR Projesi ile oluşturulacak büyük pazarın güzergahı üzerindeki ülkelerin karşılıklı yararını ve işbirliğini sağlayacağı ve sözkonusu ülkelerin ekonomilerine katkı sağlayacağını belirtmektedir (Durdular, 2016: 94).

Golovko (2009) Avrasya ülkelerinin bağımsızlıklarını aldıktan sonraki dış ticaretlerini çekim modeli yöntemi ile incelemiştir. Analiz sonucunda Avrasya ülkelerinin, küçük ve benzer olmaları nedeniyle çekim modelinin yetersiz kaldığı, kendi aralarında ihracat yaparak büyümeyecekleri sonucuna varılmış olup, Avrasya ülkelerinin dış ticaretlerini geliştirmesi için gelişme stratejilerinin tespit edilerek uygulanması, ticaretin serbestleştirilmesi ve kaynakların ham madde yerine işlenmiş olarak ihraç edilmesi gerektiğini vurgulamıştır (Golovko, 2009:16-17).

Türkiye ile Türk Cumhuriyetleri arasındaki dış ticaret pazara giriş yolları, girişimcilik, araştırma-geliştirme ve yenilikçi altyapının geliştirilmesi ve etkin bir bölgesel lojistik şebekesine ihtiyaç vardır (Yavuz vd, 2012: 35). Türk Cumhuriyetleri arasında ekonomik işbirliğinin arttırılmasına yönelik için sektörel bazda bir ortak politika oluşturulması, teşvik ve sigorta sisteminin geliştirilmesi önerilmektedir (Bal ve vd., 2009: 1-23); Alagöz, 2004: 72; Tuerdi, 2018:1-15) OBOR Projesi'nin Türkiye'nin Türkistan ve Kafkasya'da yer alan bölge ülkelerle işbirliğini daha fazla arttıracağını ve Türkiye'nin dış ticaret hacmini arttıracağı vurgulanmaktadır (Tuerdi, 2018:13). OBOR Projesi'nin Çin'den Avrupa'ya yüklerin daha kısa sürede ulaşması dışında Merkez Asya ülkelerinin karayolu, demiryolu, liman ve lojistik vb. altyapılarını geliştirmeleri açısından da bir fırsat yaratacağını ve bölgenin gelişmesine ve refahına katkı sağlayacağı öngörülmektedir (Imomnazar, 2018: 402).

Türkiye ile Türk Cumhuriyetleri arasındaki ticaretin tarihi, kültürel ve toplumsal geçmişe rağmen sözkonusu ülkelerin ekonomik açıdan büyük ölçüde Rusya'ya bağımlı olması ve bölge ülkelerinin piyasa ekonomisine tam olarak uyum sağlayamaması nedeniyle yeterli gelişememiştir (Yavuz vd., 2012:42). Ersungur (2007) Kazakistan'ın ticaretinde ülkeler arası ticaretin, Gayri Safi Milli Hasıla (GSMH) büyüklükleri ile doğru ve coğrafi uzaklık ile ters orantılı olan Çekim Modeli nedeniyle komşu ülkelerinin payının yüksek olduğunu belirtmektedir (Ersungur, 2007:297); Keskin (2018) Türkmenistan Hükümeti'nin yabancı yatırımcı için bazı kısıtlamalar getirmesi ve ithalatta ağır gümrük vergileri uygulamasına karşın, Türk yatırımcıların, altyapı, imalat sektörü, kimyasal ürünler ve pamuk işleme sanayi gibi öncelikli alanlara yatırım yaptıklarında gümrük vergisinden muaf olabileceğini ve teşviklerden faydalanabileceğini vurgulamaktadır Keskin, 2018:421).

Çin yeni ihracat pazarları keşfetmeyi hedeflemekte olup, dışarıya yaptığı yatırımlar ile yerli sermaye sorununu çözerek ülke içindeki kapasite fazlası üretimin de tüketilmesini sağlayacaktır. Ayrıca, Çin OBOR Projesi kapsamındaki güzergahlar üzerinde yer alan enerji zengini ülkeler aracılığı ile enerji kaynaklarına erişimi kolaylaştırmayı hedeflemektedir (Tutar ve Koçer, 2019: 621). Türk Cumhuriyetlerinin coğrafi olarak, OBOR Projesi'nin birinci çemberinde yer aldığını ve projedeki olumsuzlukların en fazla söz konusu ülkelerin etkileyeceği belirtmektedir (Bocutoğlu, 2017:268-269). Modern İpek Yolu Projesi'nin Türkiye ile bu Türk Cumhuriyetler arasındaki işbirliğini geliştireceğini öngörülmektedir (Seyidoğlu, 2014:215).

Kalaycı (2013) Türkiye'nin OBOR Projesi'ne ilişkin "Tarihsel İpek Yolu" güzergâhlarını ve buradaki yerleşim yerlerini belirlemek, ulaşım hatlarını ve bunlar üzerindeki üzerindeki köprü, liman, pazar vb. yerleri tesis etmek; güzergah üzerindeki ülkelerle ortak stratejiler geliştirmek, serbest ticaret bölgeleri oluşturmak, deniz ticaretini ve taşımacılığını daha da geliştirmek, ticareti kolaylaştırmak ve bu bölgelerde serbest dolaşım hakkı tanımak gibi hususlara ilişkin stratejiler geliştirilmesinin gerektiğini belirtmiştir (Kalaycı, 2013:109-118).

3. BİR KUŞAK BİR YOL (OBOR) PROJESİ

3.1 Bir Kuşak Bir Yol Projesi'nin Kapsamı ve Rotaları

Orta Asya ve Güney Asya, tarihi İpek Yolu'nun birleştirdiği iki bölge olup, tarih boyunca sözkonusu iki bölge arasında yüksek düzeyde kültürel etkileşim olmuştur. Orta Asya cumhuriyetlerinin bağımsızlığına kavuşmasından sonra İpek Yolu yeniden canlanmıştır. Orta Asya Türk Cumhuriyetlerinin ekonomik olarak gelişmesi ve dünya ile entegrasyonun sağlanması amacıyla yeni ulaşım projeleri başlatılmıştır (Purtaş, 2011: 59). Çin, OBOR Projesi ile eski İpek Yolu'nu yeniden canlandırmayı amaçlamaktadır. Söz konusu Proje ile İpek Yolu üzerindeki Orta Asya ülkelerinin (Kazakistan, Kırgızistan, Özbekistan, Tacikistan ve Türkmenistan vb.) demiryolları ile lojistik bağlantılarının sağlanması ekonomilerinin yeniden canlandırılmasıdır (Tuerdi, 2018:3). Çin söz konuusu proje kapsamında inşaat, enerji, ulaşım ve sanayi alanlarına büyük yatırımlar yapılmıştır. Projenin karayolu, demiryolu ve havayolu güzergahı Çin'den başlayarak Hollanda'ya kadar uzanmaktadır (Çekerol, 2017:144).

OBOR Projesi siyasi ve ticari fırsatlar sunmaktadır. Çin, Sovyet Sosyalist Cumhuriyetler Birliği (SSCB)'nin dağılmasıyla yeni bağımsız olan Orta Asya ülkelerinin hepsini tanımış olup, bu ülkelerle siyasi ilişkilerini geliştirmiştir. Çin Halk Cumhuriyeti söz konusu devletler arasında sınır sorunlarını çözmek ve kendisi ve yakın bölgesindeki ülkelerin iktisadi şartlarını iyileştirme amacıyla Rusya Federasyonu, Kazakistan, Kırgızistan, Tacikistan ile 1996 yılında Şanghay İşbirliği Örgütü'nü (Shanghai Cooperation Organisation-SCO) oluşturmuş olup, 2001 yılında Özbekistan, 2017 yılında Hindistan ve Pakistan ve 2021'de İran SCO'ya katılmıştır. Çin; Tacikistan, Kırgızistan ve Özbekistan ile "kapsamlı stratejik ortaklık" anlaşmalarını imzalamıştır.

Orta Asya ülkelerinin coğrafyası, alt yapı sorunları, denize direk bir ulaşımın olmaması gibi sorunları mevcuttur. Çin hükümeti oluşan bu ekonomik boşluğu iyi değerlendirerek siyasi ilişkilerin yanında ticari ilişkilerini de geliştirmiştir. Söz konusu bölgede doğal kaynakların olması, Orta Doğu, Güney Asya ve Avrupa'ya alternatif bir yol olma ihtimali Orta Asya'yı cazip hale getirmiştir. Çin, petrol vb. yatırımlarla özellikle Kazakistan, Özbekistan ve Türkmenistan'ın büyük dış ticaret ortağı haline gelmiştir. Uuluslararası yatırımcılar ve OBOR Projesi kapsamında temin edilen krediler sayesinde enerji, alt yapı ve lojistik projeleri hayata geçirmiştir (TUIC Akademi, 2021).

İpek Yolunun Canlandırılması olan OBOR Projesi kapsamında yeni tren yolları, yeni limanlar, yeni otoyolları, telekomünikasyon alt yapısının iyileştirilmesi, enerji-maden çalışmalarının yapılması bulunmaktadır. OBOR Projesi'nde birden fazla alt güzergâhların olduğu bilinmektedir. Bunlardan bir tanesi Çin-Moğolistan-Rusya güzergâhıdır. En çok rağbet görüleni ise Çin-Kazakistan-Rusya-Belarus üzerinden Avrupa'ya ulaşan güzergâhtır. Bir de tarihi olan Çin-Orta Asya-İran ve orta koridor olarak nitelendirilen Türkiye üzerinden Avrupa'ya ulaşan güzergâhtır.

Çin Halk Cumhuriyeti'nin 28 Mart 2015 tarihli "İpek Yolu Ekonomi Kuşağı ile 21. Yüzyıl Deniz İpek Yolunun Ortaklaşa İnşa Edilmesini Teşvik Üzerine Vizyon ve Faaliyetler" bildirgesine göre OBOR Projesi barış ilkesini desteklemekte, tüm ülkelerin katılımına açık, karşılıklı fayda gözetilen, piyasa kuralları ve uluslararası düzenlemelere ile uyumlu bir pazarı içermektedir. Söz konusu Proje Asya, Avrupa ve Afrika'yı kara ve deniz yoluyla birbirine bağlamayı hedeflemektedir (Durdular 2016: 80; Ticaret Bakanlığı, 2019). OBOR Projesi'nin deniz güzergahı Çin'den Vietnam, Malezya, Endonezya, Sri Lanka, Hindistan, Kenya, Yunanistan ve İtalya vasıtasıyla Avrupa'ya ulaşmak için birçok yatırım yapılmıştır (Kalaycı, 2013: 102). Bu kapsamda Çin şirketi China

Ocean Shipping Company (COSCO) Akdeniz limanlarında önemli proje ve ortaklıklara imza atmıştır. Pire limanının 2008 yılında COSCO tarafından işletilmeye başlatılmasında sonra elleçleme miktarları oldukça artmıştır (Sabancı ve Yılmaz, 2021: 92-93; Kalaycı, 2013: 102).

OBOR Projesi ile ulaşımın Yeni Avrasya Kara Köprüsü Ekonomik Koridoru; Çin- Merkez ve Batı Asya; Çin- Moğolistan- Rusya, Çin- Hindi Çini Yarımadası; Çin- Bangladeş- Hindistan- Myanmar ve Çin- Pakistan gibi 6 koridorla gerçekleştirilmesi hedeflenmektedir (Özsümer, 2018:7). Türkiye Cumhuriyetleri sözkonusu Proje'nin güzergahında olup, jeopolitik önemi haizdir. Bahsi geçen Proje'nin Türkiye'den geçen rotası İstanbul, Bursa, İznik, Antakya, Konya, Adana, Ayas, Tarsus, İskenderun, Antep, Maraş, Kayseri, Sivas, Erzurum, Erzincan ve Trabzon şehirlerini, nehir rotası ise Fırat ve Dicle nehirlerini kapsamaktadır. Sözkonusu Proje'nin Türk Cumhuriyetleri'nden geçecek rotaları ise Türkmenistan (Merv, Köhne Ürgenç, Özbekistan (Buhârâ, Semerkand, Taşkent, Şehrisabz), Kazakistan (Türkistan), Kırgızistan ve Tacikistan'dır (Kalaycı, 2013: 91).

OBOR Projesi ile kara yolu ve deniz yolu hatları oluşturulacaktır. Bunlardan ilki Çin'den Avrupa'ya kadar olan ülkeleri birbirine bağlayan "İpek Yolu Ekonomik Kuşağı" olarak adlandırılan kara hattıdır (Tuerdi, 2018: 3; MCBRIDE, 2015). Yeni İpek Yolu'nun kara bağlantısı güzergah üzerindeki kara yolu, demir yolu, hava ve deniz limanları, endüstriyel parklar doğalgaz hatları, Avrasya Kara Köprüleri gibi koridorlar ve diğer altyapı projelerini kapsamaktadır. Sözkonusu Proje'nin "Deniz İpek Yolu" olarak adlandırılan denizyolu bağlantısı ise Çin'i Hint Okyanusu ile Akdeniz ve Basra Körfezi'ni bağlayacak olup, güzergah üzerindeki büyük limanların ulaşım koridoruna entegre edilecektir (Tuerdi, 2018: 4; Durdular 2016:82).

OBOR Projesi'nin başlıca ana güzergahları şunlardır: Birincisi, Avrupa'ya ulaşan Doğu Türkistan-Kazakistan-Rusya-Beyaz Rusya güzergahıdır. Diğerleri, Avrupa'ya uzanan Doğu Türkistan-Kazakistan-Azerbaycan-Gürcistan-Türkiye-Balkanlar güzergahı, Doğu Türkistan'dan başlayarak Batı Türkistan'daki Türk Cumhuriyetleri'nden geçen çeşitli rotalardan oluşan güzergah ya da Pakistan üzerinden İran'a ve Ortadoğu'ya bağlanan güzergahdır. Ayrıca, Kaşgar'dan Pakistan'ın Gwadar limanına uzanan güzergahdır (Okur 2017: 51).

OBOR Projesi'nin 68'den fazla ülkeyi kapsayacağı, küresel ekonomi kapasitesinin %30'unu, Dünya Gayri Safi Yurtiçi Hasıla'nın %55'i, dünya nüfusunun yaklaşık %70'ini, küresel enerji kaynaklarının yaklaşık %75'ini içerdiği belirtilmektedir (Imomnazar 2018:397). OBOR Projesi'nin finansmanının 50 milyar ABD Dolar'lık kısmının "İpek Yolu

Fonu'ndan (Silk Road Fund), altyapı yatırımları için 100 milyar ABD Dolar'lık kısmının ise Asya Kalkınma Bankası'ndan (The Asian Development Bank) karşılanacağı belirtilmektedir (Imomnazar 2018:398).

3.2. Bir Kuşak Bir Yol Projesi'ne İlişkin Sorunlar

"Bir Kuşak Bir Yol (OBOR) Projesi"ne ilişkin birçok sorun bulunmaktadır. Başlıca sorunlar aşağıda belirtilmektedir (Durdular 2016:86-92; Ticaret Bakanlığı, 2019; Tuerdi, 2018: 10-11).

- Proje güzergâhı üzerindeki ülkelerin siyasi istikrarsızlıkları, sınır anlaşmazlıkları gibi iç sorunları, bu ülkelerin kendi aralarındaki sorunlar;
- Sözkonusu ülkelerin altyapı sorunları, bahsi geçen ülkeler arasındaki dış ticaret açığı;
- Yeterli şeffaflık olmaması ve yerel uygulama farklılıkları gibi mevzuattan kaynaklanan sorunlar;
- Çin'den ithal eden ürünlere uygulanan anti-damping uygulamaları;
- Bölge ülkelerinin ucuz Çin mallarının pazarda egemen olmasına ilişkin endişeler;
- ABD'nin bölge ülkelerinde ticari gücünün azalabileceğinden dolayı Projenin ABD ve Rusya ilişkilerini olumsuz etkileyebileceği endişesiyle bu ülkelerin projeye olumsuz yaklaşımları;
- Çinli şirketlerin uluslararsı ticaret konusunda yeterli tecrübeye sahip olmamaları ve uluslararasılaşmamış olması;
- İhracata uygun standarların uygulanmaması;
- Fikri mülkiyet haklarının ihlali ve taklitçilik;
- Proje güzegahında yer alan diğer ülkelerin projeye gerekli desteği vermemesi;
- Yüksek işletim maliyetleri;
- Güzergâh üzerindeki ülkelerin bazılarının projeyi Çin'in politikası olarak görmesi ve bazı ülkelerin de kendi içişlerine müdahale olarak algılaması;
- Söz konusu ülkelerin jeopolitik stratejilerindeki farklılıklar.

Ortadoğu'daki çatışma riski OBOR Projesi'nin güney rotasını da riskli hale getirmektedir. Sözkonusu risklerden dolayı en güvenli güzergahın "Orta Koridor" olduğu görülmektedir (Okur, 2017: 52). Orta koridor bir enerji koridoru olup, hem Avrupa-Asya arasında enerji akışını temin etmeyi hem de bölge ülkeleri arasındaki siyasi sorunları azaltmayı amaçlamaktadır. Güney koridorda özellikle Afrika'da altyapı yatırımları yapılmakta ve yeni ekonomik bölgeler oluşturulmaktadır (DEİK, 2023). Söz konusu Proje güzergâhı üzerindeki ülkelerin güvenli ve etkin bir ağ oluşturabilmesi için kara-deniz-hava altyapısını geliştirmesi, ticaret ve yatırımı kolaylaştırması, serbest bölgelerin oluşturulması ve ülkeler arasındaki siyasi güveni daha fazla tesis edilmesini gerekmektedir. Sözkonusu Proje'ye ilişkin bir diğer sorunda uzun mesafe karayolları, demiryolları ve güzergah üzerindeki havalanları, köprüler ve limanlar için güvenlik riski taşıyabilir (Imomnazar, 2018:402).

OBOR Projesi güzergahı üzerinde yer alan ülkelerden bazılarının düşük kredi derecelerine sahip olmasının Çin'i finansal açıdan etkilemesi, Projede yer alan Orta Doğu ülkelerindeki istikrarsızlığın risk oluşturması, Orta ve uzun dönemde Çin ekonomik nüfuzunun artması, para ve malların ve işgücünün serbest dolaşımı ve Türk Cumhuriyetlerin nüfus dengesini bozma potansiyelini taşıması Proje'ye ilişkin diğer sorunları oluşturmaktadır (Bocutoğlu, 2017:67-269). OBOR Projesi başta Çin, İran ve Pakistan olmak üzere 60'ın üzerinde ülke desteklemesine rağmen, siyasi ve ekonomik nedenlerden dolayı Japonya, ve ABD Proje'yi desteklememektedir. Bahsi geçen Projenin AB ülkeleri aleyhine haksız rekabete yol açacabileceğini değerlendirmesi ve söz konusu ülkeler ile dış politika konusunda bir ortaklık olmaması gibi nedenlerden dolayı Avrupa Birliği Proje konusunda çekimser kalmakla birlikte Projeden doğacak fırsatları da değerlendirmek istemektedir**.** Rusya projenin uzun vadede jeopolitik sonuçları nedeniyle çekimser kalmaktadır (Bocutoğlu, 2017:267).

Covid-19 pandemisi nedeniyle OBOR Projesi'ne ilişkin 2021 yılında yapılan yatırımların maliyeti, enerji başta olmak üzere 476 milyar dolar olarak olup, 2015 yılına göre %21 oranında azalmıştır. Çin firmalarının çoğunlukla Çinli işçileri çalıştırması, endüstriyel kapasiteyi arttıracak yatırımlar yapmamasının halkın tepkisini çekmesi nedeniyle Çin istihdam ve kapasiteyi artıran ve çevre dostu yatırımlar yapmaya başlamıştır (Şener ve Sugözü, 2022:5). Orta Asya ülkeleri Rusya'nın öncülüğünde oluşturulan birçok ekonomik, siyasi ve askerî birliğin üyesi olması nedeniyle Rusya-Ukrayna savaşından öncelikle etkilenen bölgeler olup, savaş sürecinde genel olarak tarafsız kalmışlardır. Söz konusu savaş nedeniyle Rusya'ya yaptırımlar öncelikli Rusya olmak üzere, bölge ülkelerde ve küresel ekonomide büyük sorunlara neden olmuştur (Buyar ve Şener, 2022: 141-143).

4. METODOLOJİ

Çalışmada literatür taraması sonucu incelenen makaleler ve çalışmalar değerlendirilerek OBOR Projesi'nin iç etkenler olan güçlü ve zayıf yönleri ile dış etkenler olan fırsatlar ve tehditlerin ortaya konulması amacıyla "Güçlü ve Zayıf Yönler, Fırsatlar ve Tehditler (Strenghts, Weaknesses Opportunities, Threats (SWOT)) Analiz Yöntemi kullanılmıştır. SWOT Analizi; işletmenin güçlü-zayıf yönler ile fırsat ve tehditleri analiz ederek gelecek için stratejiler geliştirmeyi ifade eder (Yeşiltaş, 2019:252). Güçlü yönler işletmenin iç ortamının analizi ile ortaya çıkan ve rakiplere karşı üstünlük sağlayan varlık ve yeteneklerini kapsamaktadır. Zayıf yönler işletmenin belirli amaçlara ulaşmasını engelleyen, mevcut varlık ve yeteneklerin daha güçsüz ve düşük olduğu durumlardır. Fırsatlar, işletme için olumlu sonuçlar yaratabilecek dış çevrenin ve yakın çevrenin analizi sonucundan çıkan politik, teknolojik, hukuki, sosyokültürel, uluslararası çevre, müşteriler, demografik, tedarikçiler ve rakiplerin statüsü gibi fırsat yaratan faktörlerdir. Tehditler, dış çevredeki değişimler sonucunda işletmenin belirli bir amaca ulaşmasında sorun oluşturan, varlığını sürdürememesine veya rekabette üstünlüğü kaybetmesine neden olabilecek durumlardır. (Çınar ve Oğuz, 2020:6; Kamilçelebi, 2012: 45-54). "Bir Kuşak Bir Yol Projesi nin güçlü ve zayıf yönleri ile fırsatlar ve tehditleri ortaya koyan SWOT Analizi Tablo 1 ve Tablo 2'de verilmiştir.

Tablo 1. Bir Kuşak Bir Yol Projesi'nin Güçlü ve Zayıf Yönleri

Güçlü Yanlar	**Zayıf Yönler**
Orta Asya ve Güney Asya'nın tarihi İpek Yolu'nun birleştirdiği iki bölge olması	OBOR Projesi güzergahı üzerindeki ülkelerin etkin bir bölgesel lojistik şebekesi ihtiyacı
Çin'in, dünyanın ikinci büyük ticaret hacmine sahip ekonomisi olması	Orta Asya ülkelerinin coğrafyası, alt yapı yetersizliği, denize direk bir ulaşımın olmaması
Yüklerin Çin'den Avrupa'ya daha kısa sürede ulaşması	OBOR Projesi güzergahı üzerindeki ülkelerin ticaret pazarına giriş yolları, girişimcilik, araştırma-geliştirmeyi geliştirme ihtiyacı
Çin'in yeni ihracat pazarları keşfetmeyi hedeflemesi	Türkmenistan Hükümeti'nin yabancı yatırımcı için bazı kısıtlamalar getirmesi ve ithalatta ağır gümrük vergilerinin uygulaması
Enerji kaynaklarına erişimin kolaylaşması	Dış ticaret vb. mevzuatından kaynaklanan sorunlar
Söz konusu bölgede yeni ulaşım projelerinin başlatılması	Çin'den ithal eden ürünlere uygulanan anti-damping uygulamaları
Bakü-Tiflis-Kars hattı, Asya'dan gelen trenler ve Marmaray Hattı vasıtasıyla Avrupa'daki	Çinli şirketlerin uluslararsı ticaret konusunda yeterli tecrübeye sahip olmaması

demiryollarına ulaşılması	
Çin'in OBOR Projesi kapsamında inşaat, enerji, ulaşım ve sanayi alanlarına büyük yatırım yapması	Proje güzegahında yer alan diğer ülkelerin projeye gerekli desteği vermemesi
Projenin karayolu, demiryolu ve havayolu güzergahının Çin'den başlayarak Hollanda'ya kadar uzanması	OBOR Projesi'ne dahil olan ülkeler arasında ekonomik gelişmişlik düzeyinde dengesizliğin Çin'in bölgedeki yatırımlarını zorlaştırılması
OBOR Projesi güzergahındaki ülkelerin küresel enerji kaynaklarının yaklaşık %75'ine sahip olması	Söz konusu ülkelerin jeopolitik stratejilerindeki farklılıklar
OBOR Projesi'nin Orta Doğu, Güney Asya ve Avrupa'ya alternatif bir yol olması	
Güçlü Yanlar	**Zayıf Yönler**
Tüm ülkelerin katılımına açık, karşılıklı fayda gözetilen, piyasa kuralları ve uluslararası düzenlemelere ile uyumlu bir pazarı içermesi	
Çin'in istihdam ve kapasiteyi artıran ve çevre dostu yatırımlar yapması	
Ticaret hacmini arttırması, mal, hizmet ve işgücünün dolaşımını kolaylaştırması	
Bölgelerin refahını ve istihdamı arttırması	
Söz konusu ülkelerin ekonomik kalkınması ve kültürel refahına katkı sağlaması	
Asya, Avrupa ve Afrika'yı kara ve deniz yoluyla birbirine bağlaması	

OBOR Projesi'nin başlıca güçlü yönleri; Orta Asya ve Güney Asya'nın tarihi İpek Yolu'nun birleştirdiği iki bölge olması, Çin'in, ticaret hacmiyle dünyanın ikinci büyük ticaret hacmine sahip olması, enerji kaynaklarına erişimin kolaylaşması, ticaret hacmini arttırmasıdır. OBOR Projesi'nin başlıca zayıf yönleri; Orta Asya ülkelerinin coğrafyası, alt yapı yetersizliği, denize direk bir ulaşımın olmaması ve Çin'den ithal eden ürünlere uygulanan anti-damping uygulamalarıdır.

Tablo 2. Bir Kuşak Bir Yol Projesi'ne İlişkin Fırsatlar ve Tehditler

Fırsatlar	**Tehditler**
Orta Asya ülkelerinin ulaşım ve enerji ağları ile ekonomilerini yeniden canlandırmak	OBOR Projesi'ni kapsayan uzun mesafe karayolları, demiryolları ve güzergah üzerindeki havalanları, köprüler ve limanlar için güvenlik riski
Barış ilkesini desteklemek	OBOR Projesi'nde yer alan Orta Doğu ülkelerindeki istikrarsızlık
Çin ile Avrupa arasındaki ticareti geliştirmek	Rusya-Ukrayna Savaşı'nın OBOR Projesi'ne olumsuz etkileri
Sermaye transferini kolaylaştırarak üretimi arttırmak	AB ve ABD'nin OBOR Projesini desteklememesi ve Rusya'nın çekimser kalması
Ekonomik büyümeyi ve Çin'in üretime ilişkin rekabetini arttırmak	Çin'in bölgesel nüfuzunu artırma ihtimalinden dolayı endişe duyulması
Fırsatlar	Tehditler
Sanayileşme ve küreselleşmeyi arttırmak	Bölgesel güvenlik sorunları
Ülkeler arasındaki işbirliğini arttırmak	OBOR Proje güzergâhı üzerindeki ülkelerin siyasi istikrarsızlıkları, sınır anlaşmazlıkları ve bu ülkelerin kendi aralarındaki sorunlar
Uzmanlaşmayı sağlamak	
OBOR Projesi güzergahı üzerindeki ülkelerle karşılıklı yarar ve işbirliği sağlamak	
OBOR Projesi güzergahı üzerindeki ülkelerin ekonomilerine katkı sağlamak	
OBOR Projesi'nin Türkiye'nin Türkistan ve Kafkasya'da yer alan bölge ülkelerle işbirliğini ve Türkiye'nin dış ticaret hacmini arttırmak	
OBOR Projesi'nin Merkez Asya ülkelerinin karayolu, demiryolu, liman ve lojistik altyapılarını geliştirme imkanı sağlamak	
Bölgenin gelişmesine ve refahına katkı sağlamak	
Türkiye ile Asya ülkelerinin ticaretinde iki bölge arasındaki ulaşımı kolaylaştırılmak	
Yabancı sermayeyi çekmek	

OBOR Projesi güzergahları ile yüklerin Çin'den Avrupa'ya daha kısa sürede ulaşmasını sağlamak	
Sosyal ve kültürel çalışmalara destek sağlamak	
OBOR Projesi kapsamındaki birçok limanın işletmesi ve geliştirilmesi için olanaklar sağlamak	

OBOR Projesi için başlıca fırsatlar; Orta Asya ülkelerinin ulaşım ve enerji ağları ile ekonomilerini yeniden canlandırmak, Çin ile Avrupa arasındaki ticareti geliştirmek, sanayileşme ve küreselleşmeyi arttırmak, OBOR Projesi güzergahı üzerindeki ülkelerin ekonomilerine katkı sağlamak, bölgenin gelişmesine ve refahına katkı sağlamaktır. OBOR Projesi için başlıca tehditler; OBOR Projesi güzergâhı üzerindeki ülkelerin siyasi istikrarsızlıkları, sınır anlaşmazlıkları ve bu ülkelerin kendi aralarındaki sorunlar ve Rusya-Ukrayna Savaşı'nın OBOR Projesi'ne olumsuz etkileridir.

5. Bir Kuşak-Bir Yol Projesi'nin Türkiye ve Türk Cumhuriyetleri İlişkilerine Potansiyel Etkileri

"Bir Kuşak-Bir Yol (OBOR) Projesi" güzergâhında yer alan ülkelerin ortak çıkarlarına dayanmakta olup, Çin'e yapacağı katkılar dışında Türkiye ve Türk Cumhuriyetleri ile güzergah üzerindeki diğer ülkeler açısından birçok fayda sağlayacağı beklenmektedir. Sözkonusu Proje'nin bahsi geçen ülkeler arasındaki ekonomik ilişkileri güçlendireceği, ticaret hacmini arttıracağı, mal, hizmet ve işgücünün dolaşımını kolaylaştırması, bölgelerin refahını arttıracağı, yeni istihdam alanları açarak istihdamı arttıracağı, sözkonusu ülkelerin ekonomik kalkınmasına ve kültürel refahına katkı sağlayacağı, bölge halkları arasında kültürel bağlantıları kuvvetlendireceği düşünülmektedir (Tuerdi, 2018: 4).

Türkiye'nin dış ticaret rakamları analiz edildiğinde Türkiye ile Asya ülkelerinin ticaretinde iki bölge arasındaki ulaşım yetersiz ve oldukça maliyetlidir. Projenin hayata geçmesiyle birlikte Türkiye Batı, Orta ve Güney Asya pazarına rahatça ulaşabilecek ve hammaddeleri daha ucuza karşılama imkânı bulabilecektir (Tuerdi, 2018: 6-9). Lojistik, Ar-Ge, üretim ve lojistik alanlarında yapılacak etkin çalışmalarla, OBAR Projesi ile Türkiye'nin genel ihracatında %15 artış olacağı öngörülmektedir (DEİK, 2023). Ayrıca, Proje güzergahındaki ülkelerin sanayisi gelişecek, uzmanlaşma sağlanacak ve pazar payları artacaktır (Tuerdi, 2018: 4-7).

OBOR Projesi çerçevesinde Çin; Türkiye ve Türk Cumhuriyetleri ile güzergahındaki diğer ülkeler arasında ulaştırma, enerji, ticaret, kültür ve turizm alanlarında, işbirliğini geliştirecek ve yabancı sermayeyi çekecektir. Çin, Rusya ile Kuzey Koridoru, İran ile Güney Koridoru ve Türkiye ile Orta Asya'yı bağlayan Orta Koridoru oluşturmayı hedeflemektedir. Orta Koridor geçişlerinden bir diğeri de, Türkiye-Gürcistan, Azerbaycan,Türkmenistan ve Afganistan transit ulaştırma koridorudur (Tuerdi, 2018: 4-7). Orta koridor ticari ilişkilerini geliştirecektir. OBOR Projesi'nin aynı zamanda bölgesel ve dolayısıyla küresel barışa katkı sağlayacağı düşünülmektedir.

Kazakistan; coğrafi konumunun genişliği, Orta Asya Cumhuriyetlerini Karadeniz ve Kafkasya üzerinden Avrupa'ya bağlamayı amaçlayan Avrupa Birliği (AB) tarafından oluşturulan bir Doğu-Batı Koridoru olan "Avrupa Kafkasya Asya Ulaştırma Koridoru (TRACECA)" ve Çin ve Batı Avrupa arasındaki karayolu bağlantısı projeleri nedeniyle bölgede önemli bir lojistik merkezi olma ve Uzakdoğu ile Avrupa arasındaki büyük miktarlarda yük taşımacılığı gerçekleştirme potansiyeline sahiptir (Çekerol, 2017:158).

OBOR Projesi, Uluslararası Türkmenbaşı Limanı'nın (Turkmenbashi International Port) açılması bir fırsat yaratmıştır. OBOR Projesi'nin hayata geçmesiyle birlikte Turkmenbashi Limanı'ndan Merkez Asya'da yer alan Çin, Japonya, Kore Limanlarından İran ve Azerbaycan Limanlarına kadar denizyolu ile yük taşımacılığı gerçekleştirilecektir (Imomnazar, 2018:401). Sözkonusu rota ile yükler Çin'den Avrupa'ya daha kısa sürede ulaşacak olup, demiryolu taşımacılığı deniz yolu taşımacılığından iki katı hızlı olup, 15 gün süre alması beklenmektedir. Böylece, sözkonusu Proje ile yerel kaynaklar dünya pazarlarına ulaşabilecek, yeni altyapı yatırımları hızlandırabilecek, ilgili ülkelerin lojistik ve liman altyapısı ile sektörleri ve dolayısıyla bölgesel ve ulusal ekonomileri gelişecektir. Türkmenistan-Afganistan-Tacikistan uluslararası demiryolu Çin, Hindistan ve Pakistan ile birleşecektir (Imomnazar, 2018:402). Söz konusu Proje Türkiye'nin Türk Cumhuriyetler üzerinden Çin'e bağlanması imkanını sağlayacaktır. Bu kapsamda Çin Azerbaycan ile OBOR Projesi kapsamında yakın işbirliği yapmaktadır (Bocutoğlu, 2017:268).

OBOR Projesi ile 234 demiryolu hubları ve bunlarla bağlantılı Avrasya Kara Köprüleri, Deniz İpekyolu güzergahı üzerinde yer alan yaklaşık 600.000 gemiye hizmet verecek şekilde 2.378 liman tasarlanmaktadır. Sözkonusu Proje güzergahında küresel tedarik zinciri için altyapının geliştirilmesi ve bölgesel işbirlikleri ve firmalar arası işbirliği için strateji planının geliştirilmesi gerekmektedir (Lee, P.Tae-Woo vd, 2017:294). Pekin ve Londra'yı birbirine bağlayacak olan demir yolunun orta kuşağında yer alan 30 Ekim 2017'de açılan Bakü-Tiflis-Kars demir yolu ve 29 Ekim 2013'de açılan Marmara Denizi Tüp Geçidi Projenin önemli halkalarıdır. Türkiye söz konusu Proje sayesinde Çin'de daha fazla yatırım yapma imkanına da sahip olacak, istihdam ve ekonomik büyümeye de katkı sağlayacaktır (Seyidoğlu ve Gönültaş, 2014:207).

OBOR Projesi, Türkiye ve Türk Cumhuriyetleri ile diğer ülkeler arasında daha serbest bir ticaretin oluşturulmasını, yeni işbirliklerini, sermaye, mal ve hizmetler akışının kolaylaştırılmasını ve yeni pazarlara entegrasyonun sağlanmasını sağlayacak olup, ayrıca sosyal ve kültürel çalışmaları da destekleyecektir (Özsümer, 2018:7). Çin'in Türkiye'yi yatırım yapılacak bir ülke olarak görmesini sağlamak, Türkiye'nin Çin ile birlikte teknoloji geliştirmesi ve üretmesi, Türkiye'nin bir lojistik merkezi haline gelmesini sağlamak ve Çin ile başka pazarlara girilmesi Türkiye açısından OBOR Projesi'nin sağlayacağı fırsatlar olarak değerlendirilmektedir. Ayrıca, Mersin ve İskenderun gibi yüksek kapasiteli Akdeniz limanları, Deniz İpek Yolu planlarının bir parçası haline getirilebilir (DEİK, 2023).

6. SONUÇ VE DEĞERLENDİRME

"Bir Kuşak Bir Yol (OBOR) Projesi" kapsamındaki ülkeler arasında işbirliğine dayalı olup, Proje güzergahı üzerindeki ülkelerin birbirleriyle yakın işbirliği içerisinde olması ve ortak fayda sağlamalarının uygun olacağı düşünülmektedir. OBOR Projesi kapsamında güzergah üzerindeki ülkelerin altyapısını ve bölgesel işbirliğinin geliştiilmesi, firmaların uluslararası tecrübelerinin arttırılması, sözkonusu ülkeler arasında doğru ve tam bilgi akışının sağlanması gerekmektedir. Türkiye'nin tarihi ve kültürel bağlarının bulunduğu Türk Cumhuriyetleri ile kültürel ve ekonomik ilişkilerini geliştirmesi, çeşitli alanlarda işbirliği yapması, serbest ticaret bölgeleri oluşturması, ortak yatırımların yapılması önem arz etmektedir. Türkiye ve Türk cumhuriyetlerinin ekonomik ve ticari açıdan işbirliğini ve karşılaştırmalı üstünlükler teorisine göre endüstrilerini geliştirmelesinin uygun olacağı düşünülmektedir.

Tarihi İpek Yolu TRACECA, Asya Otoyolu, Trans-Asya Demiryolu gibi projelerin önemli bir bölümü Türkistan'dan geçmekte olup, Türkiye üzerinden Avrupa'ya ulaşmaktadır. OBOR Projesi Türkiye için birçok fırsat içermektedir. Türkiye, OBOR Projesi ile Türk Cumhuriyetler üzerinden Çin'e ve Avrupa'ya bağlanacaktır. Proje'nin Türk Cumhuriyetleri ile ticari, ekonomik ve kültürel ilişkileri arttıracağı, kombine taşımacılığı geliştireceği, ulaşım ve depolama maliyetlerini azaltacağı, lojistik sektörünü geliştireceği, bölge ülkelerinin ekonomisi, sanayisi, istihdamı ve refahına büyük bir katkı sağlayacağı düşünülmektedir.

Türkiye'nin OBOR Projesi çerçevesinde Avrupa ile bağlantısının sağlanarak Proje kapsamında konumlandırılması için Çin ile birlikte teknoloji geliştirmesi ve üretmesi, bir lojistik merkezi haline gelmesi, kombine ve intermodal taşımacılığın geliştirilmesi, Mersin, İskenderun, Samsun gibi limanlara gerekli yatırımlar yapılarak COSCO gibi Çin küresel konteyner operatörleri için cazip hale getirilmesi ve OBOR Projesi'nin denizyolu bağlantısına dahil edilmesi, OBOR Projesi yatırımlarına ilişkin gerekli finansman kaynaklarının bulunması, Türk Cumhuriyetleri ve Çin ile koordinasyon halinde Proje'ye ilişkin gerekli fizibilite çalışmalarının yapılmasının uygun olduğu düşünülmektedir. OBOR Projesi'ne ilişkin yeterli verilerin sağlanamaması çalışmanın kısıtları arasındadır. Çalışmada SWOT Analizi sonucu elde edilen OBOR Projesi güzergahındaki ülkelerin karayolu, demiryolu, liman ve lojistik altyapılarını geliştirme projeleri gibi bulgulara ilişkin gelecekte detaylı çalışmalar yapılması literatüre katkı sağlayacaktır.

KAYNAKÇA

Alagöz, M. Yapar, S. ve Uçtu, R. (2004), Türk Cumhuriyetleri İle İlişkilerimize Ekonomik Açıdan Bir Yaklaşım. *Selçuk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi* 12: 59-74.

Bal, G., Rüştü, Y. ve Karkacier, O. (2009), Türkiye-Türk Cumhuriyetleri Dış Ticaret İlişkilerine Genel Bir Bakış. *Gaziosmanpaşa Üniversitesi Sosyal Bilimler Araştırmaları Dergisi,* 4(1), 1-23.

Bocutoğlu, E. (2017). Çin'in "Bir Kuşak-Bir Yol" Projesinin Ekonomik ve Jeopolitik Sonuçları Üzerine Düşünceler. *In: Uluslaararası Avrasya Ekonomileri Konferansı, Session 1C: Bölgesel Çalışmalar*, İstanbul, Türkiye.

Buyar, C. ve Şener, U. (2022). Tarihi Perspektiften, Sosyo-Ekonomik Değerler Açısından Rusya-Ukrayna Savaşı ve Orta Asya Ülkelerine Etkileri. *Uluslararası Medeniyet Çalışmaları Dergisi,* 7(2), 136-149.

Çekerol, Gülsen Serap ve Gunyashev Elman (2017). Kazakistan Lojistik Sektörü ve Sektör Paydaşlarının Lojistik Köy ile İlgili Görüşlerinin SWOT Analizi ile Değerlendirilmesi. *Akademik Bakış Dergisi,* 60, 127-168.

Çınar, F. e Oğuz, M. (2020). Türkiye'nin COVİD-19 Pandemisine Yönelik Stratejilerinin SWOT Analizi ile Değerlendirilmesi. *Sağlık ve Sosyal Refah Araştırmaları Dergisi,* 2(2), 6.

Dış Ekonomik İlişkiler Kurulu (DEİK) (2023). DEİK, Türkiye'nin Kuşak ve Yol Girişimi'ndeki Konumunu 8 Farklı Senaryoyla Ortaya Koydu. https://www.deik.org.tr/basin-aciklamalari-deik-turkiye-nin-kusak-ve-yol-girisimi-ndeki-konumunu-8-farkli-senaryoyla-ortaya-koydu, Erişim Tarihi: 05.02.2023.

Durdular, Arzu (2016). Çin'in "Kuşak-Yol" Projesi ve Türkiye-Çin İlişkilerine Etkisi. *Avrasya Etüdleri*. 49(1): 77-97.

Ersungur, M., Kızıltan, A. ve Karabulut, K. (2007). Türkiye ile Diğer Türk Cumhuriyetlerinin Ekonomik İlişkilerinin Analizi. *A.Ü. Türkiyat Araştırmaları Enstitüsü Dergisi* 35, 285-310.

Golovko, A. (2009). Çekim Modeli: Avrasya Ülkelerinin Dış Ticareti. *Econ Anadolu 2009: Anadolu Uluslararası İktisat Kongresi.* Eskişehir, Türkiye.

Imomnazar, I. (2018). Impact of the "One Belt, One Road" project o the economy of Central Asian countries. *The Business and Management Review*, 9 (3): 396-403.

Kalaycı, İ. (2013). Deniz Ticareti ve Küresel Mali Kriz: İpek Yolu'nda Türkiye İçin Yeni Stratejiler. Avrasya Etüdleri 45(1), 87-122.

Kamilçelebi, H. (2012). Türkiye'de Sigorta Sektörünün SWOT Analizi ve Bir Araştırma. Ekonomi Bilimleri Dergisi, 4 (1), 45-54.

Keskin K. M. (2018). Türkiye İle Türkmenistan Arasındaki Ticari İlişkiler ve Finansal İşbirliğine Yönelik Bir Değerlendirme. *Diyalektolog Ulusal Sosyal Bilimler Dergisi* 19, 413-422.

Kopuk, E. ve Bayraç, H.N. (2021). Bir Kuşak Bir Yol Projesi ve Ekonomik Etkileri. *Alanya Academic Review Journal*, 5(3). 1353-1374.

Lee, P. Tae-Woo, Hu, Zhi-Hua, Lee, Sang-Jeong, Choi, Kyoung-Suk ve Sung-Ho Shin (2017). Research trends and agenda on the Belt and Road (B&R) initiative with a focus on maritime transport. *Maritime Policy & Management* 45 (3), 282-300.

Okur, M. A. (2017). "Bir Kuşak, Bir Yol" Projesi'nin Jeopolitiği Türk Kuşağı ve Uygurlar. *Akademik Hassasiyetler,* 4(8): 45-55.

Özkan, Ö. ve Ay, İ.C. (2020). Marmaray hattı'nın bir kuşak bir yol kapsamında değerlendirilmesi. *Journal of Anadolu Bil Vocational School of Higher Education*, 15(60), 353-362.

Özsümer, Sıla İzmir Ticaret Odası (2018). *Çin Ekonomisi ve Bir Yol Bir Kuşak Projesi*. İzmir Ticaret Odası, İzmir: Türkiye.

Purtaş, Fırat (2011). *Orta Asya ile Güney Asya Arasında Modern İpek Yolu Projesi Afganistan, Pakistan ve Hindistan'ın Orta Asya Türk Cumhuriyetleri İle İlişkileri,* Rapor, Ahmet Yesevi Üniversitesi, Ankara.

Sabancı, B. ve Yılmaz, Z. (2021). Bir Kuşak-Bir Yol Projesi Kapsamında Akdeniz Ticaret Limanlarında Türkiye Fırsatları, *Ekonomi Maliye İşletme Dergisi*, 4(1):92-93.

Seyidoğlu, H. ve Gönültaş, S. (2014). Modern İpek Yolu Projesi ve Türkiye ile Orta Asya Türk Cumhuriyetleri Arasındaki Ekonomik İlişkiler. *Avrasya Etüdleri*, 45, 2131 -8291

Şener, U. ve Sugözü, İ.H. (2022). Orta Asya'da Yeni Bir Hegemonya Denemesi: Çin'in Bir Kuşak Bir Yol (OBOR/BRI) Projesi. *İktisadi ve İdari Yaklaşımlar Dergisi*, 4(2), 1-14.

T.C. Ticaret Bakanlığı (2019). Dış Ticaret İstatistikleri. https://ticaret.gov.tr/istatistikler/dis-ticaret-istatistikleri, Erişim Tarihi: 12.04.2023.

TUIC Akademi Çin Kuşak Yol Projesi ve Orta Asya'daki Güvenlik Tehditleri (2021). https://www.tuicakademi.org/cin-kusak-yol-projesi-ve-orta-asyadaki-guvenlik-tehditleri/ Erişim Tarihi: 15.04.2023.

Tutar, F.K. ve Bahsi Koçer, F.Ş. (2019). *Journal of Social, Humanities and Administrative Sciences*, 5(17):.621-624.

Tuerdi, Reyilaguli (2018). *Yeni İpek Yolu Projesi ve Türkiye –Çin İşbirliğine Etkileri.* İstanbul Ticaret Üniversitesi, Dış Ticaret Enstitüsü, Working Paper Series, WPS NO/ 137/ 2018-01, 1-15.

Yavuz, H, Beşel F. ve İnce, T. (2012). *Türkiye ile Türk Cumhuriyetleri Arasındaki Dış Ticaretin Yapısal, Sektörel ve Ürün Grupları İtibariyle Analizi: 1995–2011 Dönemi*. Sakarya: Sakarya Üniversitesi Yayınları, 1. Baskı, 35.

Yeşiltaş, M., Çeken, H. Ve Öztürk, İ. (2009). Karadeniz Bölgesindeki Turizm Olanaklarının SWOT Analizi İle Değerlendirilmesi. *Adıyaman Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 2(3), 250-269.

Yıldızoğlu, E. (2020). ABD ve Çin arasındaki 'yeni soğuk savaş' dünya için ne kadar büyük bir risk?. . BBCNews, https://www.bbc.com/turkce/haberler-dunya-53404403, Erişim Tarihi: 04.03.2023.

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ASSESSING KEY FACTORS IN MARINE MAIN ENGINE SELECTION USING FUZZY AHP METHOD

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ABSTRACT

The main engine selection is a critical decision in the shipbuilding process, as it impacts the vessel's overall performance, efficiency, and operational costs. In this article, we present a comprehensive evaluation of marine engine selection criteria using Fuzzy Analytical Hierarchy Process (AHP). This approach provides a systematic framework for evaluating the criteria based on their relative importance, incorporating both qualitative and quantitative data. In the selection of the main engine, three main criteria were determined as economic criteria, technical criteria, and company-related criteria, and each main criterion was detailed with four sub-criteria. The results indicated that after considering the relative significance of each sub-criterion, fuel oil consumption emerged as the top priority, accounting for 17.01% of the overall importance. Following closely behind, easy operation held the second position with a rating of 16.11%, signifying its considerable importance.

Keywords: *Main Engine Selection, Merchant Ships, Shipbuilding, Decision-Making, Fuzzy AHP*

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Gemi Ana Makine Seçiminde Temel Faktörlerin Bulanık AHP Yöntemi ile Değerlendirilmesi

ÖZET

Gemi ana makine seçimi, geminin genel performansını, verimini ve işletme maliyetlerini etkilediği için gemi inşa sürecinde kritik bir karardır. Bu çalışmada Bulanık Analitik Hiyerarşi Sürecini (AHP) kullanarak gemi ana makine seçim kriterlerinin kapsamlı bir değerlendirmesi yapılmıştır. Bu yaklaşım, nitel ve nicel verileri içeren kriterleri göreceli önemlerine dayalı olarak değerlendirmek için sistemli bir çerçeve sunmaktadır. Ana makine seçiminde, ekonomik, teknik ve şirketle ilgili kriterler olmak üzere üç ana kriter belirlenmiş ve her bir ana kriter dört alt kriter ile detaylandırılmıştır. Sonuçlar, her bir alt kriterin göreceli önemini birlikte değerlendirildiğinde, yakıt tüketiminin genel önemin %17.01'ini oluşturan en yüksek öncelik olarak ortaya çıktığını göstermiştir. Bunu yakından takip eden makinenin kolay kullanımı ise %16,11'lik oranla ikinci sırayı alarak büyük önem arz etmiştir.

Anahtar Kelime: *Ana Makine Seçimi, Ticari Gemiler, Gemi İnşa, Karar Verme, Bulanık AHP*

1. INTRODUCTION

Making decisions is an important factor that will play a significant role in determining the outcome of any given event. It entails examining choices, reflecting on their potential outcomes, and selecting the most suitable option. Successful decision-making requires an in-depth understanding of the situation, well-defined objectives, and the ability to evaluate and compare numerous options. Fuzzy decision-making utilized when the information available for solving a problem is unclear and insufficient, is a commonly studied subject in academic literature. The Fuzzy Analytical Hierarchy Process (AHP) method is one of the widely used fuzzy decision-making techniques and has seen successful implementations in many fields (Cebi et al., 2016; Kahraman et al., 2015; Kaya et al., 2019; Mardani et al., 2015).

Further, fuzzy AHP is a popular tool in several maritime areas, including naval architecture, maritime transportation, maritime risk management, marine engineering, etc. It makes the incorporation of subjective knowledge and ambiguity possible, which ultimately leads to findings that are more accurate and reliable. Fuzzy AHP offers a flexible and organized framework for decision making in the maritime sector by considering a wide range of factors and expert opinion. This method provides valuable insights and enables more informed decision making in a wide range of maritime applications. For instance Kafalı and Özkök

(2015) used fuzzy AHP to assess the criteria for shipyard selection by shipowners. Türk and Özkök (2020) utilized the Fuzzy AHP method to assess the critical factors in choosing a shipyard location. The same research group (2022) also evaluated the risk of falling accidents in shipyards. Şahin and Yip (2017) effectively applied the Fuzzy AHP approach in the selection of technology in the maritime industry. Çelik and Akyüz (2018) performed a Fuzzy AHP study in the maritime transportation sector. Şahin and Şenol (2015) conducted an analysis of marine accidents using the Fuzzy AHP method. Kassav et al. (2022) carried out a Fuzzy AHP implementation in the field of maritime supply chains.

As was briefly discussed earlier, numerous decision-making issues can be found in a variety of maritime areas, and associated research is carried out in an effort to find answers to these issues. One of the significant decision-making problems in maritime sector is the selection of the main engine for a ship. Selecting the main engine is a crucial step in the shipbuilding process. When it comes to selecting the main engine for a ship, there are a few key considerations to keep in mind. It is necessary to appropriately determine these criteria and to establish the degree to which each of them should be given importance. When this is completed, selecting the best option from the alternatives is simple. The main engine of the ship not only meets the energy needs of the ship, but also affects safety, efficiency, cost, and environmental factors. In light of this, ship owners can obtain long-term economic and operative benefits from making the most effective decision.

Although the selection of ship's main engine is of vital importance, there is surprisingly little research in the academic literature on the topic of ship main engines. In a study by Bulut et al. (2015), they used the AHP method to choose a main engine for a Panamax bulk carrier. The main motivation of the study was to compare the fuzzy AHP using the rotational priority search (RPI) method and the classical fuzzy AHP method. In the study, six key criteria were identified, power, cost of purchase, fuel consumption, maintenance, majority in the current merchant fleet, damage history of the main engine model. For the case study, six alternative models were selected from two major manufacturers, with power capacities ranging from 8,000 to 14,000 kW. According to the classic fuzzy AHP analysis, cost of purchase and popular usage in the current world fleet were the most important criteria, followed by power, fuel consumption, damage history and maintenance, respectively. Then, RPI method was performed and it was determined that the results were largely similar to the classic fuzzy AHP. While there were some differences in the importance levels of the last three criteria, the first two criteria were obtained as similar.

In the study conducted by Herişçakar (1999), AHP and SMART methods were used in ship main engine selection. The case study focused on a 6000 DWT chemical tanker, whose main engine power was 4000 kW. The study identified five key objectives when it came to choosing the main engine: low cost, reliability, best technical features, easy maintenance and handling, and compliance with international rules and regulations for the environment. Later, these main objectives were turned into first-level criteria such as financial criteria, reliability, technical features, maintenance and environment, and related sub-criteria were added to them. Six options with a total power of about 4000 kW were selected. At the end of the study, SULZER 6ZAL40S and DEUTZ 645L8 were the best alternatives with the SMART method, while SULZER 6ZAL40S was the alternative with the best score in the solution with AHP.

Uzun and Kazan (2016) compared three methods, AHP, TOPSIS and PROMETHEE, for selection a marine engine. They applied the methods to a fishing vessel, the NB 25 Wartsila. The study considered 12 criteria and evaluated 7 main engines to determine the most suitable engine for the vessel. The main criteria were; technical specifications, contract criteria, reliability, operating costs and maintenance costs. The technical features were further divided into sub-criteria such as power, speed, weight, volume, class requirements and other technical competencies. The contract criteria included initial investment cost and delivery time, while the operating costs were further divided into fuel consumption and oil consumption. As a result of the application, it was observed that the AHP and PROMETHEE methods produced similar results. In general, Wartsila, MAN, and MAK were determined as the best alternative.

Previous studies have not thoroughly explored the problem of ship main engine selection and mainly focused on comparing different methods. They also lacked examination of the details of the ship main engine selection problem, leading to weaknesses in criteria determination. For instance, engine power is often used as a criterion, but it is determined at the design stage and should only be considered as a constraint. In other words, before starting a ship's main engine selection, the ship's engine power must be determined and the selection is carried out among the engines with a power close to this value.

The main purpose of the presented study was to evaluate the marine main engine selection criteria. First, the ship main engine selection problem was explained in detail. Then, the main engine selection criteria for a merchant ship were determined by considering the literature and expert opinions. Finally, a pairwise comparison of the criteria was performed and the importance weights were calculated with the fuzzy AHP method. Because one of the most important steps in the selection of the main engine is the selection of the appropriate one among the alternatives, this study revealed the necessary criteria for selection stage. It is thought that the present study will serve as a valuable resource for researchers working in the field of selection of marine main engine. The main contributions of this study can be summarized as follows: (i) the ship main engine selection problem is presented in a comprehensive way, (ii) the main engine selection criteria for a merchant ship are determined, (iii) the importance weights of the main engine selection criteria are calculated.

2. MARINE ENGINE SELECTION PROBLEM

Determining the ship's main engine is an iterative process consisting of calculating the ship's main engine power and selecting the appropriate main engine. In general, the ship main engine determination process can be summarized in seven steps as shown in Figure 1 (Diesel, 2018).

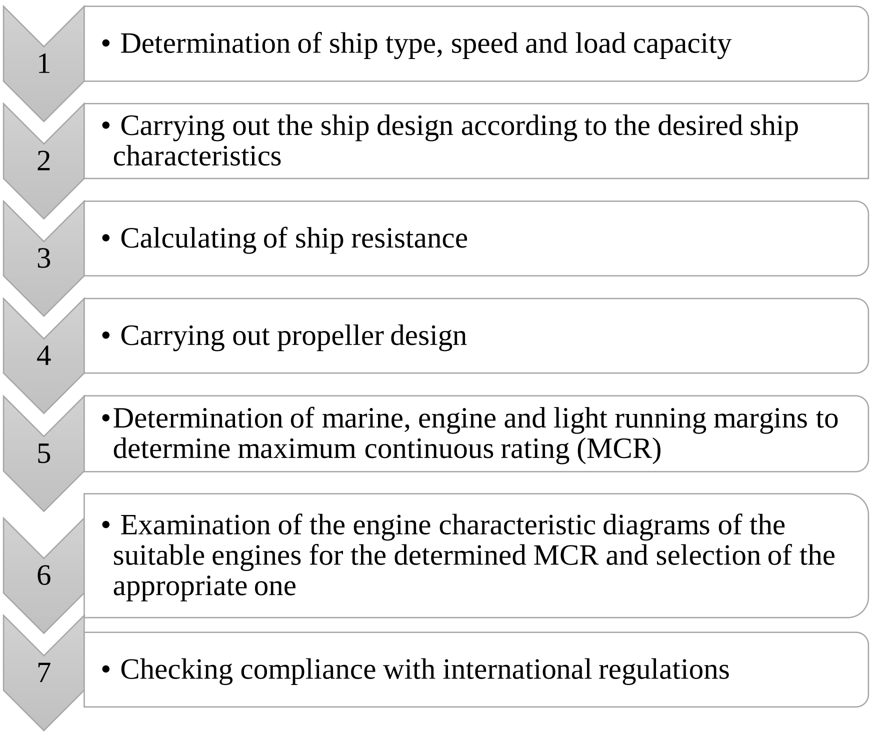

Figure 1: Main engine selection spiral (Diesel, 2018).

First of all, the desired load capacity and service speed of the ship are determined by the ship owner. Then, the ship design is carried out according to the desired ship characteristics. In the third step, ship resistance calculations are carried out. Then, propeller design is performed. In the initial project phase, the required propeller power and propeller rpm estimates are based on theoretical calculations of calm water resistance for loaded ship and propeller working conditions behind the hull. After the resistance calculations are validated, the design is further optimized by experimental towing tank tests to obtain the final propeller curve for the project. In the step 5, some margin must be added to the propeller design point (PD). One of these, the sea margin, includes resistance increase caused by the expected average wind and waves. A reasonable sea margin ranging from about 10% to 30% depending on the project must be established by the designer. Another margin added to the propeller design point is the engine margin. Generally, it is not desirable to use 100% engine power for normal operation due to increased fuel consumption and a desire for power reserve. For this reason, an engine margin is often added. Engine margin can vary between 10% and 30% depending on the priorities of the project. In addition, the engine margin can be higher than conventional engine margins to comply with the "IMO Minimum Propulsion Requirements" regulation. Weather conditions change during the voyage of the ships, and over time, contamination occurs on the hull and propeller. During the voyage of the ships, contamination occurs on the hull and propeller. As it is known, a dirty hull reduces the speed of the arriving water and increases the slip on the propeller. In addition, ship resistances increase in cruising in heavy seas. Therefore, the light running margin is also added. After adding all the margins, the SMCR point is obtained and the appropriate main engine for this point is determined (Diesel, 2018; Gürgen, 2021).

At this stage, there are many criteria depending on the project and the selection is made by evaluating these criteria. In general, the selection of the engine with greater power causes a decrease in fuel consumption, while increasing the initial investment cost and machine dimensions. Therefore, it is inevitable to use decision-making methods to evaluate these criteria. The last stage of the ship main engine selection process is to check the compliance of the selected engine with international regulations. NO_X and SO_X emission restrictions and regulation of EEDI are the leading ones. EEDI was introduced by IMO to reduce greenhouse gases from ships. If the EEDI is high, options such as speed reduction, hull optimization and specific fuel consumption reduction should be considered by returning to the first step and this process should be repeated until the restrictions are met. (Diesel, 2018; Gürgen, 2021).

As mentioned above, determining the most suitable one among the main engine options is a decision-making problem involving many criteria. Therefore, at this stage, the main engine selection criteria must be determined appropriately and they must be weighted. In this study, the criteria for selecting the main engine of a merchant ship were established through review of existing literature and consultation with marine engineers, as presented in Figure 2.

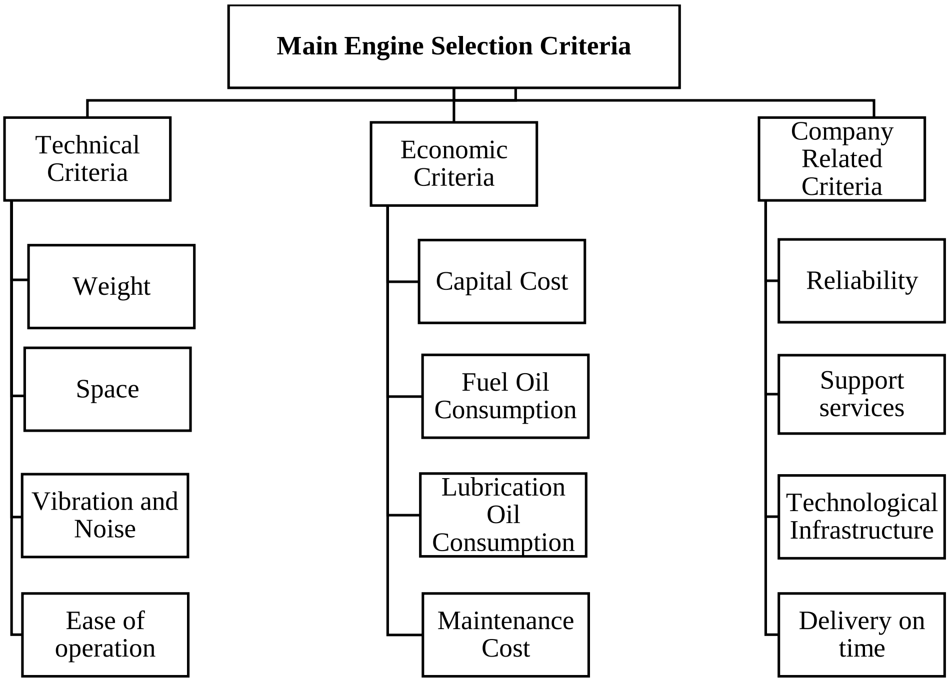

Figure 2: Main engine selection criteria for a merchant ship

As shown in Figure 2, there are 3 main criteria and 12 sub-criteria in main engine selection. The sub-criteria of technical criteria were determined as main engine weight, space, vibration-noise and easy operation. Engine weight is usually not a very important issue for the majority of merchant ships. However, it plays a very important role in ferries and high-speed boats. The power-to-weight ratio is vital in the design of warships and catamarans, as high speed is required from a relatively small ship. Engine dimension is considered as an important criterion in the selection of a main engine. Reducing the dimension of the engine will cause the engine room to be smaller and increase the cargo carrying capacity of the ship. However, height can also be a constraint, especially for low-speed two-stroke engine. In addition, since the volume is a priority issue in warships, the power/volume ratio is very important for these ships. Vibration and noise are factors that can cause problems in both the engine room and the living space. Today, there are international standards that must be complied with for both noise and vibration. In addition, it is desired that the vibration and noise level be as low as possible. Noise and vibration are becoming more important for some vessels, such as cruise ships, fishing vessels, oceanographic vessels, and warships operating submarine detection equipment. The marine engineers want to work on diesel engine that are light and easy to maintain, with less maintenance parts. In addition, new technologies such as hybrid and dual fuel are not preferred by conservative marine engineers due to system complexity and lack of experience. If a ship's main engine is not fully understood by the marine engineer, a negative aspect of that machine will be formed due to usage errors (Gürgen, 2021; Herişçakar, 1999; Watson, 1998).

The sub-criteria of economic criteria were determined as initial investment cost, fuel consumption, oil consumption and maintenance cost. The purchasing cost of the ship's main engine is undoubtedly one of the important criteria for choosing an engine. The cost of the main engine also includes the transportation cost and the installation (gear box, pump, etc.) cost. Fuel consumption of a marine main engine has a significant share in operating costs. The preference of engine with lower fuel consumption contributes to the reduction of operating costs. In order to make comparisons between the machines in terms of fuel consumption, the specific fuel consumption is usually given in the catalogs instead of the fuel consumption. Specific fuel consumption shows the amount of fuel consumed by an engine per kilowatt hour, and its unit is expressed in g/kWh. The decrease in the specific fuel consumption of an engine depends on its efficiency. As it is known, lubrication is used in ship engine to reduce friction. The fuel injected into the cylinder mixes with the oil film between the piston ring and the cylinder liner, and some oil burns together with the fuel. However, there are some factors that affect oil consumption. Examples of these are engine design, operating conditions, oil and fuel quality, system losses and maintenance status. The cost of cylinder lubricating oil is one of the biggest contributors to total operating costs, alongside the cost of fuel. The maintenance cost of a ship's main engine is one of the important factors affecting the sustainability of the machine. The number and cost of maintenance parts are factors that directly affect the maintenance cost. For example, an increase in the number of cylinders for a main engine will cause an increase in the number of parts requiring maintenance. In addition, the cost of spare parts is also considered as an important parameter and varies according to the manufacturers (Diesel, 2018; Gürgen, 2021; Herişçakar, 1999; Watson, 1998).

The sub-criteria of the company (engine manufacturer) related criteria were determined as reliability, support services, technological infrastructure and delivery on time. While reliability is important for all ships, it is especially very important on ocean-going ships. Also, reliability is vitally important for warships, and the main engine must be highly reliable to minimize the consequences of any loss of capability from mechanical failure or enemy movement. Generally, main engine that have been tried before and proven to be reliable by marine engineers are preferred. Main engines with frequent breakdowns and complex systems are not preferred. Support services include customer service, technical support, repair-maintenance services and training support. In particular, the supply of spare parts should be easy and accessible. Any problem in the supply of spare parts can cause very heavy economic losses for the ship. The technological infrastructure of the engine manufacturer is very important in terms of their competition with each other. The existence of environmentally friendly technologies that reduce fuel consumption and exhaust emissions, waste heat recovery systems and technologies, and R&D activities are evaluated within the technological infrastructure. Especially in order to meet the international restrictions introduced in recent years, the above-mentioned parameters are of great importance. Delivery on time and assembly of the main engine in the shipbuilding process is one of the important criteria. Failure to deliver the main engine at the time specified in the project delays the launch of the ship and causes serious economic losses for both the shipyard and the ship owner. In addition, shipyards do not want the main engine to be delivered early in order to reduce storage costs. Therefore, delivery on time of the engine is considered as an important criterion (Gürgen, 2021; Herişçakar, 1999; Watson, 1998).

3. FUZZY AHP METHOD

For real-world problems, decisions are accomplished using incomplete and non-numerical information. The decision makers generally prefer to make judgments within certain intervals due to the fuzzy nature of the process of comparing alternatives, rather than making fixed-valued judgments. The classical AHP method created by Satty (1980) has a major drawback because it utilizes precise expressions. For this reason, researchers have combined the fuzzy theory presented by Zadeh (1965) with the classical AHP method to present more realistic tools for real-world decision making problems. In 1983, triangular fuzzy numbers were used for the first time in the AHP method with the study by Laarhoven and

Pedrycz (1983). In the following years, this idea was adopted and different approaches were presented by many researchers. The most well-known of these are the studies by Buckley (1985) and Chang (1996). The extended fuzzy AHP method presented by Chang was used in the study, and the steps of the method are given below.

In Chang (1996)'s fuzzy extend analysis method, $X = \{x_1, x_2, \dots, x_n\}$ is a set of objects and $U = \{u_1, u_2, \dots, u_n\}$ is goal set. Thus, m extend analysis values for each object can be given as follows:

$$M^1{}_{g_i}, M^2{}_{g_i}, \dots M^m{}_{g_i}, i = 1,2, \dots, n \tag{1}$$

where $M^j{}_{g_i}$ $(j = 1,2, \dots, m)$ are triangular fuzzy numbers.

Step 1: The fuzzy synthetic extent for the i-th object is computed using the following formula.

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j\right]^{-1} \tag{2}$$

$\sum_{j=1}^{m} M_{g_i}^j$ is calculated as the following equation.

$$\sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \tag{3}$$

$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j\right]$ expression at the Equation 2 can be determined as follows:

$$\sum_{\text{i}=1}^{\text{n}} \sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i\right) \tag{4}$$

Then, the inverse of the vector is calculated as follows

$$\left[\sum_{\text{i}=1}^{\text{n}} \sum_{j=1}^{m} M_{g_i}^j\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \tag{5}$$

Step 2: The degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is given as:

$$V(M_2 \geq M_1) = \sup_{y \geq x} \left[\min\left(\mu_{M1}(x), \mu_{M2}(y) \right) \right] \quad (6)$$

$M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ are triangular fuzzy numbers and the degree of possibility is calculated as follows:

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2)$$
$$= \mu_{M_2}(d) = \begin{cases} 1 \quad , & m_2 \geq m_1 \\ 0 \quad , & l_2 \geq u_1 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} , & otherwise \end{cases} \quad (7)$$

where *d is* y-axis value of the highest intersection point D between μ_{M_1} and μ_{M_2}, and is shown in Figure 3.

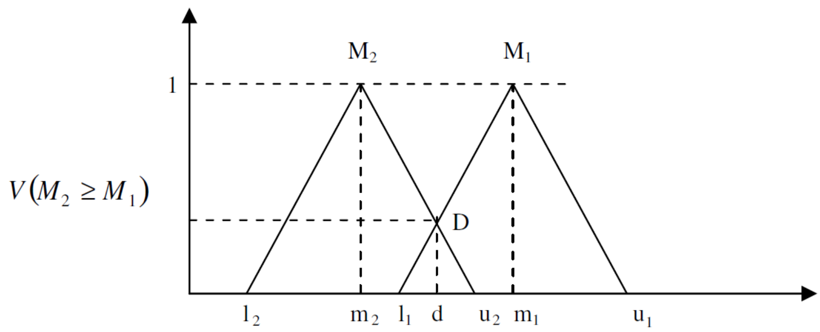

Figure 3: The intersection of M_1 and M_2 fuzzy number

Step 3. The degree of possibility for a fuzzy number to be greater than k fuzzy numbers can be defined as follows:

$$V(M \geq M_1, M_2, \dots, M_k)$$
$$= V[(M \geq M_1) \text{ ve } (M \geq M_2) \text{ ve } \dots (M \geq M_k)]$$
$$= \min V(M \geq M_i), \text{ i} = 1, 2, 3, \dots, \text{k} \quad (8)$$

for k= 1, 2, …, n ; $k \neq I$, assume that $d'(A_i) = \min V(S_i \geq S_k)$, then the weight vector is given as follows:

$$W' = (d'(A_1), d'(A_2), \ldots, d'(A_n))^T \tag{9}$$

Step 4. Finally, W' is normalized and W is produced as follows:

$$W = (d(A_1), d(A_2), \ldots, d(A_n))^T \tag{10}$$

Generally, evaluations are performed by more than one expert or decision maker for fuzzy AHP applications. Then, the above-mentioned steps are carried out by aggregating obtained evaluations and aggregated results need to be consistent. However, although consistency analysis is a critical step for group decision making, it is often overlooked in the literature. In this study, central consistency index (CCI) proposed Bulut et al. (2012) based on the geometric consistency index (Aguarón and Moreno-Jiménez, 2003; Crawford and Williams, 1985) was used. $A = (a_{Lij}, a_{Mij}, a_{Uij})$ is fuzzy decision matrix and $w = [(w_{L1}, w_{M1}, w_{U1}), (w_{L2}, w_{M2}, w_{U2}), \ldots, (w_{Ln}, w_{Mn}, w_{Un})]^T$ is priority vector derived from A vector. The CCI is calculated as follows:

$$CCI(A) = \frac{2}{(n-1)(n-2)} \sum_{i<j} (\log\left(\frac{a_{Lij} + a_{Mij} + a_{Uij}}{3}\right) - \log\left(\frac{w_{Li} + w_{Mi} + w_{Ui}}{3}\right) + \log(\frac{w_{Lj} + w_{Mj} + w_{Uj}}{3}))^2 \tag{11}$$

A value of $CCI(A)$ equal to zero indicates that the matrix is completely consistent. In the study by Aguarón et al. (2003), $\overline{GCI}$ values according to the number of criteria are given as follows:

- $\overline{GCI} = 0.31 \quad (n = 3)$
- $\overline{GCI} = 0.35 \quad (n = 4)$
- $\overline{GCI} = 0.37 \quad (n > 4)$

where n is number of criteria. CCI is fuzzy version of $\overline{GCI}$ and the matrix will be consistent when $CCI(A) < \overline{GCI}$

4. IMPLEMENTATION

In general, the criteria to be considered during the selection process of the main engine selection of a ship have been explained in Section 2 and illustrated in Figure 2. Furthermore, specific criteria to a particular project can also be considered by incorporating them into the selection process. In this study, the evaluation of the effective criteria in the selection of the main engine of a ship was carried out using the Fuzzy Analytical Hierarchy Process (AHP) method proposed by Chang (1996). The steps taken towards this objective are shown in Figure 4.

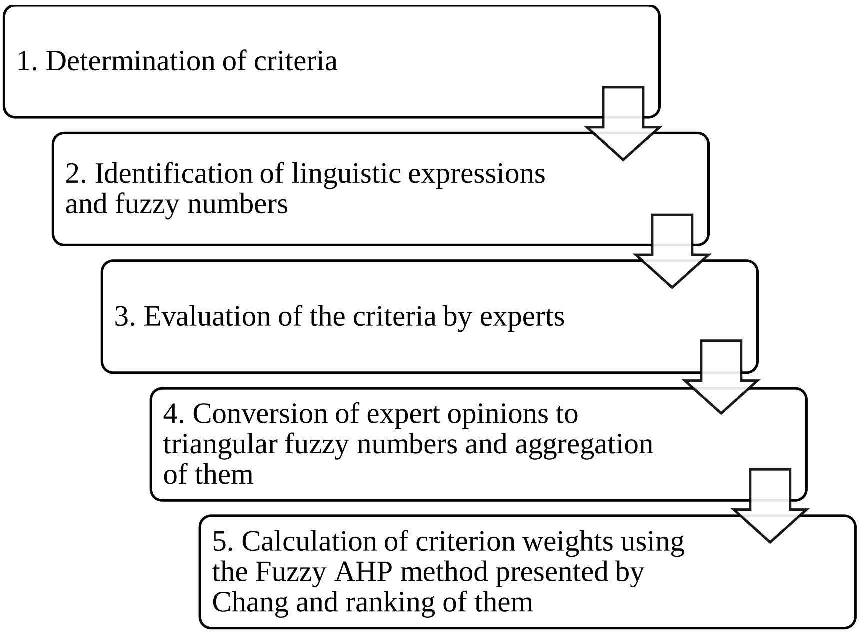

Figure 4: The main steps in the evaluation of ship main engine selection criteria

As seen in Figure 4, the first step of identifying the criteria has been discussed in the second section. Then, the linguistic expressions are defined as in Türk and Özkök's study (2020). Linguistic expressions and fuzzy sets are given in Table 1.

Table 1: Linguistic expressions and fuzzy sets

Linguistic expressions	**Fuzzy sets**
Equally important (E)	(1, 1, 1)
Moderately more important (M)	(1, 3, 5)
Strongly more important (S)	(3, 5, 7)
Very strongly more important (VS)	(5, 7, 9)
Demonstratively more important (D)	(7, 9, 9)

After the criteria and linguistic expressions were determined, expert opinions were collected. Questionnaires containing pairwise comparisons of the main and sub-criteria were prepared and the verbal answers given by the engineers specialized in the field of ship engine were recorded. Evaluations were carried out by considering a merchant ship such as a container ship, tanker, general cargo ship. A total of 5 experts participated in the study and the impact weights of the experts were taken equally. All the answers obtained were converted into triangular fuzzy numbers in order to apply the method, and the answers given by each expert to the related question were collected and aggregated decision matrices were formed. Finally, the consistency of the decision matrices was checked and the method was applied. Please take note that this study provides a general assessment for selecting conventional diesel main engines in commercial ships. Within a broad framework, these findings can be deemed reasonable for studies conducted in the sub-classes of commercial ships. However, it is important to acknowledge that conducting separate studies with different experts for each sub-class may result in slight variations in the weighting of criteria. Furthermore, it is worth noting that significantly different outcomes can arise for ships with diverse concepts, such as warships.

5. RESULTS AND DISCUSSION

Since there are five experts in the study, it is necessary to obtain aggregated decision matrices. The arithmetic average method was applied by taking the effect values of all experts equal in the aggregation stage. As a result, the aggregated matrix for the main criteria, technical criteria, economic criteria and company-related criteria were given in Table 2, 3, 4 and 5, respectively.

Table 2: Aggregated pairwise comparisons for the main criteria

	Technical criteria	**Economic criteria**	**Company-related criteria**
Technical criteria	(1, 1, 1)	(0.49, 0.93, 1.50)	(2.28, 3.53, 5)
Economic criteria	(2.04, 3.27, 4.61)	(1, 1, 1)	(2.04, 3.66, 5.4)
Company-related criteria	(0.47, 1.31, 2.17)	(0.33, 0.80, 1.50)	(1, 1, 1)

Table 3: Aggregated pairwise comparisons for the technical criteria

	Weight	**Space**	**Vibration and Noise**	**Ease of operation**
Weight	(1, 1, 1)	(0.31, 0.36, 0.54)	(0.89, 1.72, 2.69)	(0.15, 0.22, 0.54)
Space	(3.00, 4.61, 6.21)	(1, 1, 1)	(1.06, 1.48, 2.02)	(0.47, 0.50, 0.57)
Vibration and Noise	(2.27, 3.53, 4.49)	(2.03, 2.84, 3.26)	(1, 1, 1)	(0.71, 1.17, 1.77)
Ease of operation	(3.00, 5.02, 7.01)	(2.60, 3.80, 5.01)	(2.42, 4.04, 5.68)	(1, 1, 1)

Table 4: Aggregated pairwise comparisons for the economic criteria

	Capital Cost	**Fuel Oil Consumption**	**Lubrication Oil Consumption**	**Maintenance Cost**
Capital Cost	(1, 1, 1)	(0.87, 1.69, 2.54)	(1.85, 2.68, 3.53)	(0.82, 1.64, 2.46)
Fuel Oil Consumption	(2.66, 3.92, 5.29)	(1, 1, 1)	(2.60, .4.60, 6.60)	(1.62, 2.42, 3.24)
Lubrication Oil Consumption	(1.45, 2.26, 3.12)	(0.15, 0.24, 0.57)	(1, 1, 1)	(0.88, 1.31, 1.86)
Maintenance Cost	(1.08, 1.53, 2.20)	(1.46, 1.90, 2.44)	(2.83, 4.06, 4.88)	(1, 1, 1)

Table 5: Aggregated pairwise comparisons for the company-related criteria

	Reliability	**Support services**	**Technological Infrastructure**	**Delivery on time**
Reliability	(1, 1, 1)	(1.67, 2.50, 3.37)	(2.26, 3.49, 4.84)	(2.02, 2.84, 3.66)
Support services	(2.51, 3.47, 4.72)	(1, 1, 1)	(1.80, 2.60, 3.40)	(2.20, 4.20, 6.20)
Technological Infrastructure	(1.27, 2.12, 2.97)	(0.65, 0.68, 0.73)	(1, 1, 1)	(1.88, 3.13, 4.60)
Delivery on time	(1.05, 1.46, 1.91)	(0.17, 0.26, 0.70)	(0.49, 1.34, 2.30)	(1, 1, 1)

After the aggregated decision matrices were obtained, consistency analysis was performed. The central consistency index proposed by Bulut et al. (2012) was used for the consistency analysis. The consistency ratios of the aggregated decision matrices for the main and sub-criteria, and the maximum values according to the number of relevant criteria were given in Table 6. The results indicated that the consistency ratio of all decision matrices was lower than the maximum value, leading to the conclusion that all decision matrices were deemed consistent.

Table 6: The consistency ratio of aggregated decision matrices

Main and sub criteria	**Maximum value**	**Consistency ratio**
Main criteria	$CCI_{max} = 0.31$	0.2077
Technical criteria	$CCI_{max} = 0.35$	0.2255
Economic criteria	$CCI_{max} = 0.35$	0.2030
Company-related criteria	$CCI_{max} = 0.35$	0.1599

After showing that the combined decision matrices are consistent, the important weights of all main and sub-criteria were calculated with the fuzzy AHP method proposed by Chang (1996). The crisp and normalized weights of all main and sub-criteria were given in Table 7. In addition, the relative weights of the sub-criteria were calculated by taking into account the weight of the relevant main criteria.

Table 7: The important weights of main and sub criteria

Main and sub criteria	**Normalized crisp weights**	**Relative crisp weights**
Technical Criteria	**0.348**	-
Weight	0.004	0.001
Space	0.250	0.087
Vibration and Noise	0.283	0.098
Ease of operation	0.463	0.161
Economic Criteria	**0.456**	-
Capital Cost	0.23	0.105
Fuel Oil Consumption	0.373	0.170
Lubrication Oil Consumption	0.124	0.057
Maintenance Cost	0.273	0.124
Company Related Criteria	**0.196**	-
Reliability	0.314	0.062
Support services	0.347	0.068
Technological Infrastructure	0.228	0.045
Delivery on time	0.111	0.022

The findings indicated that economic criteria were the most crucial of the main criteria, followed by technical criteria and company related criteria respectively. These results revealed that economic criteria were the most influential factor in selecting a main machine, with a 45% impact. Despite being the least effective criteria, the significance of company related criteria cannot be ignored.

Figure 5 presents the technical criteria's importance weights as percentages. The most critical criteria was found to be ease of operation, with a 46% weight. This was followed by vibration and noise, volume, and weight, respectively. It's not surprising that weight was considered the least important in the selection of a main engine for a merchant ship.

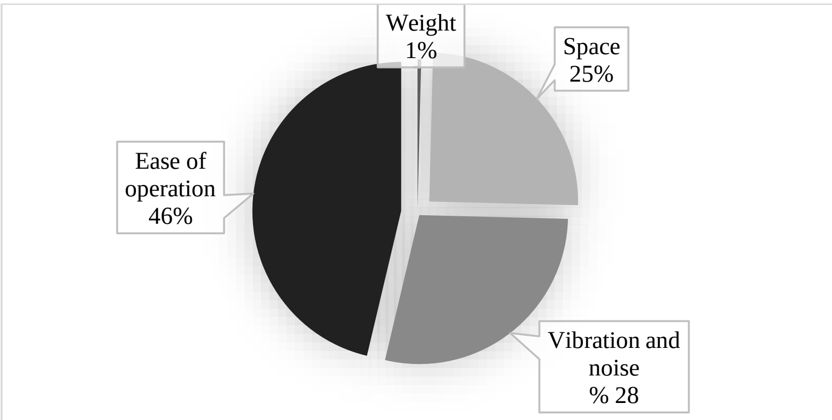

Figure 5: The importance weights of the technical criteria

In Figure 6, the importance weights of the economic criteria were shown as percentages. The criterion with the highest importance was determined as fuel consumption. Then, the maintenance cost and the capital cost were important criteria, respectively. Lubrication oil consumption was the least effective criterion with a weight of 13%.

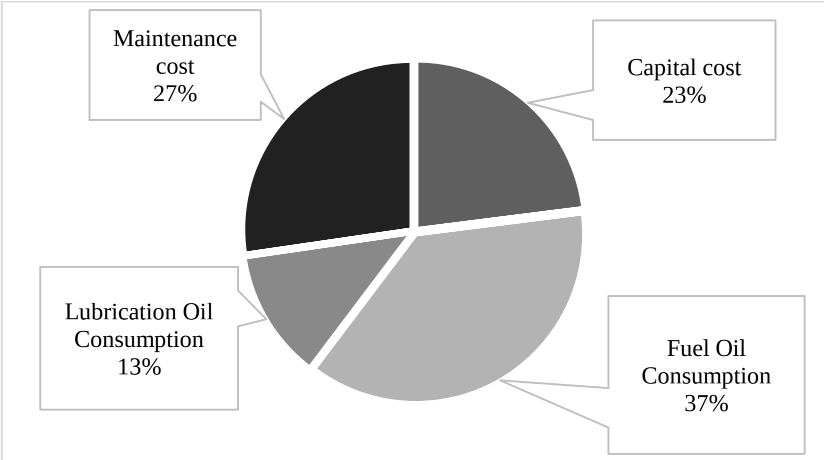

Figure 6: The importance weights of the economic criteria

The importance weights of the company related criteria were shown in Figure 7 as a percentage. Among the sub-criteria related to the company, the most important criteria was determined as support services with a value of 35%. This was followed by reliability, technological infrastructure and delivery on time, respectively.

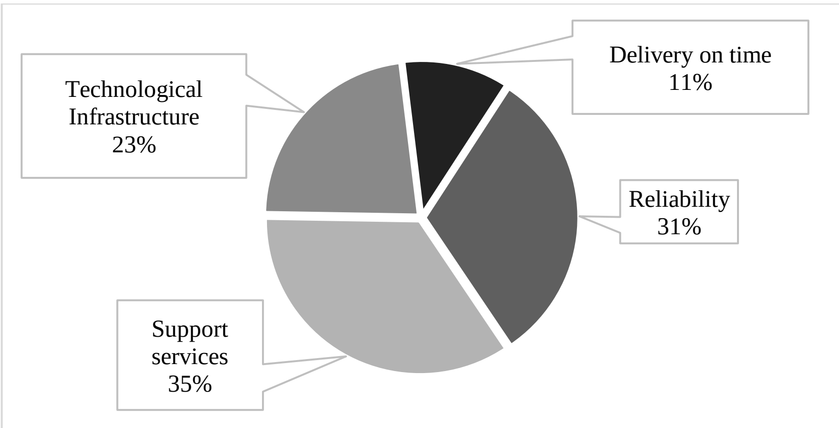

Figure 7: The importance weights of the company related criteria

Comparison of all sub-criteria was shown in Figure 8. The most important criterion among the sub-criteria is fuel oil consumption with a value of 17.01%. The fuel consumption of the main engine, which has a large share in the ship operating costs, is desired at the lowest possible level. Therefore, it is reasonable to determine fuel consumption as the most important criterion. Especially considering the long-term, the selection of the main engine with lower fuel consumption is of great importance. Easy operation of the main engine was the second most important criterion with a value of 16.11%. As it is known, the main engine of the ships is operated by the marine engineer, and they have two big expectations for the main engine: the main engine has few parts that require maintenance and its easy operation. Engine weight was the least effective criterion with a value of 0.14%. The fact that weight was not an important criterion for merchant ships was effective in this result. However, weight would be crucial if a main engine was chosen for a warship.

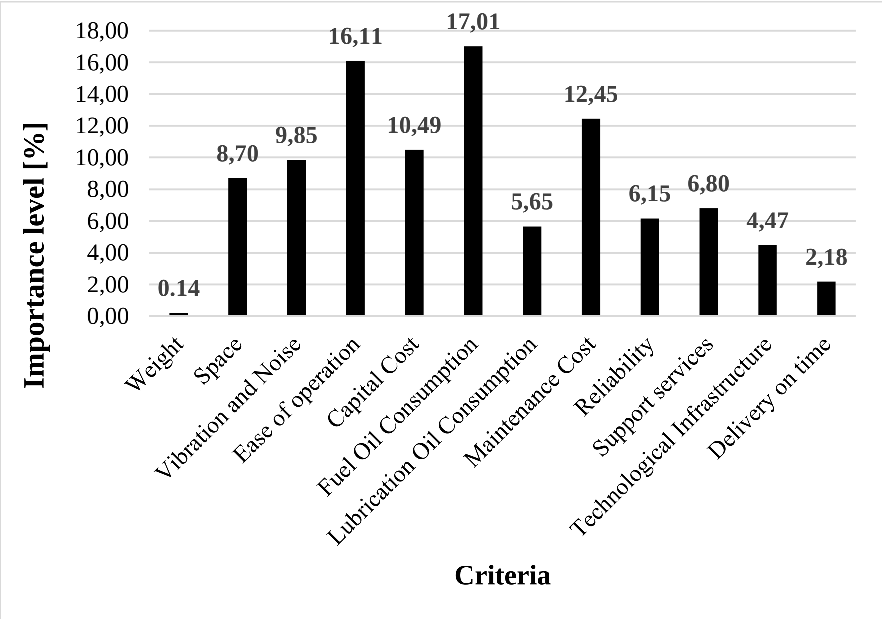

Figure 8: The relative weights of all sub-criteria

6. CONCLUSION

This study aimed to evaluate the key factors in the selection of a marine main engine using the Fuzzy AHP method. The study analyzed the main criteria such as economic criteria, technical criteria, and company-related criteria. The technical criteria were divided into sub-criteria of main engine weight, space, vibration-noise, and ease of operation. The economic criteria were split into initial investment cost, fuel consumption, oil consumption, and maintenance cost. The criteria related to the engine manufacturer were reliability, support services, technology infrastructure, and timely delivery.

As a consequence of the findings of the research, when the main criteria were compared with each other, it became clearly obvious that the economic factors were the most significant aspect. The economic criteria were the first to be considered, then the technical criteria, and finally the company-related factors. When the importance levels of each of the sub-criteria were taken into account, it was concluded that fuel oil consumption was the most important factor, scoring 17.01% importance. With a rating of 16.11%, easy operation took the position as the second most important factor. After these came the maintenance costs then the cost of capital, then the vibration and noise levels, in that order. It was determined that weight was the was the least effective criterion in the selection of the main engine

In this study, fuzzy AHP method was used to evaluate the main and sub-criteria. The use of the Fuzzy AHP method allows for a more comprehensive analysis of the criteria, taking into account the uncertainty involved. Additionally, Fuzzy AHP method provides a systematic and structured approach for decision making, ensuring fairness and consistency. Overall, the utilization of Fuzzy AHP in decision making improves the accuracy and reliability of the decision making process. The findings emphasize the significance of fuel consumption and ease of operation and also suggest that company-related criteria should not be overlooked. The findings of this study can serve as a valuable reference for those involved in the selection process of a marine main engine. By highlighting the importance of various criteria, the study can guide decision-makers towards making informed choices.

Some potential studies can be conducted in the future. In this study, the traditional diesel engine has been taken into consideration as the main engine. However, the selection criteria for main engines for ships utilizing innovative motor technologies such as dual-engine and methanol-fueled engines can be evaluated. Detailed studies can be conducted for specific types of merchant ships. Additionally, a study can be carried out for warships where different criteria will be emphasized.

REFERENCES

Aguarón, J., Moreno-Jiménez, J.M.a. (2003). The geometric consistency index: Approximated thresholds. *European Journal of Operational Research* 147 (1), 137-145.

Buckley, J.J. (1985). Fuzzy hierarchical analysis. *Fuzzy sets and Systems* 17 (3), 233-247.

Bulut, E., Duru, O., Keçeci, T., Yoshida, S. (2012). Use of consistency index, expert prioritization and direct numerical inputs for generic fuzzy-AHP modeling: A process model for shipping asset management. *Expert Systems with Applications* 39 (2), 1911-1923.

Bulut, E., Duru, O., Koçak, G. (2015). Rotational priority investigation in fuzzy analytic hierarchy process design: An empirical study on the marine engine selection problem. *Applied Mathematical Modelling* 39 (2), 913-923.

Cebi, S., Ozkok, M., Kafali, M., Kahraman, C. (2016). A fuzzy multiphase and multicriteria decision-making method for cutting technologies used in Shipyards. *International Journal of Fuzzy Systems*, 18, 198-211.

Celik, E., Akyuz, E. (2018). An interval type-2 fuzzy AHP and TOPSIS methods for decision-making problems in maritime transportation engineering: the case of ship loader. *Ocean Engineering* 155, 371-381.

Chang, D.-Y. (1996). Applications of the extent analysis method on fuzzy AHP. *European Journal of Operational Research* 95 (3), 649-655.

Crawford, G., Williams, C. (1985). A note on the analysis of subjective judgment matrices. *Journal of mathematical psychology* 29 (4), 387-405.

Diesel, M. (2018). *Basic principles of ship propulsion.* Technical Report.

Gürgen, S. (2021). *Determination of ship main engine and establishment of optimum organic rankine cycle waste heat recovery system with artificial intelligence approaches*, Department of Naval Architecture and Marine Engineering. Karadeniz Technical University, Trabzon, Turkey.

Herişçakar, E. (1999). Gemi ana makine seçiminde çok kriterli karar verme yöntemleri ahp ve smart uygulaması. *Gemi Inşaatı ve Deniz Teknolojisi Teknik Kongresi* 99, 240-256.

Kafalı, M., Özkök, M. (2015). Evaluation of shipyard selection criteria for shipowners using a fuzzy technique. *Journal of Marine Engineering & Technology*, 14(3), 146-158.

Kahraman, C., Onar, S.C., Oztaysi, B. (2015). Fuzzy multicriteria decision-making: a literature review. *International journal of computational intelligence systems* 8 (4), 637-666.

Kashav, V., Garg, C.P., Kumar, R., Sharma, A. (2022). Management and analysis of barriers in the maritime supply chains (MSCs) of containerized freight under fuzzy environment. *Research in Transportation Business & Management* 43, 100793.

Kaya, I., Çolak, M., Terzi, F. (2019). A comprehensive review of fuzzy multi criteria decision making methodologies for energy policy making. *Energy Strategy Reviews* 24, 207-228.

Mardani, A., Jusoh, A., Zavadskas, E.K. (2015). Fuzzy multiple criteria decision-making techniques and applications–Two decades review from 1994 to 2014. *Expert Systems with Applications* 42 (8), 4126-4148.

Sahin, B., Senol, Y.E. (2015). A novel process model for marine accident analysis by using generic fuzzy-AHP algorithm. *The Journal of Navigation* 68 (1), 162-183.

Sahin, B., Yip, T.L. (2017). Shipping technology selection for dynamic capability based on improved Gaussian fuzzy AHP model. *Ocean Engineering* 136, 233-242.

Satty, T.L. (1980). *The analytic hierarchy process*. New York: McGraw-Hill.

Sümeyra, U., Kazan, H. (2016). Çok kriterli karar verme yöntemlerinden AHP TOPSIS ve PROMETHEE karşılaştırılması: Gemi inşada ana makine seçimi uygulaması. *Journal of Transportation and Logistics* 1 (1), 99-113.

Türk, A., Özkök, M. (2020). Shipyard location selection based on fuzzy AHP and TOPSIS. *Journal of Intelligent & Fuzzy Systems* 39 (3), 4557-4576.

Türk, A., Özkök, M. (2022). Comprehensive Risk Assessment Analysis of Accidental Falls in Shipyards Using the Gaussian Fuzzy AHP Model. *JEMS Maritime Sci* 10 (4), 211-222.

Van Laarhoven, P., Pedrycz, W. (1983). A fuzzy extension of Saaty's priority theory. *Fuzzy sets and Systems* 11 (1-3), 229-241.

Watson, D.G. (1998). *Practical Ship Design*. Elsevier.

Zadeh, L.A. (1965). Fuzzy sets. *Information and Control* 8 (3), 338-353.