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DETERMINATION OF CHEMICAL TANKER SELECTION CRITERIA FOR SHIPPING COMPANIES

Ozan Hikmet ARICAN[1]
Esma Gül EMECEN KARA [2]

ABSTRACT

Chemical tanker ships are one of the most used types of tanker ships in the maritime market. The use of chemical tankers in national and international waters is increasing day by day. Maritime businesses and shipowners prefer to lease the ships that are active in the market for some time instead of building and owning new ships. Due to the increase in preferences, it has been seen that it is an important issue to determine the selection of ships to carry this type of chemical cargo in different criteria. Many different criteria and methods are used to choose the most ideal of these chemical tankers based on the temporal charter of the maritime enterprises. In this regard, this study is aimed to determine the criteria that should be used for the selection of chemical tankers and to group these criteria. For this purpose, a survey study was conducted. 85 different chemical tanker selection criteria and the best 23 distinguishing criteria were determined using the Delphi method. It is envisaged that these 23 criteria will allow the authorized personnel of the company to choose the most ideal alternative chemical tanker.

Keywords: *Chemical tanker, Delphi method, Chemical tanker operations, Ship Management, Ship selection criteria*

[1]Öğr. Gör. Kocaeli University, Maritime Faculty, Maritime Transportation Management Engineering Department, ozanhikmet.arican@ogr.iuc.edu.tr, https://orcid.org/0000-0003-2061-6112

[2]Doç. Dr. Istanbul University-Cerrahpaşa, Engineering Faculty, Maritime Transportation Management Engineering Department, İstanbul, Turkey, emeceng@istanbul.edu.tr, https://orcid.org/0000-0001-6963-0965

1. INTRODUCTION

Due to the development of trade all over the world and the increase in the need for raw materials, the amount of cargo carried has increased gradually. The fact that the transportation prices are lower than the others and the quantities transported are much higher than other transportation modes makes the sea route the first choice. According to all cargoes, the volume of transportation in sea transportation is around 11 million tons (DTO, 2021). 30% of this amount of cargo is transported by tanker group ships. According to 2021 data, 316 thousand tons of cargo transported by sea is carried by chemical tanker-type ships (Malaksiano and Melnyk, 2020).

Tankers are a crucial cog in the entire global marine cargo operation. With their massive structure, they help transport bulk goods and materials around the world, maintaining continuity in other industrial and commercial operations. However, tankers are not limited to just one particular type or type. There is a wide variety of tankers used in the transoceanic freight transport process. The classification of tankers can be based on several factors. There are two categories in which transport tankers can be classified: By Type / Purpose and By Size. Tankers classified by purpose use it more widely. These are specified as Oil Tankers, Gas Tankers and Chemical Tankers (Dugenci et al, 2020). Among these, chemical tanker ships, where small partial transportation is frequently used and which have the advantage of carrying thousands of different cargoes, stand out as the most important ship type.

The Chemical Tanker Transportation market is divided into groups as follows in the world maritime markets according to cargo differences (IMO,2016):

- Group 1 Organic chemicals: Organic chemicals are compounds containing carbon-hydrogen covalent bonds such as sugars, lipids, amino acids, and proteins. Methane, butane, ether, and ethylene are examples of organic chemicals commonly used in the automobile, food, and pharmaceutical industries.

- Group 2 Corrosives (Abrasives): Chemical tankers are called some very corrosive cargoes, such as sulfuric acid (H2SO4), hydrochloric acid (HCl), and nitric acid (HNO3). In addition, many cargoes carried by heating cause corrosion and damage the cargo tank and equipment.

-Group 3 Vegetable Oils and Animal Fats: Edible (oily) oils are obtained from vegetable and marine sources. Vegetable oils include those obtained from the processing of seeds, sunflower oil, or fruit, e.g., Palm oil. Cooking oils also include those of animal origin, such as butterfat, lard, and tallow. Marine oils are derived from fish, but their composition differs significantly depending on the fish species. Lubricants can also be classified according to their processes before shipment. Most are shipped raw, but shipments of refined products often described as "refined, bleached, and deodorized," have increased significantly in recent years. Refined oils are generally more susceptible to poor storage and processing conditions than crude oils.

- Group 4 Petroleum products: These are cargoes obtained from crude oil (petroleum) because it is processed in oil refineries. Unlike petrochemicals, which have well-defined, often pure organic compounds, petroleum products are complex mixtures. Most petroleum is converted to petroleum products, including various fuel classes. The main ones are diesel, gasoline, aviation fuel Jet A1, asphalt, and other fuels.

Chemical tankers can have different equipment and designs according to the cargo they carry in 4 different groups mentioned above. In particular, the operator or the charterer should decide on the ship selection according to the cargoes to be carried on the ship.

In practice, most large chemical tanker charterers demand the availability of chemical tanker ships to be chartered from businesses without specifying qualifications and preferences. Enterprises conduct ship research and report the compliance of the ship with the inspection. However, inspections are made during the port operation of the ship and in a short time according to the operational suitability of the ship (Arican et al., 2020). There is no checklist that the inspection expert can use while conducting inspections, showing the criteria to be evaluated and their priorities specific to the cargo to be transported. This situation can cause some problems for all parties by affecting the right decision-making process in ship selection due to time constraints.

While defining maritime requirements and requirements, it is necessary to define and evaluate many maritime stakeholders within the system to solve the content of ship evaluation and selection problems (Wibowa and Deng, 2012). These stakeholders are said to be ship owners, chemical tanker ship operators and chemical tanker charterers worldwide, especially in the area involving chemical tanker ships. It is

these 3 main groups that provide the greatest benefit in ship selection, and each of these stakeholders aims to benefit from the ship to a different extent (Balmat et al, 2009). For example, ship owners are more interested in the efficiency of the ship, whereas the ship operator is interested in maritime costs and international rules, while for large tanker charterers, the gains in the return of rental investments are of interest (Panayides and Cullinane, 2002). Getting to know these stakeholders with different interests is an important issue for ship selection.

The study aims to bring a new approach to ship selection for chemical tanker enterprises. In this direction, the most important criteria and sub-criteria from the elements that bring together all the important features of the ship, including the ship's fixed components, are determined. To prevent the complexity and error that may occur in ship selection, the most appropriate criteria will be evaluated in line with the wishes of the enterprises and the indirect requests of the main charterers. For this purpose, a survey study is conducted using the Delphi method. Thus, the distinguishing criteria for selecting chemical tankers have been identified by consensus.

2. LITERATURE REVIEW

Various studies have been carried out on ship selection so far. These studies discuss the selection criteria specific to the ship type, and the majority of them use multi-criteria decision-making methods. Yan et al. (2021) conducted a study on ship selection on the arrest of ships in PSC inspections. Sellars and Martin (1992) describe procedures for the selection and evaluation of ship roll stabilization systems. Stabilization systems included passive tanks, bilge keels, active ailerons and rudder roll stabilization with combined active and passive systems. They reviewed the establishment of stabilizer design criteria and procedures for stabilization system selection, including cost/benefit analyzes of specific situations (Sellars and Martin, 1992). Yang et al. (2011) conducted a study on ship selection with fuzzy logic. Using the multi-criteria decision-making technique, criteria for ship selection were determined and these criteria were evaluated on alternative ships with the TOPSIS method (Yang et al., 2011). Anderson et al. (2021) studied the propeller system and design of a cargo ship. Parameters were determined upon the selection of the propeller system on a 120m dry cargo ship. Simulation-based modelling was used as a method (Andersson et al., 2021). Yan et

al. (2022) made the ship selection based on the port state control and the deficiencies in these controls. A survey was conducted to identify high-risk vessels. Yakut (2004) modelled the ship selection for the Turkish Naval Forces with the fuzzy logic method (Yakut, 2004). Maleksiano and Melnyk (2020) also researched the selection of ships for the transport of large-sized cargoes in their study. In the research, evaluation was made based on large-sized cargo dimensions, freight costs and time-term rental principles. The scope of the study is explained as discussing some perspectives and practical aspects of ship selection considering the possibility of transporting project cargoes and operating at economical speeds. In addition, shipping companies stated in the study that their figures are usually calculated with TCE (time charter equivalent) values so that investors can compare the performance of ships operating in the spot and time charter markets (Malaksiano and Melnyk, 2020). Balakrishnan and Karsten (2017) studied ship selection for the problems encountered in container transportation in the sector. A model proposal was introduced in the study and they stated that one of the distinguishing features of the model is that it imposes limitations on the number of transfers for each container, which is a common service requirement in practice. They report the computational results for realistic problem examples from a benchmark set of shipping problems using a standard solution applied to the reduced and augmented model.

In addition to these studies, few studies address tanker class ships. Pham et al. (2020) conducted a study on the selection of propellers for tanker ships. Propeller system preferences were determined by considering the operational efficiency of ships with a tonnage of more than 5000 deadweights (Pham et al., 2020). In another study, a study prepared by Ffooks (1995) was conducted on the selection model related to the design of Liquid Natural Gas (LNG) ships on some important factors (Ffrooks, 1995). Yang et al. (2009) conducted a study on ship selection based on uncertain environmental conditions. In this study, alternative ships were selected by determining criteria and sub-criteria with fuzzy logic. It is stated by which criteria the best ship is determined. Here, large-tonnage crude oil tankers were studied as a type (Yang et al., 2004). Xie et al. (2008) have a study on identifying tanker ships both qualitatively and quantitatively in the ship selection process with an evidential reasoning approach (Xie et al., 2008). Contrary to these studies mentioned, this study focuses specifically on the selection of chemical tanker ship and determines the selection criteria using the Delphi method.

3. METHODOLOGY

To identify the criteria and sub-criteria used in the selection of chemical tanker ships, the Delphi method will be used. The Delphi method is a popular technique used in survey studies. Using sequential questionnaires, opinions are evaluated in a non-contrasting manner, with repeated feedback on the current state of the group's consensus. This informs group members about the current state of their collective opinion, helps identify issues that participants may have overlooked or may consider unimportant, and allows participants to change their minds (Iqbal and Pipon-Young, 2009; Keeney et al, 2011). In addition, unlike brainstorming techniques for a nominal group technique, it allows for the collection of opinions without the need to physically bring the participants together. Thus, it responds to the demand for improved communication between larger, diverse and/or geographically dispersed groups that cannot be met with other available techniques. This allows a wide range of views to be expressed on which the analysis will be based. It minimizes psychological effects such as conformity to the dominant view or other social pressures and it aids independent thinking and the gradual formulation of reliable judgments (Linstone and Turoff, 2002).

Different levels of consensus and scoring methods are used in Delphi applications depending on the number of samples, the purpose of the research and the available resources (Green et al.,1999; Graham and Milne, 2003; Morrison and Barratt, 2010; Hasson et al. 2000). Similar to the study by Hasson et al., 75% agreement and 1-5 scoring have been employed in the study. 10 experts from companies that operate chemical tanker ships were chosen for the survey study. They work in the departments of chartering and ship operations. They have at least ten years of experience in the industry and are considered experts in their field. Table 1 lists the characteristics of the experts.

3.1. Delphi Method

The Delphi method is an iterative multi-stage approach that attempts to reach a consensus on the opinions of the “experts” through a group facilitation technique and a series of structured questionnaires (rounds) filled in anonymously by the participants. As part of the process, responses from each questionnaire are briefly fed back to the participants (Hasson et al., 2000). The process of working with the Delphi method is given in Figure 1.

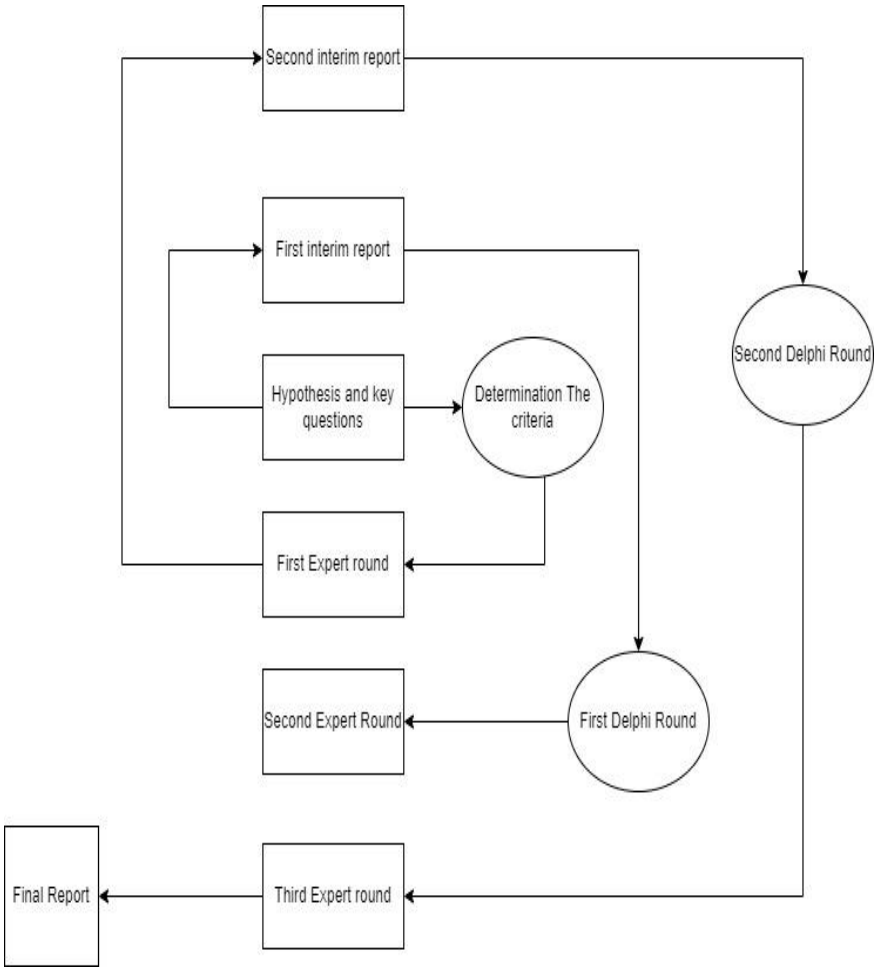

Figure 1: Delphi Round Chart

In the first stage, a session panel is held with experts and it is requested specify the selection criteria. A form describing the subject is sent to each expert separately, unaware of each other, and the criteria are asked to be written. Similar criteria are indicated by writing under a single name. In the second stage (1st Delphi Round), the criteria combined in a single form should be re-evaluated by the experts. The scoring used in this evaluation is given in Table 2.

Table 2: Delphi Scoring Method (Hasson et al., 2000)

Point	Meaning
1	Definitely Shouldn't Be
2	Shouldn't Be
3	Undecided
4	Should Be
5	Definitely Should Be

The arithmetic average, the standard deviation, the median, the score in the last quarter and the score in the first quarter of each criterion are calculated to determine the criteria. Those with an average score of 4 and above enter the first evaluation. In addition, those with a quarter width less than 1.2 are considered to remain in the survey. These two values must be present in the selection of criteria. In the third stage (2nd Delphi Round), the combined questionnaire of the criteria and the mean values calculated and the previous score given by the expert are written and the questionnaire is sent back to the experts separately. The aim here is to see the average scores of other experts on the first score given by the experts and to see whether there will be a decisive change and if there is a change, the score is done (Woundenberg, 191). If there is a change, this change is entered in the table. An example for Delphi criteria selection calculation (an agreement of 75%) is given in Table 3.

Table 3: Example Delphi Criteria Selection Calculation

Criteria	Mean	Standard Deviation	Q3(%75)	Median	Q1(%25)	Quarter Width
C1	3,92	0,67	4	4	3,25	0,75
C2	3,67	0,89	4,75	3	3	1,75
C3	4,38	0,79	5	5	4	1
C4	4,58	0,65	5	5	4,25	0,75

The column defined as average in Table 3 gives the arithmetic average of the 1-5 scale scores given by all experts. The important thing in this

column is that the mean should not be below 4 (Woudenberg, 1991) The standard deviation of all scores is calculated in the second column. In the third column, the score in the last quarter is calculated in the grouping of the scores as Q3 (75%). The median, on the other hand, is found by taking the exact mean value of the scores graphically, that is, 50% left and 50% right proximity (Dalkey and Helmer, 1963). T1 (25%) qualifies the score that is in 25% of the scores graphically (Woudenberg, 1991). The quarter width is also the distance of the band between the last quarter and the first quarter. According to Zeliff and Heldenbrand (1993), agreed items are less than 1.2 in the quarter width interval (Zeliff and Heldenbrand, 1993). In the table, the criteria should be in the questionnaire. Those above '4' points and those below the value of quartile width 1.2 mean those with high eligibility as criteria.

4. RESULTS AND DISCUSSION

A total of 183 criteria were specified by 10 experts and similar ones were removed and the number of criteria was combined into 85. The number of criteria set by the experts in the first place is given in Table 4.

Table 4: Number of Criteria Written by Experts

Expert	Finding Criteria Number	Number of Similar Criteria	Number of Criteria Removed from the List
Ex.1	20	9	1
Ex.2	18	9	0
Ex.3	21	9	1
Ex.4	19	8	0
Ex.5	15	7	0
Ex.6	23	11	1
Ex.7	16	8	0
Ex.8	19	9	1
Ex.9	16	7	0
Ex.10	16	8	1

Brief explanations and abbreviations of the 85 criteria found are given in Appendix (Table A1). The first Delphi round calculations based

on the expert scoring of 85 criteria are given in Appendix (Table A2). The final version of the criteria is given Table 5. As can be seen from Table 5, there are a total of 23 criteria determined above the '4' value which is the 'stay' value and those below the '1,2' value which is the 'quarter width'. That is, these criteria are the dominant criteria to be considered for the selection of chemical tanker ships.

Table 5: Selected Criteria

Criteria	Mean Value	Quarter Width	Criteria	Mean Value	Quarter Width
BT	4,38	1	CPL	4,28	1
FST	4,58	0,75	SA	4,20	1
CHS	4,25	1	MPCT	4,22	1
CTS	4,65	0	SPAIN	4,50	1
CTQ	4,36	1	SPIRN	4,13	0,75
ICT	4,24	1	MAERH	4,21	1
CPC	4,25	1	BTC	4,22	1
BCMLMS	4,35	1	MCF	4,19	1
NS	4,36	1	BST	4,29	1
DWT	4,20	1	CPT	4,33	1
SPC	4,12	0,75	EWPC	4,03	0,75
VCCT	4,43	1			

Among these criteria, the cargo tank coating criterion has the highest score with 4.65 and the criterion of daily water production capacity has the lowest score with 4.03. The distribution of these selected criteria in Table 5 according to the sections of the ship is given in Table 6.

Table 6: Sections Concerning the Criteria

Criteria	Cargo	Engine	Fixed Ship Information	Economical	Other
BT				X	
FST		X			
CHS	X				
CTS	X				
CTQ	X				
ICT			X		
CPC				X	
BCMLMS		X			
NS	X				
DWT			X		
SPC	X				
VCCT	X				
CPL	X				
SA			X		
MPCT	X				
SPAIN					X
SPIRN					X
MAERH		X			
BTC		X			
MCF				X	
BST			X		
CPT	X				
EWPC				X	

According to Table 6, the criteria related to cargo operations will be decisive in the selection of chemical tankers. These criteria are the type of cargo heating systems, the coating characteristics of the cargo tanks, the quantity of the cargo tanks, the capacities of the cargo pumps, the types of the cargo pumps, the nitrogen system, the MARPOL Annex I slop amounts, the locations of the cargo pumps and the maximum temperature allowed for the cargo tanks. The fixed equipment and dimensions used in chemical tanker cargo operations are very important criteria in terms of cargo operations. When we look at the main headings of the other criteria, it is seen that the presence of a bow thruster is important in terms of berthing-unberthing manoeuvres of tanker ships. The biggest reason for this is that the ship has to request tugboats during berthing-unberthing manoeuvres when there is no bow thruster on the tanker ship. Deadweight, which indicates the capacity of the chemical tanker, is the amount of cargo that the ship can carry. It stands out as an important criterion, especially for maritime enterprises to know the maximum amount of cargo to be loaded on chemical tankers.

The prominent criteria regarding ship machinery systems are the amount of fuel consumed by the ship engine at full capacity and full speed, the fuel tank capacities of the ship, the type of ship fuel system, the ship's machinery and aux engine working/running hours. These criteria in the sections where the ship's movement components are located are important criteria affecting the selection of chemical tankers. As a result of the new rules determined by International Maritime Organization (IMO), the quality of the ballast water treatment system is now an important criterion. Both the installation of the ballast treatment system on the ship and the method used by the system are important criteria. One of the other criteria, the ship's accidents and the number of cases it was involved in, were also stated as an effective criterion in the selection. The reason why this criterion is important is the presence of risk factors in the ship's structure and the high level of risk. Another important criterion is the number of remarks detected by port controls/ SIRE / CDI in past inspections of the ship. The number of cargo types and cargo qualities that the chemical tanker can carry is also important criteria. What is stated in this criterion is that the number of cargo types specified in the ship's fitness certificate is important. The high variety and large number of these cargo types mean that maritime enterprises can find cargo for the ship easily and quickly.

5. CONCLUSION

Chemical tankers can carry different quantities and different types of liquid cargo together. Differences in these cargoes and situations that require special safety cause a preference among chemical tanker ships in terms of their characteristics. These preferences are not only the dimensional features of the ships but also their hardware, system and structural features.

This study has tried to determine the criteria that can be used in the selection of chemical tankers with different structural features and special equipment for chemical cargoes with different structural characteristics. In this respect, 23 distinguishing criteria have been identified. 9 of these criteria are related to cargo operations. Others are related to ship machinery equipment and information, and the structural information of chemical tankers such as deadweight, bow thruster, and ship age.

The study is thought to be a guiding application proposal for maritime companies operating chemical tanker ships to select the most suitable ships for the chemical cargoes desired to be transported from the ships actively operated in the market. Due to the different designs and structures of chemical tankers according to the types of cargo, it is aimed to find solutions to the characteristics of the ships and the fact that maritime enterprises do not have problems while operating these ships in the maritime market. It is aimed that this study will help maritime enterprises and work on new selection criteria by updating and improving the criteria with the developing and changing ship technology in the future.

* This study is derived from the doctoral thesis titled “Ship Selection Model in Chemical Tanker Management”.

Ethics Committee Approval: The survey conducted in this study was given by the Istanbul University Cerrahpaşa Social and Human Sciences Ethics Committee with the approval of the ethics committee numbered 2022/21 on 27.01.2022. (Number: E-74555795-050.01.04-298363)

REFERENCES

Andersson, J., Gustafsson, R., Eslamdoost, A., & Bensow, R. E. (2021). On the Selection of Optimal Propeller Diameter for a 120-m Cargo Vessel. Journal of Ship Research, 65(02), 153-166.

Arican, O. H., Dugenci, I., Kara, G., & Unal, A. U. (2020). Transportation of Chemical Cargoes by Tanker Ships. In Handbook of Research on the Applications of International Transportation and Logistics for World Trade (pp. 288-309). IGI Global.

Balmat F., Lafont F., Maifret R., Pessel N.,2009, Maritime risk assessment (MARISA), a fuzzy approach to define an individual ship risk factor, Ocean Engineering, 36, 1278-1286.

Balakrishnan, A., & Karsten, C. V. (2017). Container shipping service selection and cargo routing with transshipment limits. European Journal of Operational Research, 263(2), 652-663.

Dalkey, N.C., Helmer, O., 1963. An experimental application of the Delphi Method to the use of experts. Management Science 9, 458–467.

DTO, (2021), Denizcilik Sektör Raporu, Deniz Ticaret Odası, İstanbul.

Dugenci, I., Arican, O. H., Kara, G., & Unal, A. U. (2020). Operational Process in Lpg and Lng Gas Ships in Maritime Transportation Logistics. In Handbook of Research on the Applications of International Transportation and Logistics for World Trade (pp. 310-329). IGI Global.

Ffooks, R. C. (1995). Some Important Factors in LNG Tanker Design Selection. In Advances in Cryogenic Engineering (pp. 269-275). Springer, Boston, MA.

Hasson, F., Keeney, S., & McKenna, H., 2000, Research Guidelines for the Delphi Survey Technique. Journal of Advanced Nursing, 32(4), 1008-1015.

Keeney, S., McKenna, H., & Hasson, F., 2011, The Delphi technique in nursing and health research. John Wiley & Sons.

Linstone, A. H., & Turoff, M., 2002, The Delphi Method: Techniques and Application.

Malaksiano, M. O., & Melnyk, O. M. (2020). Vessel selection prospects and suitability assessment for oversized cargo transportation. Scientific Notes of Taurida National VI Vernadsky University. Series: Technical Sciences, 31 (70), 1, 135-140.

Ndour, B., Force, J.E., McLaughlin, W.J., 1992. Using the Delphi method for determining criteria in agroforestry research planning in developing countries, Agrofo. Syst., 19, 119–129.

Panayides P. M., Cullinane K., 2002, The Vertical Disintegration of Ship Management: Choice Criteria for Third Party Selection and Evaluation, Maritime Policy & Management, 29, 45-64,

Pham, V. V., Hoang, A. T., & Do, H. C. (2020, May). Analysis and evaluation of database for the selection of propulsion systems for tankers. In AIP Conference Proceedings (Vol. 2235, No. 1, p. 020034). AIP Publishing LLC.

Sellars, F. H., & Martin, J. P. (1992). Selection and evaluation of ship roll stabilization systems. Marine Technology and SNAME News, 29(02), 84-101.

Woudenberg, F., 1991, An evaluation of Delphi. Technological forecasting and social change, 40(2), 131-150.

Xie, X., Xu, D. L., Yang, J. B., Wang, J., Ren, J., & Yu, S. (2008). Ship selection using a multiple-criteria synthesis approach. Journal of Marine Science and Technology, 13(1), 50-62.

Yakut, E. Ö. (2004). Bulanık mantık ile Türk Deniz Kuvvetleri'nin gereksinimine uygun gemi seçimi.

Yan, R., Wang, S., & Peng, C. (2022). Ship selection in port state control: status and perspectives. Maritime Policy & Management, 49(4), 600-615.

Yan, R., Wang, S., & Peng, C. (2021). An artificial intelligence model considering data imbalance for ship selection in port state control based on detention probabilities. Journal of Computational Science, 48, 101257.

Yang, Z. L., Bonsall, S., & Wang, J. (2011). Approximate TOPSIS for vessel selection under uncertain environment. Expert Systems with Applications, 38(12), 14523-14534.

Yang, Z. L., Mastralis, L., Bonsall, S., & Wang, J. (2009). Incorporating uncertainty and multiple criteria in vessel selection. Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment, 223(2), 177-188.

Zeliff, N. D. ve Heldenbrand, S. S., 1993, What Has Being Done In The International Business Curriculum?. Business Education Forum, 48 (I),23-2S.

APPENDIX

Table A1: Explanation of the Criteria

CRITERIA	ABBREVIATIONS	EXPLANATION
Tank Machine Device Type	TMDT	Fixed or mobile machines are used for cleaning the cargo residues of ship cargo tanks with the help of seawater and fresh water.
Annex 2 Underwater Line Cap.	UWL	Fixed seawater discharge line for The International Convention for the Prevention of Pollution from Ships (MARPOL) Annex II cargoes to pump washing water.
Bow Thruster	BT	Auxiliary propeller used for forwarding manoeuvring.
Fuel System Type	FST	Type of fuel used by the ship's engine according to MARPOL Annex VI.
L X B X D Optimization	LBDO	Width-height compatibility of the ship.
Cargo Heating System	CHS	Fixed system content that provides heating of the cargo in the ship's cargo tanks.
Cargo Tank Coating	CTC	Qualitative type of paint of ship tanks.
Cargo Line	CL	Ship loading and unloading fixed circuits.
Cargo Tank Quantities	CTQ	It is the numerical expression of cargo tanks.
Slop Tank Place	STP	It is the separated tank where the washing waters are stored on the ship within the scope of MARPOL.
Aft Ballast Tanks	ABT	It is the most aft tank of the ship's ballast tanks and helps to adjust the trim condition of the ship.
Ice Class Type	ICT	Having the necessary rules and equipment to navigate in the ice areas.
Multiple Dwt	MD	It is the case that different deadweight tonnages are in the certificate.
Ballast System	BS	How the ballast system is treated is the nature of the system.
Flag State	FS	It is the nature of the flag state in which it is registered.
Uscg Necessaries	USCG	Compliance with the rules must provide operationally in American waters and ports.
Tank Radar System	TRS	It is a system in which basic values such as pressure, temperature and level of cargo tanks are monitored through a computer-based system.
Past Cargoes	PC	What are the cargoes it has loaded in the

		past?
Anchor Type	AT	It is the type of anchor at the head of the ship.
Sampling Device Type	SDT	It is the quality of the instrument from which the samples are taken from the ship's cargo tanks.
Cargo Pump Cap.	CPC	It is the performance measure in cubic meters discharged per hour by the cargo pumps.
Cargo Pump Type	CPT	It is a type of load relief pump. Different load pumps are available on existing ships.
M/E Type	MT	Indicates the operating system type of the ship's main engine.
Bunker Cons. Max Load Max Speed	BCMLMS	It is the amount of fuel consumed at full cargo and maximum speed.
Bunker Cons. Max Load Eco Speed	BCMLES	It is the amount of fuel consumed at full cargo and an economical speed.
Bunker Cons. In Ballast Max Speed	BCBMS	It is the amount of fuel consumed in ballast and at maximum speed.
Bunker Cons. In Ballast Eco Speed	BCBES	It is the amount of fuel consumed in the ballasted state and at an economical speed.
Ig System	IS	It is the type of flue gas system used by the ship in cargo tanks and cargo operations.
N2 System	NS	It is the type of Nitrogen system used by the ship in cargo tanks and cargo operations.
Deadweight Tonnage	DWT	It is the total amount carried by ship on the summer loading line with cargo, fuel, ballast, fresh water and other specified weights.
Gros Tonnage	GT	It is the value of the entire closed volume of the ship.
Ship Height	SH	It is the distance from the water level of the ship to the tip of the topmast.
Ship Displacement	SD	Lightship weight, cargo, fuel, ballast, fresh water and other specified weights are the total amount carried by ship in the summer loading line of the ship.
Slop-Producing Cap(Annex I)	SPC	It is the total amount of washing water of the MARPOL Annex I cargoes of the ship.
Ship Full Load Speed	SFLS	It is the speed at which the ship produces the machine on the full cargo.
Ship Class Society	SCS	It is an independent inspection body that ensures that the ship complies with maritime rules.
Variability of The Cargo Carriage Type	VCCT	It is the variety of the cargoes previously carried by ship.
Minimum Ship-Safe Manning	MSSMTS	It is the minimum number of personnel

And Total Salary		providing the management and dispatch of the ship and the amount of salary paid to this personnel.
Ship Manouvribility Status	SMS	It is information about how the ship's manoeuvring situation and the manoeuvring character structure.
Windlass Quantity And Positions	WQP	The position and number of windlass on the ship.
Mooring Rope Quantity	MRQ	The number of ropes used in the manoeuvre at the fore and aft sides.
Stern Thrusters	ST	It is the propeller system located at the stern of the ship that helps manoeuvres.
Integrated Bridge System	IBS	It is the case that the ship's bridge equipment is a system that is connected in terms of species. It is the state of being able to control every device from a single place at the same time.
Ship Rudder System Type (Flap; Backy; Azimuth)	SRST	It is the knowledge of the type of the ship's steering system.
M/E System Type (Cpp, Fix Propeller)	MST	It is the type of machine propeller system.
Voyage Area (A1, A2, A3, A4)	VA	It is the permitted navigational area for the ship's communication systems in the Global Maritime Distress Safety System (GMDSS) system.
Slop Tank Capacities	STC	It is the expression in m3 of the maximum capacity that the specified Slop tanks can take, excluding the cargo tanks.
Ship Cargo Line Reducer Quantities	SCLRQ	It indicates the size, type and system type of the attachments that provide the connection of the ship cargo lines to the shore manifolds.
Accommodation Place Area Size	APAS	The ship's living space is of sufficient volume and it meets the personnel needs.
Bridge Equipment Type	BET	They are the characteristics of bridge devices in terms of brand, model and number.
Evaporate Water-Producing Capacities	EWPC	It is the equivalent of the daily amount of water produced by the ship's water-making machine during the cruise, in tons.
Cargo Pump Location	CPL	It is the location of the fixed-cargo pumps on the ship.
Ship Age	SA	It is the year of service from the construction of the ship to the present day.
Cargo Type	CT	It is characteristic of the type of cargo carried by ships in chemical tankers.
Permissible Cargo Carriage	PCCD	It is the value of the maximum transport

Density		density allowed by the cargo tanks.
Max Permissible Cargo Temprature	MPCT	It is the value in degrees of the maximum transport temperature allowed by the cargo tanks.
Remaining Cargo Quantities After Discharging (As Per P&A Manual)	RCQAD	It is the amount of cargo that the cargo pumps cannot press after discharge in the cargo tanks of the ship.
Ship Past Accident or Incident Number	SPAIN	If there is a serious accident that the ship has experienced before, it is the numerical value of this.
Ship Past Inspection Remark Numbers	SPIRN	It is the number of deficiencies written in previous Chemical Distrubition Instutute (CDI), Port State Control (PSC) and Ship Inspection Programme (SIRE) inspections of the ship.
Ship Deck Paint Condition	SDPC	Indicates the state of the ship's deck paint condition.
M/E And Aux Engine Running Hours	MAERH	Indicates the working hours of the main and auxiliary machines until this time.
Single Cabin Quantities	SCQ	It is the number of single cabins in which the personnel in the ship accommodation space can stay.
Social Activity Places Sufficient	SAPS	It is the state of the social activity areas in and outside the ship's living quarters. Such as a swimming pool, and gym.
Bunker Tank Capacities	BTC	It is the total capacity of the fuel tanks. Fuel Oil (FO) and Diesel Oil (DO) tanks can be separated.
Cargo Hose Crane	CHC	It refers to the status of the fixed cranes that enable the cargo hoses to be carried in operations.
Ship Security Level	SSL	Indicates the ship's security level under ISPS and the situations in which the security is breached.
Equipment Cost	EC	Expresses the costs of ship equipment.
Provision Cost	PC	It is the monthly price equivalent of the monthly and 15-day provisions.
Monthly Charterer Fee	MCF	It is the charterer's cost of the ship. It is the monetary amount paid to the ship owner monthly.
Ship Carrying Cost	SCC	It is the transportation cost of the ship in the voyage charter per unit ton.
Ship Maintenance Cost	SMC	It is the monthly monetary value of the ship's maintenance and repair expenses.
Insurance Cost	IC	Annual insurance costs of the ship.
Maintenance Attitude Efficiency	MAE	Maintenance is the equivalent of the ship's

		operational efficiency in terms of attitude.
Communication Cost	CC	It is the monetary compensation paid to satellite devices used in shipboard and company communications. This includes the internet fee.
Ship Seaworthiness	SS	The ship's seaworthiness and good equipment.
Fire Equipment	SE	Ship fire fighting equipment is suitable according to SOLAS and is in good condition.
Ship Surface View	SSV	The physical state of the ship's surface visible areas.
Ship Underwater View	SUV	It is the physical condition of the underwater areas of the ship. The level of pollution and the presence of damaged areas are important here.
Sts Suitability	STSS	It qualifies the ship's suitability for the ship to ship transfers. Equipment, rope and fixed circuits must be suitable.
Galley Space Volume	GSV	The size of the galley is hygienic and suitable for cooking.
Ballast System Type	BST	It includes controlling the ballast system manually or remotely.
Cargo Tank Shape Type	STST	It includes the physical shape of the cargo tanks. If there are blind spots in the cargo tanks here, a troublesome cleaning operation occurs.
Safety Equipment Type	SET	It is the conformity of ship safety equipment according to SOLAS.
Fixed Gas Sampling Type	FGST	It is the type and working principle of the ship's stationary gas measurement system.
Cargo Control Room Type	CCRT	The location of the ship's cargo control room and how its system is easy.

Table A2: The Criteria Revealed in the First Delphi Round

Criteria	Mean	Standard Deviation	Q3(%75)	Median	Q1(%25)	Quarter Width
TMDT	3,92	0,67	4	4	3,25	0,75
UWL	3,67	0,89	4,75	3	3	1,75
BT	4,38	0,79	5	5	4	1
FST	4,58	0,65	5	5	4,25	0,75
LBDO	3,92	0,51	4	4	4	0
CHS	4,25	0,78	5	4,5	4	1
CTC	4,65	0,62	5	5	5	0
CL	3,92	0,67	4	4	3,25	0,75
CTQ	4,36	0,79	5	5	4	1
STP	2,75	0,87	3	3	2	1
ABT	3,08	0,67	3,75	3	3	0,75
ICT	4,24	0,78	5	4,5	4	1
MD	3,25	1,29	4,75	3	2,25	2,5
BS	3,58	0,79	4	4	3	1
FS	3,17	0,72	4	3	3	1
USCG	3,92	0,90	4,75	4	3,25	1,5
TRS	3,92	0,79	4,75	4	3	1,75
PC	3,92	0,51	4	4	4	0
AT	2,83	0,72	3	3	2	1
SDT	3,42	1,00	4	3	3	1
CPC	4,25	0,67	5	5	4	1
CPT	4,33	0,67	5	4,5	4	1
MT	3,92	0,67	4	4	3,25	0,75

BCMLMS	4,35	0,67	5	5	4	1
BCMLES	3,92	0,67	4	4	3,25	0,75
BCBMS	3,92	0,51	4	4	4	0
BCBES	3,92	0,67	4	4	3,25	0,75
IS	4,36	0,67	5	5	4	1
NS	3,92	0,29	4	4	4	0
DWT	4,20	0,75	5	4	4	1
GT	3,50	0,52	4	3,5	3	1
SH	3,42	0,79	4	3	3	1
SD	3,67	0,65	4	4	3	1
SPC	4,12	0,67	4,75	4	4	0,75
SFLS	3,92	1,00	5	4	3	2
SCS	3,58	1,00	4	4	3	1
VCCT	4,43	0,67	5	5	4	1
MSSMTS	3,67	0,89	4	4	3	1
SMS	3,67	0,65	4	4	3	1
WQP	3,67	0,78	4	4	3	1
MRQ	3,33	0,78	4	3,5	3	1
ST	2,42	0,90	3	2	2	1
IBS	3,25	0,75	3,75	3	3	0,75
SRST	3,50	0,80	4	3,5	3	1
MST	3,50	0,80	4	3,5	3	1
VA	3,83	0,72	4	4	3	1
STC	3,50	0,80	4	3,5	3	1
SCLRQ	3,50	0,52	4	3,5	3	1

APAS	3,17	0,72	4	3	3	1
BET	3,75	1,06	4,75	4	3	1,75
EWPC	4,03	0,67	4,75	4	4	0,75
CPL	4,28	0,67	5	5	4	1
SA	4,20	0,52	5	4,5	4	1
CT	3,92	0,29	4	4	4	0
PCCD	3,92	0,67	4	4	3,25	0,75
MPCT	4,22	0,67	5	4,5	4	1
RCQAD	3,50	1,09	4,75	3	3	1,75
SPAIN	4,50	0,52	5	4,5	4	1
SPIRN	4,13	0,58	4,75	4	4	0,75
SDPC	3,25	0,97	4	3,5	3	1
MAERH	4,21	0,52	5	4,5	4	1
SCQ	3,92	0,51	4	4	4	0
SAPS	3,08	0,90	4	3	3	1
BTC	4,22	0,62	5	4	4	1
CHC	3,67	0,89	4	4	3	1
SSL	3,42	1,00	4	3,5	3	1
EC	3,33	1,23	4	4	3	1
PC	2,92	1,08	4	3	2,25	1,75
MCF	4,19	0,65	5	4	4	1
SCC	3,92	0,79	4,75	4	3	1,75
SMC	3,83	1,11	4,75	4	3,25	1,5
IC	3,92	0,79	4,75	4	3	1,75
MAE	3,92	0,90	4,75	4	3,25	1,5

CC	3,75	0,87	4	4	3	1
SS	3,92	0,79	4,75	4	3	1,75
SE	3,92	0,90	5	4	3	2
SSV	3,50	0,67	4	4	3	1
SUV	3,83	0,72	4	4	3	1
STSS	3,83	0,94	4,75	4	3	1,75
GSV	3,50	0,52	4	3,5	3	1
BST	3,33	0,67	5	4,5	4	1
STST	3,50	0,67	4	4	3	1
SET	4,29	0,67	5	4,5	4	1
FGST	3,83	0,94	4,75	4	3	1,75
CCRT	3,89	0,49	4,25	4	4	1,25