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Quantitative Analysis of Maritime Safety Based on Ordered Logistic Regression Model

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Abstract

With the continuous development of the world economy and technology, the communion between countries is increasingly strengthened, which leads to the rapid growth of international trade volume and the constant increase of the demand for maritime transportation. The occurrence of maritime accidents will not only bring huge economic losses but also seriously pollute the marine ecological environment. Therefore, Maritime traffic safety has drawn much attention nowadays. Maritime traffic safety is the focus of current research in maritime fields. This paper comprehensively analyzes and studies related research results in maritime and other fields at home and abroad, and makes a detailed classification and explanation of risk factors affecting maritime traffic safety. Due to the establishment of ordered logistic regression models, the influence degree of different maritime risk factors on maritime traffic safety is quantitatively evaluated and analyzed, and then specific suggestions and countermeasures are proposed. The results of this study will also help relevant government departments and policymakers to adopt appropriate and effective strategies to prevent global water safety accidents.

Keywords

Maritime traffic safety; Ordered logistic regression model; Quantitative assessment; Human factor; Ship factor.

1. INTRODUCTION

Marine transportation has advantages that other transportation modes such as road transportation and air transportation do not have, such as huge transportation capacity, large capacity, low freight, and strong adaptability to the goods carried. Besides, marine transportation also has the unique geographical advantages of the world, so marine transportation has gradually become the main mode of trade between countries in the world today. However, the increase of trade volume is accompanied by an increase in the number of ships and an increase in navigation density, and the overall navigation environment is deteriorating. Besides, the shipping market is gradually moving towards the direction of large-scale, specialized, and high-speed ships, which also greatly increases the risk of causing water traffic accidents.

Once a water traffic accident occurs, the possible losses and harms are immeasurable. Therefore, to reduce and avoid the occurrence of marine accidents on ships, it is necessary to strengthen the research on the causes of waterborne accidents on ships and to grasp the influencing factors that lead to accidents.

The research purpose of this article is to establish a valid, comprehensive and reasonable maritime safety evaluation system by constructing an ordered logistic regression model, and

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conduct qualitative and quantitative analysis of the risk factors affecting water traffic safety to determine the factors that most affect water traffic safety, thus assisting relevant government departments and policymakers to adopt appropriate and effective strategies to prevent global water safety incidents.

The rest part of this paper is structured as followed: Section 2 presents a review of the relevant literature on the research of marine traffic safety and logistic model. Section 3 gives a brief introduction to the methodology of this study and an assessment of the influencing factors affecting marine safety is described in Section 4. We explain the data source and count accidents according to different factors in Section 5. Section 6 is dedicated to the detailed establishment of the model and result discussion. The paper's conclusions are summarized in Section 7.

2. LITERATURE REVIEW

2.1. Research on Maritime Traffic Safety Assessment

To prevent and reduce the occurrence of maritime traffic accidents and to realize safe and efficient maritime transportation, people have studied the marine traffic system composed of man-ship-environment in many aspects. Based on the summary and analysis of previous research results, (Shao Z, 2001) applied the control theory, fuzzy reasoning system, neural network and computer simulation to the research field of quantitative evaluation of marine traffic safety. According to the control theory and the method of fuzzy inference system, he also established FIS maritime traffic safety evaluation model and considering the mutual influences of human factors, ship factors and environmental factors of the risks of manipulating the ship in the maritime traffic safety system, the safety of the man-ship environmental system was comprehensively evaluated. Based on the investigation into the safety situation of China's coastal waters, (Hu and Zhang, 2012) used the "formal safety assessment" method of the international maritime organization to analyze the hazard and accident characteristics of the coastal waters, and proposed some risk control schemes based on the resulting risk distribution results. (Kujala et al., 2009) analyzed the safety of maritime traffic in the Gulf of Finland. They first calculated the detailed accident data over the past ten years and then studied the risk of ship collisions at two locations using theoretical models. Finally, the results of the theoretical model were compared with actual accident statistics. (Hashimoto and Okushima, 1990) proposed a method to measure the effectiveness of policy to improve maritime traffic safety in shipping channels. They used operational models involving traffic, navigation and ship characteristics, and used them to quantify the risk of collision and deviation in actual navigation. Also, traffic control, speed regulation, and midline indication were considered as channels safety policies and these models were used to assess their impact.

The water transportation system is a complex dynamic system composed of multiple factors such as human, ship, environment, management and other elements, while the water traffic accident is the damage process caused by the coupling imbalance of human, ship, environment, management and other influencing factors. The relationship between accident influencing factors and accidents reflects the potential characteristics and rules of accidents, and the studies of accident influencing factors are conducive to digging out the deep causes of accidents. Considering the different severity of water traffic accidents, (Zhang L, 2017) made an in-depth study on the causes of accidents from the perspective of the relationship between accidents and human, ship, environment, management and other factors by using decision tree and other theoretical methods. (Su B, 2006) synthesized some research results in the maritime field at home and abroad, explained the concept of human factors in the maritime field, determined the nature, content and the performance of human factors in the maritime field, revealing the role of human factors to provide technical support for eliminating the negative effects of human factors in the maritime field. After analyzing human factors in maritime affairs, (Zeng H, 2000)

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used a combination of qualitative and quantitative analysis, and established a quantitative evaluation model of human factors with the help of mathematical tools of the fuzzy inference method. Finally, he used the software in MATLAB engineering calculation software. The fuzzy toolbox realized the computerization of the model, which can conveniently and intuitively give the size of the evaluation value and its trend that changes with various factors. Based on the historical data of global oil spill accidents from 1970 to 2015, (Chen et al., 2018) established an entropy weight grey correlation analysis method to analyze the key factors of oil spill accidents and evaluated the influence degree of each factor in different ship operations. (Puisa et al., 2018) introduced the analysis results of passenger ship maritime incidents and accidents in the past ten years to clarify the general causality. The research aimed to provide valuable information for strengthening the overall maritime safety control and active safety management at the ship and shipping company level opinion.

2.2. Research on the Logistic Regression Model

This study applies a logistic regression model to determine the role of various risk indicators that affect the probability of the occurrence of maritime accidents and rank the relative importance of different influencing factors. The logistic regression model is a proven and powerful modeling tool that predicts the probability of the consequences of an accident by filling in data in the logarithmic curve of the utility function. Nowadays, logistic regression models are widely used in the fields of automatic disease diagnosis, data mining, economic forecasting, etc. to study the influencing factors of events and to predict the occurrence probability of incidents based on risk factors.

(Yu A, 2003) gave a detailed explanation of the types, ecological significance, and limitations of Logistic models, and introduced the corresponding improved models obtained by different scholars for their limitations. (Shi C and Zhang M, 2005) did a more detailed analysis of the logistic regression model. By explaining the relationship between regression analysis and probability assumption, and incorporating the regression model into the generalized linear model framework for derivation and analysis, it is convenient to comprehensively understand the regression model and its theoretical basis and construction method, which is beneficial to the reasonable application of the regression model.

To explore the influencing factors of road traffic accidents in megacities and analyze the spatiotemporal distribution of the severity of traffic accidents, (Chen Y, et al., 2018) based on the binary logistic regression model, proposed an identification method of influencing factors of traffic accidents to discuss the impact of time, weather, visibility, lighting conditions, road linearity, road physical isolation and other 14 road environmental factors on the severity of traffic accidents. Based on the 2013 data provided by Divvy system in Chicago, (Faghih-Imani and Eluru, 2015) applied the random utility maximization method in the form of multinomial logit model (MNL) to study the decision-making process of identifying the destination position after picking up the bicycle at the bike-sharing system (BSS) station. (Thrane, 2015) used survey data, combined with actual travel behavior and multinomial Logit (MNL) regression model, to study how travel distance in kilometers and hours, some travel-related characteristics and some socio-demographic variables affect the choice of transportation mode. (Bai S, 2010) established the credit default probability model of enterprise supply chain financing by using the ordered multi-classification logistic model, and proposed the credit default probability estimation methods of different grades. (Rezapour et al., 2019) applied an ordered logit model to study the influencing factors of the severity of degraded crashes.

The above research reports all have a certain practical and theoretical significance and provide basic methods, ideas, and means for this study. By analyzing the above-mentioned research status at home and abroad, there are few studies on applying the logistic model to maritime safety assessment, and this method is feasible. Therefore, according to the

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characteristics of the data in this study, we used ordered Logistic regression analysis to analyze the factors affecting maritime traffic safety.

3. METHODOLOGY

When you study the effect of X on Y, if Y is quantitative data, you can use linear regression analysis, and if Y is fixed, logistic regression analysis is required. The goal of logistic regression is to determine the most appropriate model that describes the relationship between the categorical dependent variables and a set of independent or explanatory variables. The logistic regression model fits the data of the influencing factors into a logarithmic curve of a logarithmic function. There are three types of Logistic regression: binary Logistic regression, multiple Logistic regression and ordered Logistic regression. According to the characteristics of data samples collected in this paper, we adopted the method of ordered Logistic regression analysis.

The definition of an ordered logistic model is as follows (Peng J, 2009):

$$y^* = \alpha + \sum_{i=1}^{n} \beta_i Z_i + \varepsilon$$

Where y^* indicates the inherent trend of the observed phenomenon, which cannot be directly measured; ε is the error term; α is the constant term; β_i is the coefficient term.

When the observed response variable consists of J categories $(\mathrm{j} = 1, 2, \cdots, \mathrm{J})$, the corresponding values are y = 1, y = 2, ⋯, y = J, and the relationship between the values is $(\mathrm{y} = 1) < (\mathrm{y} = 2) < \cdots < (\mathrm{y} = \mathrm{J})$, then there are a total of J-1 unknown boundary points to separate each adjacent category, which is:

If $y^* \leq \mu_1$, then y = 1;

If $\mu_1 \leq y^* \leq \mu_2$, then y = 2;

……

If $\mu_{j-1} \leq y^*$, then y = J;

Where μ_J represents a demarcation point, it has J-1 values, which is $\mu_1 < \mu_2 < \mu_3 < \cdots < \mu_{J-1}$. In the parameter estimation process, the first boundary point μ_1 is usually defined as 0, which can reduce one parameter estimation. Since the setting of this scale is arbitrary, it is feasible to start or end at any order. Therefore, after defining $\mu_1 = 0$, there will be J-2 μ values to be estimated.

The cumulative probability of a given Z value can be expressed as:

$$\begin{aligned} \mathrm{P}(y \leq j) &= p\left(y^* \leq \mu_j\right) \\ &= p\left[\left(\mathrm{\alpha} + \sum_{i=1}^{n} \beta_i Z_i + \varepsilon\right) \leq \mu_j\right] \\ &= p\left[\varepsilon \leq \mu_j - \left(\alpha + \sum_{i=1}^{n} \beta_i Z_i\right)\right] \\ &= F\left[\mu_j - \left(\alpha + \sum_{i=1}^{n} \beta_i Z_i\right)\right] \end{aligned}$$

In this paper, the classification variable y (y = 1, 2,) can be introduced to indicate the severity of maritime accidents (1 for small and medium-sized accidents, 2 for large-scale accidents). Where $\mathrm{P}(y = j)$ represents the probability of the accident.

Similar to the binary logistic model, an ordered logistic model can be defined as:

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$$\ln\left(\frac{P(y\le j)}{1-P(y\le j)}\right)=\mu_j-\left(\alpha+\sum_{1}^{n}\beta_i Z_i\right)$$

Where $P(y \le j)$ can be estimated by:

$$P(y\le j)=\frac{e^{[\mu_j-(\alpha+\sum_1^n \beta_i Z_i)]}}{1+e^{[\mu_j-(\alpha+\sum_1^n \beta_i Z_i)]}}$$

Once $P(y \le j)$ is calculated, the probability of each category can be expressed as:

$$P=(y=j)=P(y\le j)-P\big(y\le (j-1)\big)$$

4. ASSESSMENT OF MARITIME SAFETY INFLUENCING FACTORS

4.1. Maritime Risk Characteristics

(1) Objectivity. Maritime risks exist objectively, so people can only change the conditions that lead to the formation and development of maritime risks within a certain range, thereby reducing the probability of maritime accidents and minimizing risk losses, and they cannot eliminate maritime risks.

(2) Uncertainty. Maritime risk is objective, but for a specific maritime risk loss, its occurrence is uncertain and unpredictable. Loss is an inevitable consequence of the risk. People can only understand and understand maritime risk, and then strictly prevent the occurrence of risk accidents, and minimize the damage caused by risks.

(3) Universality. In the course of ship operation, maritime risks are always present, may occur at any place and at any time, and pose a threat to the safety of the environment, human life and property. With the increase in the size of ships and the increasing volume of international trade in the world today, the losses caused by maritime accidents are also increasing.

(4) Testability. Although the study of the occurrence of a single risk is uncertain, the probability of a water traffic accident is measurable from the perspective of studying the overall risk. To study the laws of risk, you can use probability theory or the law of large numbers to statistically analyze the probability of overall risk accidents.

4.2. Classification of Maritime Risk Factors

Various factors are leading to maritime accidents and they involve many aspects. Each factor is interrelated or independent, and each factor has a different degree of influence on the scale of maritime accidents. In general, marine transportation systems are complex dynamic systems composed of four elements: people, ships, environment, and management. Correspondingly, water traffic accidents are directly induced by these factors. When there are several types of unsafe conditions, hidden dangers will occur and further cause water traffic accidents (Zhang L, 2017). The following figure describes the basic factors affecting the navigation safety of ships and their interrelationships.

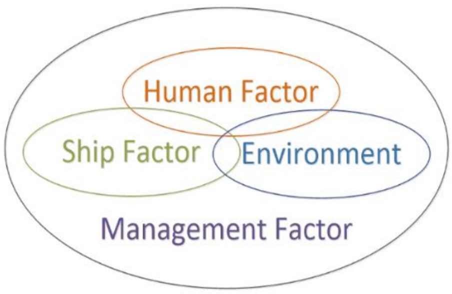

Figure 1. Basic factors affecting ship navigation safety and their interrelationships

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Since the accidents involved in the accident reports collected in this study were mainly caused by human and ship reasons, this article mainly discusses the aspects of ship factors and human factors.

(1) Human Factor

The human factor refers to a wrong behavior in which a person fails to perform its proper function and causes a system failure or a malfunction. Numerous studies have shown that the human factor is the main cause of maritime traffic accidents. Statistics from IMO documents show that more than 80% of maritime accidents are related to human errors (Hao Y, 2017).

The human factors include many aspects: (1) the unsafe supervision of ship personnel, that is, the watchman has not maintained sufficient lookout or has not adequately monitored the use of radar and other instruments, or the manager knows the defects in a certain safety field but do not correct the problem, etc.; (2) the poor state of the ship's crew, that is, the mental fatigue of the ship's pilot, or the influence on the crew's judgment caused by sickness or taking drugs, or the lack of experience of the ship's crew; (3) unsafe behaviors of ship personnel, that is, decision-making mistakes of crew members, or unauthorized departure of responsible personnel from their posts, or crew members' failure to comply with safety regulations., etc.

In this study, we collected and analyzed the 156 marine accident reports, and finally selected the 6 human factors that occurred most frequently. The six human factors were insufficient lookout, insufficient communication, insufficient consideration of environmental factors, misjudgment of the route, improper ship operation, and improper emergency measure.

(2) Ship Factor

The ship factor refers to the role played by the structure, strength, performance, machinery, and equipment of the ship in the occurrence of the accident. It includes ship age, ship type, the gross tonnage of ships, navigation control equipment, course stability, status and performance of navigation aids, heading maintenance, ship braking and turning performance, etc.

In this study, we selected ship type, ship age and the gross tonnage of the ship as the main 3 ship factors affecting marine traffic safety.

4.3. Marine Accident Type

At present, countries around the world have related regulations on the classification and definition of maritime accidents. Although the details differ, the basic principles are the same. The types of maritime accidents mainly include the following:

(1) Collision accident; (2) Stranded accident; (3) Reef accident; (4) Touch damage accident; (5) Wave damage accident; (6) Fire and explosion accidents; (7) Windstorm disaster; (8) Sinking accident; (9) Other maritime accidents that cause personal injury or death or bring direct economic losses.

Based on the 156 accident investigation reports collected in this paper, we collected statistics and sorts out the types of maritime accidents involved, which are mainly divided into six categories: collision, fire or explosion, stranding or sinking, equipment failure, accidents caused by natural disaster and other accidents.

5. DATA

5.1. Data Source

We selected 156 water safety accident investigation reports published by Shenzhen Maritime Safety Administration, Shanghai Maritime Safety Administration and Hebei Maritime Safety Administration considering the quality and convenience of the accident report, and made statistics according to the accident severity, accident type, ship type, and human factors.

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5.2. Data Statistics

5.2.1 Statistics by Accident Severity

In this paper, the accident levels involved in 156 accident reports are divided into two categories: small and medium-sized maritime accidents and large-scale maritime accidents. According to statistical results, small and medium-sized maritime accidents accounted for 103, while large-scale maritime accidents were 53. The proportion of accident severity is shown in figure 1 below.

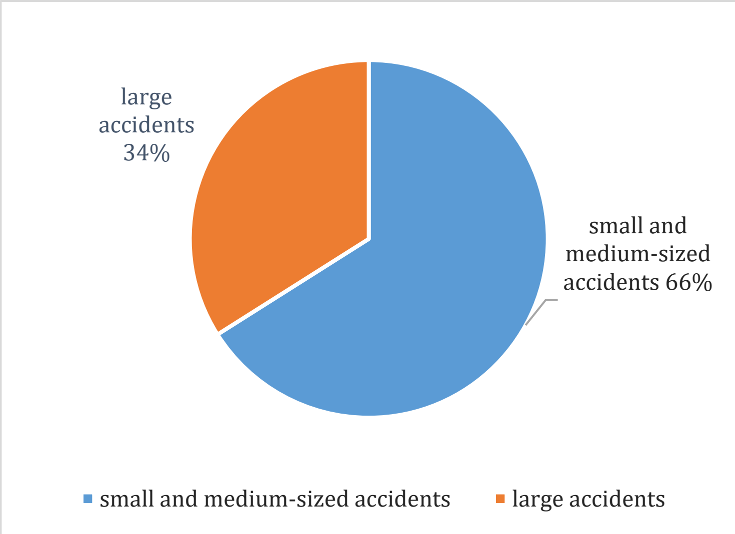

Figure 2. Statistics by accident severity

5.2.2 Statistics by accident type

In this paper, there are six types of maritime accidents involved in 156 accident reports: collision, fire or explosion, failure of ship equipment or machinery, stranding or sinking, maritime accidents caused by natural disasters, and other accidents. Among them, there were 105 collision accidents, 29 grounding or shipwreck accidents, 8 other accidents, 7 fire or explosion accidents, 4 equipment or machine failure accidents, and 3 maritime accidents due to natural disasters. The statistical results are shown in figure 2 below.

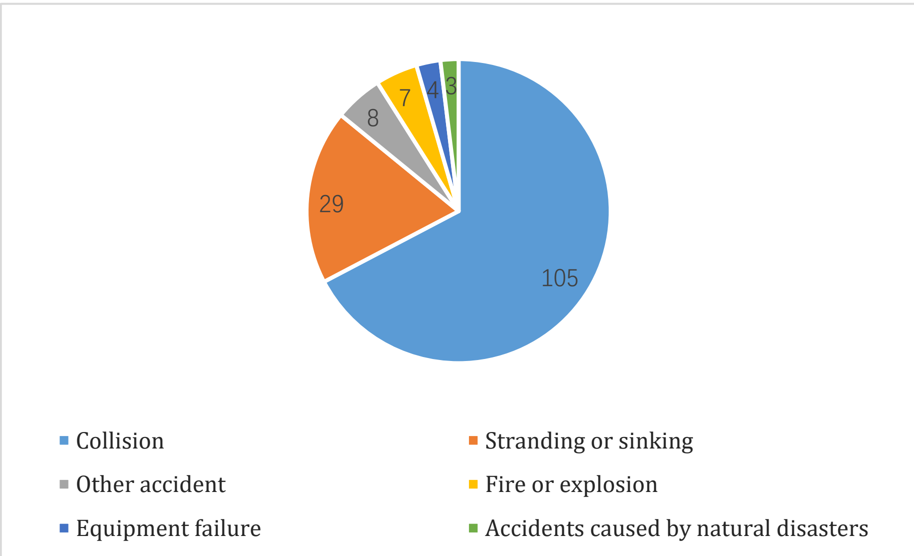

Figure 3. Statistics by accident type

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5.2.3 Statistics by ship type

In his paper, we classify the 156 accident reports into six categories: container ship, dry cargo ship, fishing boat, oil tanker, passenger ship and other ship. Among them, there were 84 dry cargo ships, 26 container ships, 18 other ships, 13 oil ships, 8 passenger ships and 7 fishing boats. The statistical results are shown in figure 3 below.

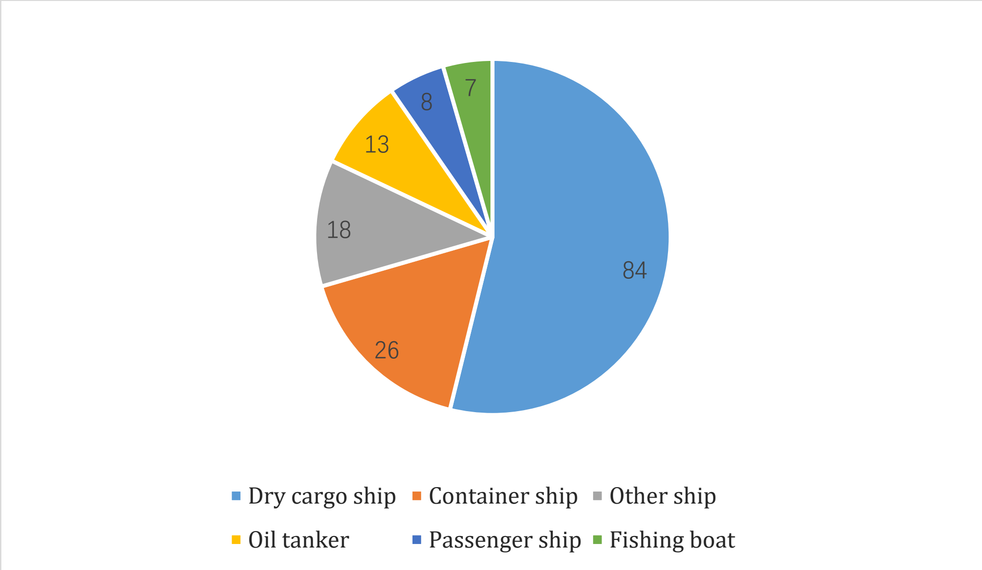

Figure 4. Statistics by ship type

5.2.4 Statistics by human factor

In this study, we sorted out the human factors involved in the 156 accident reports and selected the six human factors most likely to cause maritime accidents: improper lookout, improper communication, insufficient consideration of environmental factors, misjudgment of route, improper ship operations, and improper emergency measure. The statistical results are shown in Figure 4 below.

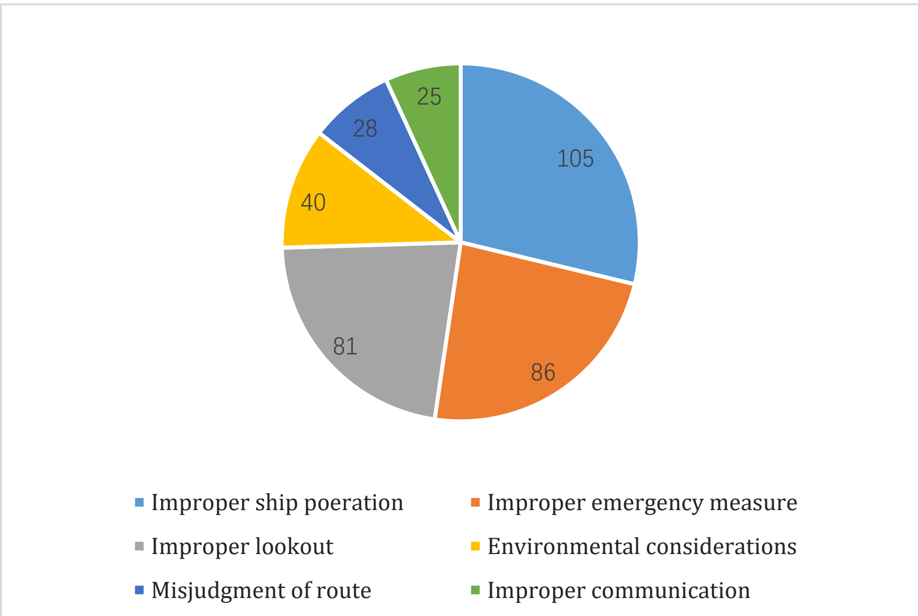

Figure 5. Statistics by human factor

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6. MODEL APPLICATION AND RESULT DISCUSSIONS

To explore the significant factors affecting water traffic safety, this paper established a maritime safety risk assessment system, and verified the risk factors affecting water traffic safety through stepwise regression and Logistic regression of the independent variables, thus obtaining the significant risk factors.

6.1. Variable definition and description

According to the data results of the 156 water traffic accident investigation reports in this paper, we choose the accident severity as the dependent variable, and assign it the value of "1 =small and medium-sized accident, 2 = large-scale accident". After integrating and grouping, we selected the accident type, 6 human factors, 3 ship factors as independent variables, as described in the following table. These 9 independent variables include categorical variables and continuous variables.

Table 1. Variable definition and description

Variables			Description and measurement
Dependent variable			
Accident severity		Small and medium-sized accident	1 If the accident is a small or medium-sized accident
		Large-scale accident	2 If the accident is a large-scale accident
Explanatory variables			
Accident type		Collision	1 If the accident type is collision
		Fire or explosion	2 If the accident type is fire or explosion
		Equipment failure	3 If the accident type is equipment failure
		Stranding or sinking	4 If the accident type is stranding or sinking
		Natural disaster	5 If the accident type is an accident caused by natural disasters
		Other	0 otherwise
Human factor		Improper lookout	1 If an improper lookout, 0 otherwise
		Improper communication	1 If an improper communication, 0 otherwise
		Environmental consideration	1 If an insufficient consideration of environmental factors, 0 otherwise
		Misjudgment of route	1 If a misjudgment of the route, 0 otherwise
		Improper ship operation	1 If an improper ship operation, 0 otherwise
		Improper emergency measure	1 If an improper emergency measure, 0 otherwise
Ship factor	**Ship type**	Container ship	1If the ship type is a container Ship
		Dry cargo ship	2 If the ship type is a dry cargo ship
		Fishing boat	3 If the ship type is a fishing boat
		Oil tanker	4 If the ship type is an oil tanker
		Passenger ship	5 If the ship type is a passenger ship
		Other	0 otherwise
	Gross tonnage of the ship		Continuous variable
	Ship age		Continuous variable

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6.2. Modeling Process

6.2.1 Correlation analysis

Because the dependent variable is rank-ordered, the chiral test is used for correlation analysis of the categorical independent variables, and the Spearman correlation coefficient method is used for correlation analysis of the continuous independent variables. The results obtained are as follows.

Table 2. Chi-square test results

	Variable	small and medium-sized	large-scale accident	χ^2	p
Accident type	Collision	64	41	7.9416	0.159
	Fire or explosion	5	2		
	Equipment failure	2	2		
	Stranded or sunken	21	8		
	Natural disaster	3	0		
	Other	8	0		
Human factor	Improper lookout	49	32	2.2984	0.130
	Improper communication	18	7	0.4737	0.491
	Environmental consideration	32	8	4.6830	0.030
	Misjudgment of route	20	8	0.4441	0.505
	Improper ship operation	69	36	0.0139	0.906
	Improper emergency measure	50	36	5.3136	0.021
Ship type	Container ship	18	8	19.5757	0.002
	Dry cargo ship	55	29		
	Fishing boat	0	7		
	Oil tanker	12	1		
	Passenger ship	7	1		
	Other	11	7		

Table 3. Spearman correlation coefficient

	Gross tonnage of the ship	Ship age
Accident severity	-0.0745	-0.1490*

* indicates significant at the 10% level.

From the above results, the P-value of the environmental consideration and improper emergency measure is less than 0.05, and the P-value of the ship type is less than 0.01, indicating that there are significant differences in the distribution of the grade of maritime accidents in these three indicators. At the same time, the correlation coefficient between maritime accident severity and ship age is significant at the level of 10%. Therefore, it is preliminary judged that here may be a certain correlation between the accident severity and environmental

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consideration, improper emergency measure, ship type and ship age. In the following steps, the regression analysis method will be used for in-depth analysis.

6.2.2 Regression analysis

According to the characteristics of the sample data, this paper uses the ordered logistic regression analysis method to analyze, and the results obtained are as follows.

Table 4. Regression analysis results

	Coefficient	Standard error	z	P
Collision	15.15745	1271.858	0.01	0.990
Fire or explosion	16.118	1271.858	0.01	0.990
Equipment failure	17.42422	1271.859	0.01	0.989
Stranded or sunken	15.37075	1271.858	0.01	0.990
Natural disaster	0.727026	2256.617	0.00	1.000
Improper lookout	0.503029	0.496691	1.01	0.311
Improper communication	-0.8157	0.64028	-1.27	0.203
Environmental consideration	-0.92666	0.526708	-1.76	0.079
Misjudgment of route	-0.95588	0.571874	-1.67	0.095
Improper ship operation	0.062036	0.479222	0.13	0.897
Improper emergency measure	1.190868	0.460698	2.58	0.010
Container ship	-0.75242	0.779907	-0.96	0.335
Dry cargo ship	-0.11334	0.64002	-0.18	0.859
Fishing boat	17.5434	1891.761	0.01	0.993
Oil tanker	-2.84562	1.321951	-2.15	0.031
Passenger ship	-1.42774	1.253455	-1.14	0.255
Gross tonnage of the ship	4.25E-06	1.13E-05	0.38	0.707
Ship age	-0.01859	0.029554	-0.63	0.529
Pseudo R2	0.2399			
LR chi2	47.97			
P	0.0002			

It can be seen that R2 is 0.2399, so fitness is acceptable. And the p-value of the overall model test is 0.0002, which is less than 0.01, indicating that the overall estimation result is ideal.

6.3. Discussion of Causes of Maritime Accidents

The following conclusions can be drawn from further analysis of the estimated results of the variables in the above table.

6.3.1 Accident type

In terms of maritime accident types, the corresponding P-values of the significance test of the estimated coefficients of the five dummy variables are all greater than 0.1, so these estimated coefficients did not pass the significance test, which indicates that the maritime accident types have no significant impact on the maritime accident severity.

6.3.2 Human factor

In terms of human factors, the P values of the significance test of the estimated coefficient of environmental considerations and the misjudgment of the route are less than 0.1, and the P-value of the improper emergency measure is less than 0.05. While the P-values of an improper lookout, improper communication and improper ship operation are all greater than 0.1, so the

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estimated coefficients of environmental consideration and misjudgment of the route pass the significance test at the level of 10%, and the estimated coefficient of improper emergency measure passes the significance test at the level of 5%. This shows that environmental consideration, misjudgment of the route, and improper emergency measures have a significant impact on the level of maritime accidents. Based on the positive and negative estimation coefficients, it can be seen that when the crew fails to fully consider environmental factors and the pilot's route judgment is not correct, it is more likely to cause small and medium-sized accidents; when the crew's emergency measure is improper, it is more likely to cause large-scale accidents.

This shows that the crew lacks experience, knowledge and skills, it fully reveals the importance and urgency of relevant management departments to improve the comprehensive quality of the crew. As far as the maritime departments are concerned, they should strengthen the supervision and management of seafarers' training. As for the shipping company, it is necessary to formulate different plans according to the different characteristics of the crew to ensure that the crew meets the requirements before they can take up their posts. To prevent accidents, a comprehensive plan must be formulated before the voyage, and various safety plans must be formulated for each possible safety accident.

6.2.3 Gross tonnage of the ship

The corresponding P-value of the estimated coefficient significance test of the ship's gross tonnage is greater than 0.1, so the coefficient fails the significance test, indicating that the ship's gross tonnage has no significant influence on the maritime accident severity.

6.2.4 Ship type

Regarding the type of ship, the P-value of the significance test of the estimated coefficient of the oil tanker is less than 0.05, which indicates that the oil tanker has a significant impact on the maritime accident severity. Specifically, when the ship type is an oil tanker, it is more likely to cause small and medium accidents. This reflects the need for maritime-related departments to focus on strengthening the supervision of this type of ship.

In daily operations, oil tankers are subject to oxidative corrosion of seawater and cargo oil, and external forces such as wave shocks and hull sway, so the hull will slowly corrode and damage and major problems will gradually occur. Therefore, to ensure the safety of the navigation of oil tankers, we must strengthen the maintenance of the oil tankers. The strength of the oil tanker's hull structure is also an important factor affecting its navigational safety. Periodic evaluation of the strength of the hull structure of oil tankers can promptly discover hidden safety hazards and also have a positive effect on preventing the occurrence of oil spills.

6.2.5 Ship age

The corresponding P-value of the significance test of the estimated coefficient of ship age is greater than 0.1, so the coefficient does not pass the significance test, which indicates that ship age does not have a significant effect on the maritime accident severity.

7. CONCLUSIONS

Appropriate quantitative analysis and assessment of the factors affecting maritime traffic safety will help to provide a strong scientific basis for the maritime traffic safety administration and effectively reduce the possibility of maritime accidents. Logistic regression model is established in this study, proposing an effective, comprehensive and reasonable maritime security evaluation system to identify the risk factors of the impact of water traffic safety, and assess the probability of each risk factors, thus specifically analyzing the risk factors that can most affect the water traffic safety to put forward concrete suggestions for improving maritime traffic safety.

According to the results of this paper, the government, relevant maritime departments and other stakeholders can make reasonable decisions on the prevention and treatment of Marine accidents. On the whole, the comprehensive quality of the crew and the tanker have a greater influence on the occurrence of marine accidents. Given this, it is recommended that government departments and policymakers take appropriate and effective measures to manage and prevent incidents based on these factors.

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REFERENCES

[1] Shao Z: Research on Assessment Models of Maritime Traffic Safety and Simulation Application (Ph.D., Dalian Maritime University, China 2001). p.1.

[2] Shao Z, Wu Z, and Fang X: Methods of safety quantitative evaluation in marine traffic system, Journal of Dalian Maritime University, (2002) No.1, p.9-12.

[3] Hu S, Zhang J: Risk Assessment of Marine Traffic Safety at Coastal Water Area, Procedia Engineering, Vol.45 (2012), p.31-37.

[4] Kujala P, Hänninen M, Arola T, et al.: Analysis of the marine traffic safety in the Gulf of Finland, Reliability Engineering & System Safety, Vol. 94 (2009) No.8, p.1349-1357.

[5] Hashimoto A , Okushima T: Evaluating marine traffic safety at channels, Accident Analysis & Prevention, Vol. 22 (1990) No.5, p.421-442.

[6] Zhang L: Analyis on Waterway Traffic Accident cause (MS. Dalian Maritime University, China 2017). p. 5.

[7] Su B: The Research For Human Element In Maritime Region (MS. Dalian University of Technology, China 2006) p.6.

[8] Zeng H: Analysis and Evaluation of Personal Factors for Affecting Navigation Safety (MS. Dalian Maritime University, China 2000) p.11.

[9] Puisa R, Lin L, Bolbot V, et al.: Unravelling causal factors of maritime incidents and accidents, Safety Science, Vol. 110 (2018), p.124-141.

[10] Chen J, Zhang W, Li S, et al.: Identifying critical factors of oil spill in the tanker shipping industry worldwide, Journal of Cleaner Production, Vol. 180 (2018), p.1-10.

[11] Yu A: A Study on Logistic Model (MS. Nanjing Forestry University, China 2003). p.5.

[12] Shi C, Zhang M: Analysis of Logistic regression models, Computer Aided Engineering, Vol. 14 (2005) No. 3, p.78-82.

[13] Chen Y, Li X, Sun Z, et al.: Identification mehod of factors affecting traffic accident based on Logistics, Technology & Economy in Areas of Communications, Vol. 20 (2018) No.5, p.1-5.

[14] Faghih-Imani A, Eluru N.: Analysing bicycle-sharing system user destination choice preferences: Chicago's Divvy system, Journal of Transport Geography, Vol. 44 (2015), p.1-12.

[15] Christer Thrane: Examining tourists' long-distance transportation mode choices using a Multinomial Logit regression model, Tourism Management Perspectives, Vol. 15 (2015), p.115-121.

[16] Hao Y, Hu S and Chen X: Grey relational analysis method for human error identification based on the MAIB accident reports, Journal of Safety and Environment, Vol. 17 (2017) No.3, p.1008-1010.

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[17] Bai S: A Research into the Risk Early warning of Enterprise Supply Chain Financing Based on Ordered Logistic Model, Economic Survey, (2010) No.6, p.72-77.

[18] Mahdi R, Mihan M and Khaled K: Ordered logistic models of influencing factors on crash injury severity of single and multiple-vehicle downgrade crashes: A case study in Wyoming, Journal of Safety Research, Vol. 68 (2019), p.107-118.

[19] Peng J, Tu H, He J, et al.: The Application of Ordered Logistic Regression Model in the Default Probability Measure, The theory and practice of finance and economics, Vol. 30 (2009) No.160, p.4-9.