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Analysis of Maritime Management in Far Sea Area Based on Logistic Regression Model

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Abstract

In recent years, with the attention paid to the water safety management of far sea area. As a maritime department that implements water safety responsibilities. it is necessary to enhance the comprehensive managers capabilities of managers officers and ensure the water safety of far sea area under severe water conditions and harsh conditions. An important work, this paper through the research on the widely used discrete choice model in the field of traffic behavior analysis, adopts the logistic regression method to study the impact of maritime management in far sea area, and analyzes the impact in the process of managers in far sea area. and apply the research results to the remote site in far sea area for empirical analysis, so as to improve the managers capabilities of maritime personnel and improve the level of maritime services.

Keywords

Far sea; Maritime Management; Maritime Services; Discrete Choice; Logistic Regression.

1. INTRODUCTION

The issue of water safety management in the far sea area has always been a challenge in the field of maritime managers. The far sea area face problems such as variable weather, harsh climate, complex navigation environment, and imperfect communication conditions. The maritime safety management of in the far sea area involves many aspects, covers a wide range of points, and is difficult to supervise. It is a weak point in implementing maritime management. There are no nearby land or islands in the far sea area, and ships often need to be in a 24-hour navigation state. Illegal activities that occur in the far sea area are relatively hidden, which pose a huge challenge to maritime regulatory capabilities. According to statistics from the Shanghai Maritime Search and Rescue Center, in the data of maritime search and rescue for the entire year of 2021, 62.5% of the searches and rescues occurred from the baseline of the territorial sea to the territorial sea line, and 67.1% of the casualties occurred. From this, it can be seen that the issue of water safety management in the far sea area is an urgent task to be solved. According to relevant literature analysis, the research on water safety management in the far sea area is still in a blank state. The purpose of this paper is to study the comprehensive managers capacity building of maritime management personnel in the far sea area, in order to explore the breakthrough point to solve the problem of water safety management in the far sea area.

Up to now, although the maritime management department has tried many solutions to the issue of implementing water safety management in far sea area, such as drone technology and electronic cruise control, it has also achieved certain results. However, there are still some safety management issues in some water areas, ultimately falling into the construction of managers teams. For some loopholes in water safety management, it is necessary to achieve specific problem analysis to ensure the comprehensive implementation of water safety management in the far sea area, and to implement the goal of safeguarding the far sea area.

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This paper attempts a new quantitative analysis method that applies the discrete selection model to the field of maritime managers and management. The discrete selection model is currently a widely used analysis method in the field of traffic behavior analysis, such as travel purpose selection, transportation tool selection, and travel preference selection. The theory is currently relatively mature in development. This paper applies discrete selection model analysis to the field of maritime managers, which is a new attempt. The purpose is to study the impact of maritime managers personnel on the implementation of maritime safety management in the far sea area under the influence of navigation environment, climate, boat driving, sailing distance, managers personnel, and other factors. Then, linear regression method is used to analyze and calculate the data, and a quantitative indicator table is established, By analyzing the results, the key influencing factors of water regulatory issues in the far sea area domain can be identified. Through the analysis of key factors, find solutions to solve the regulatory difficulties in the sea areas, strengthen water safety management capabilities, enhance the comprehensive managers capabilities of maritime personnel, and implement far sea maritime defense strategy.

2. LITERATURE REVIEW

2.1. Research on Maritime Management

Maritime management is an important guarantee for ensuring the safety of water traffic and waterway transportation. Many scholars have conducted research on this issue. (Yang,2011) conducted a risk analysis on the offshore supply chain in the Taiwan Strait. (Maria et al., 2014) Establishing a Bayesian Network Model for Maritime Safety Management. (Zhang, et al. 2022) analyzed the new system and potential impact of foreign ships sailing in China. (Qu, et al. 2023) studied the monitoring enhancement mode under deep learning for the use of maritime management in low visibility conditions. (Liu, et al. 2023) developed a traffic network data mining method for maritime transportation management. (Liu, et al.2023) research an improved FMEA method based on the expert trust network for maritime transportation risk management.

2.2. Research on the discrete choice and logistic regression model

Discrete choice approach is a method for multivariate analysis, widely used in sociology, medicine, biology, and more. (Laura, et al.2023) developed A discrete choice model based on Markov Chain Choice Model Used for product pricing. (Deng, et al.2023) Discrete choice models with Atanassov-type intuitionistic fuzzy membership degrees. (Samare, et al 2023) analysis The effect of cheap talk mitigation on internal and external validity of discrete choice experiments. (Ambuj, et al. 2023) Reducing sample size requirements by extending discrete choice experiments to indifference elicitation.

Logistic regression analysis is a generalized linear regression analysis model commonly used in fields such as data mining, automatic disease diagnosis, and economic prediction. (Wang, et al.2023) Learning non-parametric kernel via matrix decomposition for logistic regression. (Joshua et al. 2023) Using logistic regression models to predict the suitability of commercial wind farm site selection in the United States. (Nuttanan, et al 2023) Random feature selection using random subspace logistic regression. (Fang et al. 2023) Using logistic regression model to construct a cross-border e-commerce talent training platform. (Kim, et al 2023) Estimating a model of forward-looking behavior with discrete choice experiments, analysis The case of lifetime hunting license demand. (Wu, et al 2023) Construct of a predictive model for osteoporosis related factors in postmenopausal women using logistic regression and Bayesian networks. (Du, et al 2023) Comparative Analysis of Logistic Regression and Gradient

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Enhancement Decision Trees. (Matt, et al 2023) A predictive analysis model for predicting the results of national rugby league matches using decision trees and logistic regression.

3. DATA

3.1. Data Source

This study used a questionnaire survey to obtain data. A total of 312 questionnaires were distributed in this study. Through the setting of auxiliary questions, 300 valid questionnaires were ultimately obtained, with a validity rate of 96%. The setting of the problem is divided into three aspects: Firstly, the basic information of managers personnel, mainly including gender, age, educational background, and other content; The second aspect is the navigation environment, mainly including navigation density, weather and sea conditions, etc; The third aspect is the regulatory content, mainly including ship safety inspections, on-site management and inspection, and emergency response to maritime emergencies. See Figure 1.

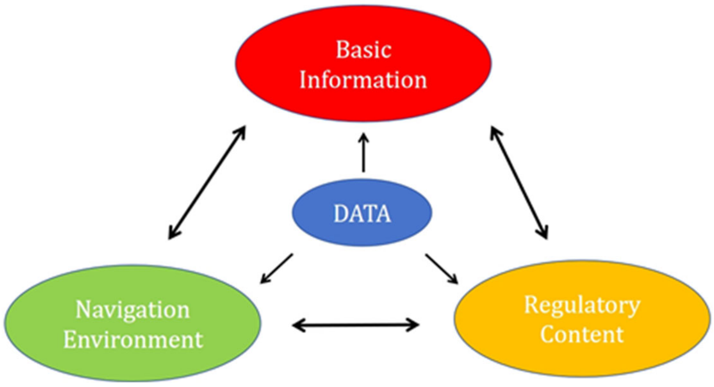

Figure 1. DATA Classification

3.2. Data Statistics

3.2.1. Basic Information of Managers Personnel

Among the managers personnel involved in the investigation, the proportion of males reached 67.7%, while females accounted for 32.3%. In terms of age, 20% are aged between 20 and 30, 31% are aged between 30 and 40, 25% are aged between 40 and 50, and 24% are aged over 50. Among them, in terms of educational background, undergraduate and master's degrees account for a relatively large proportion, accounting for 45% and 35.7% respectively, while specialized degrees account for 18%, and master's degrees or above account for 1.33%. Among the working years, the majority are 0-5 years and 15-20 years, accounting for 21% and 33% respectively. The proportion of navigation majors is 63%, and non navigation majors are 37%. According to the survey, 57% of personnel have managers experience in far sea field. See Figure 2, Figure 3, Figure 4, Figure 5.

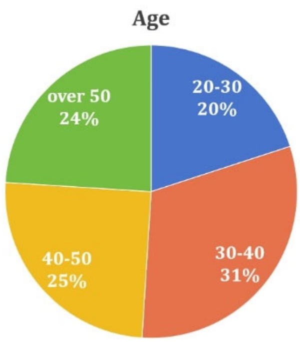

Figure 2. Age

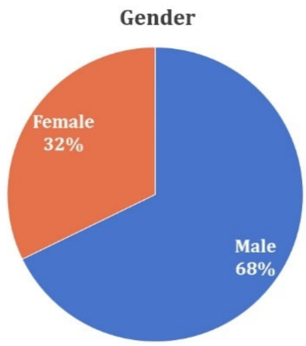

Figure 3. Gender

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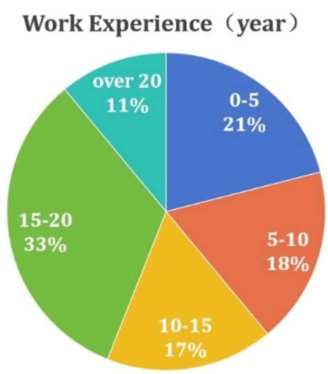

Figure 4. Work Experience

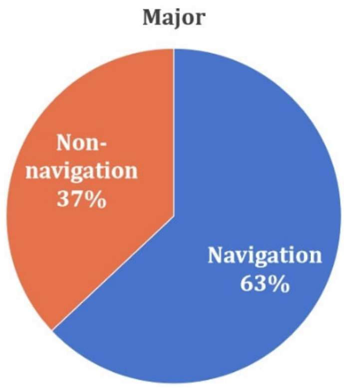

Figure 5. Major

3.2.2. Navigation Environment

In the process of managers in far seas area, it is usually constrained by the navigation environment. In this questionnaire survey, managers personnel generally believe that the impact of high navigation density on managers is significant when ships are in navigation. For harsh weather conditions, the impact is usually significant when rainfall occurs, dense fog is produced, and visibility is below 2nmile. In terms of time, managers personnel generally believe that during summer nights, it has a significant impact on maritime managers. See Figure 6.

3.2.3. Regulatory Content

In terms of maritime managers, in addition to implementing ship safety inspections and on-site management, emergency response to maritime emergencies is also an important content. managers personnel generally believe that in the event of a person falling into the water, it has the greatest impact on managers. In the process of ship safety inspection and on-site inspection, the proportion of life-saving and firefighting equipment and pollution prevention measures is the highest in the investigation of managers personnel. In addition, 57% of far sea areas maritime managers agencies have experience in driving wheel boats, and 18% have cruising distances of over 300nmile.

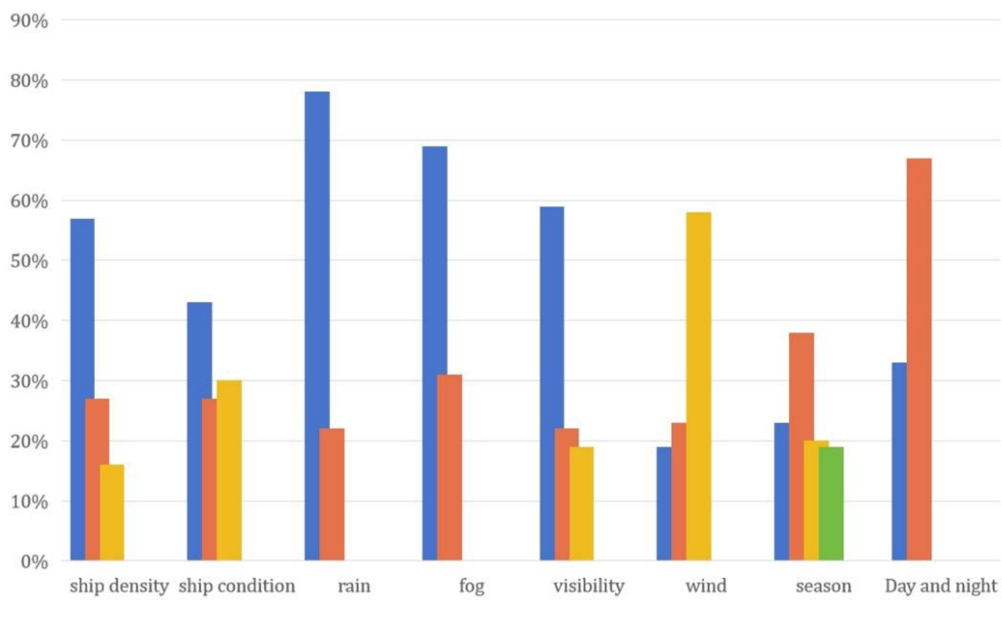

Figure 6. Navigation Environment

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4. METHODOLOGY

4.1. Logistic Regression Model

In order to explore the impact analysis of the far sea area on maritime managers capabilities, "*whether the far sea area has an impact on maritime managers*" is used as the explanatory variable. The results of this explanatory variable only have two results, "*yes*" and "*no*", namely "*impact*" and "*no impact*", which belong to the [*0,1*] binary classification variable. The construction of such variables is in line with the problem of binary decision-making, and a binary logistic regression model is used for analysis, To explore the influencing factors of managers in far sea water domain, define the assignment of variables as "*y=1*", that is, "the impact of far seawater domain on managers capabilities"; Define '*y=0*', which means' *the far sea area does not affect managers* '. This definition is to construct two critical points. In real situations, the probability range of the influencing factor variable is [*0,1*]. Therefore, the binary logistic model in this study is constructed as follows:

$$In\left(\frac{p(y=1)}{1-p(y=1)}\right)=\alpha+\sum_{i=1}^{k}\beta_i x_i$$

The probability of the impact of the far sea area on maritime managers capabilities is：

$$p(y=1|x)=\frac{e^{\alpha+\sum_{i=1}^{k}\beta_i x_i}}{1+e^{\alpha+\sum_{i=1}^{k}\beta_i x_i}}$$

In the above formula, x_i represents the explanatory variable that affects maritime managers in the far sea area, and k is the number of explanatory variables, α is the intercept term, β_i is the coefficient of x_i, reflecting the direction and degree of the impact of this variable on maritime managers in the far sea area. It is usually obtained using the maximum likelihood estimation method. The probability ratio of whether the construction of the mid to far sea area has an impact on maritime managers is the ratio of event occurrence $p\ (y=1)/[1-p\ (y=1)]$. $e^{\beta i}$ reflects the multiple of the change in event occurrence ratio caused by each change of one unit in the explanatory variable x_i.

4.2. Variable Selection

Through preliminary questionnaire collection, this paper found that the independent variable *xi* that affects the explanatory variable, also known as the dependent variable "*y=whether the far sea area has an impact on maritime managers*", is mainly classified into the following three categories: the first category is the basic factors of personnel, mainly including age, gender, education, length of employment, professional category, and managers experience. The second category is environmental factors, mainly including ship navigation density, ship status, rainwater impact, fog impact, visibility, wind impact, seasonal impact, and managers time. The third category is regulatory content, including emergency response to maritime emergencies, management and inspection, safety inspections, cruise mileage, and boat driving. In the classification of variables, in addition to the above classifications, this paper also provides specific classifications for specific variables, mainly based on the idea of qualitative analysis. In addition to analyzing the impact of maritime managers in the far sea area as the dependent variable, various independent variables of influencing factors are also classified. The independent variables are mainly divided into continuous variables and categorical variables, such as age options of 20-30 years old, 30-40 years old, 40-50 years old For those over 50 years old who have a continuous relationship like this, it is a continuous variable, and for example, the four categories of seasons such as spring, summer, autumn, and winter are classified variables. Some variables have two options, which are either yes or no, such as managers

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experience, with or without managers experience. With only these two options and no third option, such variables are binary variables. Similarly, if there are multiple options for a variable, they are multivariate variables. The specific variable names, assignments and meanings, mean values, and standard deviations are shown in the table 1.

Table 1. Variable Description

Preference grouping	Variable	Variable Interpretation	Variable encoding	Mean Value	Standard Deviation
Dependent Variable	Y	If far sea area have an impact on maritime management		0.67	0.47
Managers	X_1	Age	1=20-30 years old、2=30-40 years old、3=40-50 years old、4=50 years old above	2.53	1.06
	X_2	Gender	1=male、0=female	0.67	0.46
	X_3	Education	1=Junior college、2=Undergraduate degree、3=Master's degree、4=Master's degree above	2.2	0.74
	X_4	Work Experience	1=0-5 years、2=5-10 years、3=10-15 years、4=15-20 years、5=20 years above	2.95	1.34
	X_5	Major	1=Navigation major、0=Non-Navigation major	0.63	0.48
	X_6	Relevant Experience	0=No、1=Yes	0.43	0.49
Navigation Environment	X_7	Ship density	1=High density、2=Density average、3=Low density	1.81	0.81
	X_8	Ship condition	1=On board、2=mooring、3=In port	1.85	0.82
	X_9	Rain	1=raining、0=No rain	0.71	0.45
	X_{10}	Fog	1= fog、0= No fog	0.63	0.48
	X_{11}	Visibility	1=2nmile blew、2=2-10nmile、3=10nmile above	1.72	0.75
	X_{12}	Wind	1=4 level blew、2=5-7 level、3=7 level above	2.1	0.84
	X_{13}	Seaon	1=spring、2=summer、3=autumn、4=winter	2.43	1.11
	X_{14}	Day and night	1=day、0=night	0.27	0.44
Regulatory Content	X_{15}	Emergency Response	1= man over board、2=collision、3=fire、4=Stranding、5=others	2.03	1.06
	X_{16}	Management and inspection of defects	1=Self inspection before sailing、2=Certificate and document preparation、3=Crew manning、4=Passenger and freight transportation and binding、5=Pollution prevention measures、6=Compliance with regulations for navigation, berthing, and operations、7=Entry and exit procedures、8=Pay relevant fees and taxes、9=others	4.49	2.75
	X_{17}	Safety inspection defects	1=Certificate documents、2=Lifesaving equipment、3=Firefighting equipment、4=accident prevention、5=Structure, stability, and related equipment、6=Navigation safety、7=Pollution prevention、8=Dangerous goods、9=others	4.28	2.81
	X_{18}	Cruise Mileage	1=0-100nmile、2=100-200nmile、3=200-300nmile、4=300nmile	2.31	1.09
	X_{19}	Boating	1=boating、0=non-boating	0.43	0.49

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5. MODEL RESULTS AND ANALYSIS

5.1. Model Result

Conduct a binary logistic regression analysis on the influencing factors of maritime managers in the far sea area, and the regression results are listed in the table below. From the various statistics of the overall test of the model, the chi square value of the model is 189.237. The corresponding significance probability value is 0.00 less than 0.05, Cox Snell R^2 and Nagorno R^2 are 0.468 and 0.65, respectively, with a log likelihood value of 192.671. This indicates that the overall fitting effect of the model is good. The chi square value of the Hosmer Lemeshoe test is 9.517, and the probability of significance value is 0.301, which is greater than 0.05. This indicates that the overall model has good adaptability and can be used for specific analysis. The indicators related to the model are listed in Tables 2, 3.

Table 2. Model testing and summary

	Model testing	
Chi square	Degree of freedom	Significance
189.237	21	0.000
	Summary	
Log likelihood	CS R^2	NR^2
192.671[a]	0.468	0.650
	HL testing	
Chi square	Degree of freedom	Significance
9.517	0.468	0.650

Tanle 3. Regression results of logistic regression model

Results of ogistic regression model								
							EXP(B) 95% confidence interval	
	B	**Standar d error**	**Wald**	**Degree of freedom**	**Significance**	**Exp(B)**	**lower limit**	**upper limit**
Age	-1.37	0.328	17.5	1	0.000	0.253	0.133	0.482
Gender	-10.4	8071.730	0.00	1	0.999	0.000	0.000	
education	7.11	1.134	39.3	1	0.000	1227.15	132.86	11333.8
Work Experience	-1.29	0.356	13.1	1	0.000	0.274	0.136	0.551
Major	2.61	0.606	18.6	1	0.000	13.712	4.182	44.953
Relevant Experience	.041	0.593	0.00	1	0.945	1.042	0.326	3.328
Ship Density	-.941	0.653	2.08	1	0.149	0.390	0.109	1.402
Ship Condition	-.776	0.457	2.87	1	0.090	0.460	0.188	1.128
Rain	-3.10	1.239	6.28	1	0.012	0.045	0.004	0.508
Fog	1.56	1.233	1.61	1	0.204	4.787	0.427	53.646
Visibility	-.112	0.370	0.09	1	0.763	0.894	0.433	1.849
Wind	.384	0.647	0.35	1	0.553	1.468	0.413	5.219
Seaon			5.56	3	0.135			
Seaon(1)	1.40	1.000	1.96	1	0.161	4.064	0.572	28.866
Seaon(2)	-.315	1.390	0.05	1	0.821	0.730	0.048	11.136
Seaon(3)	1.47	1.421	1.07	1	0.300	4.365	0.269	70.760
Day and Night	-13.9	8071.730	0.000	1	0.999	0.000	0.000	.
Emergency Response	6.33	1.203	27.7	1	0.000	565.226	53.462	5975.82
management and inspection of defects	0.75	0.528	2.06	1	0.151	2.134	0.758	6.007
Safety inspection Defects	-3.44	0.758	20.69	1	0.000	0.032	0.007	0.141
Cruise Mileage	1.01	0.477	4.523	1	0.033	2.756	1.083	7.016
Boating	0.22	0.701	0.10	1	0.748	1.253	0.317	4.952
Constant	2.94	8071.731	0.000	1	1.000	19.093		

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5.2. Analysis Of Managers Personnel

According to the results of the model, there is a significant positive correlation between education, major, and managers experience. Education and managers experience are continuous variables, that is, the higher the education level, the more significant the impact of maritime managers personnel with relevant managers experience on the comprehensive maritime managers of far sea area. The professional category is a categorical variable, and according to research statistics from the questionnaire, maritime managers personnel with relevant managers experience have a significant impact on the managers of far sea area. In addition, for age, gender, and years of employment, the overall model results show a negative and significant impact, indicating that the age, gender, and years of employment of managers personnel are not particularly significant for the managers in the far sea area.

5.3. Analysis Of Navigation Environment

According to the results of the model, the influence of fog, wind, and season all show a positive impact. Fog and season are classified variables. According to survey statistics, the managers in the mid to far sea area is significantly affected in summer and winter when the wind level is above 7. Thick fog is also an important influencing factor affecting managers. In addition, due to the wide sea area of far, there will not be crowded vessel traffic flow. In terms of vessel navigation density, the impact on comprehensive maritime managers is not significant, and in terms of vessel status, the enforcement of maritime management is not obvious. The vessel status will be controlled in advance, which will also have a special impact on managers. In terms of rainwater, due to the wide water area, the impact of rainwater is not positive, The impact of managers time is also negatively correlated. Whether during the day or night, for maritime managers, once a maritime emergency occurs, maritime managers personnel will respond as soon as possible, and the impact on time is not significant.

5.4. Analysis Of Regulatory Content

According to the model results, there is a positive trend in emergency response to maritime emergencies, ship safety management and inspection, cruising mileage, and boat driving. According to questionnaire surveys, managers personnel encounter the most cases of personnel falling into the water during the implementation of emergency response to maritime emergencies in the far sea area. Due to the vast sea area of far, once a person falls into the water, it is far from traditional managers resources, The probability of personnel survival is relatively low, which is a significant influencing factor for the water safety management of far sea area. In the process of implementing ship safety inspections, the implementation of ship safety inspections has a negative impact on the managers of far sea area. It can be concluded that for managers personnel, they are not interested in ship safety inspections in far sea area or are not aware of this due to the limited opportunities for implementing ship safety inspections. In addition, both driving and cruising distances have a positive impact. In the process of managers in the far sea area, managers personnel generally have to drive their own boats, while in the far sea area, driving a boat often has more cruising distances, which has a greater impact on managers personnel. This sample analysis shows that driving a boat and cruising distances above 300 nautical miles have the greatest impact on managers in the far sea area, Scientific planning is required for the driving and cruising range of boats, and managers personnel usually need to carry out relevant managers work in difficult and high-intensity work, which will inevitably affect the quality of managers work.

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6. CONCLUSION AND EMPIRICAL ANALYSIS

6.1. Conclusion

This study is based on a discrete selection analysis of sample data from 300 managers in far waters. At the same time, a binary logistic regression model is used to analyze the influencing factors of comprehensive maritime managers in far waters. The research results indicate that in terms of managers personnel, age, gender, and years of employment have a negative impact, while education, professional category, and managers experience have a positive impact; In terms of navigation environment, the influence of fog and wind has a positive impact on seasonality, while the density of ship navigation, ship status, rainwater, and visibility have a negative impact; In terms of regulatory content: emergency response to maritime emergencies, defects in on-site management and inspection, positive impact on cruising mileage and boat driving, while negative impact on ship safety inspection.

6.2. Empirical Analysis

Based on the above conclusions, in order to better analyze the impact of far sea area on maritime management, this paper uses the currently under construction Sea Patrol Management Base as an example to conduct empirical analysis and provide guidance and suggestions for the maritime management of far sea area. The Maritime Patrol Management Base is currently located on Zhejiang Province. It is a maritime patrol management base located in the easternmost part. The base is regularly manned and integrates maritime management, rescue, and ship safety inspections. As a leading area for maritime safety management in the far sea area, it is an important step in implementing the far ship monitoring leading area strategy. Building a maritime management base can effectively solve the shortcomings of maritime management in the far sea area and better solve the maritime management problems in the far sea area. Establishing a leading area for far seawater management requires sound development strategies. Through the theoretical analysis of this paper, the research results are applied to the construction of the base and development suggestions are proposed.

6.2.1. Optimize Personnel structure

According to the current situation, there is an unreasonable structure among the stationed personnel in the base, and the structure of managers personnel should be optimized to enhance their overall quality. The members of the managers team need to be further optimized to ensure a reasonable personnel structure and complementary advantages. At present, due to the relatively poor conditions in the managers of far sea area, many managers personnel have developed a fear of difficulty, especially some highly educated and high-quality managers personnel who are more inclined to carry out managers work within the jurisdiction of the port, resulting in a particularly severe polarization phenomenon. Therefore, in order to break this polarized phenomenon, incentive policies should be strengthened for managers personnel in remote seawater areas. By tilting policies, a large number of high-quality managers personnel should be attracted to engage in managers related work in remote waters. At the same time, the personnel structure of the managers team should be adjusted, and regular rotation in far sea areas should be carried out using the "Belt and Road" model, with one senior managers officer leading multiple managers interns, Promote the improvement of the managers team, while cultivating more professional maritime managers talents who integrate wheel and boat driving, management and inspection, and emergency response, in order to improve the overall managers quality.

6.2.2. Innovative managers models

Integrate, utilize, and optimize meteorological information acquisition methods to scientifically and accurately grasp weather and sea conditions. Although the climate is variable and the environment is complex, with the improvement of scientific methods, the accuracy of

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weather prediction in the far sea area is also increasing. Meteorological and hydrological observation stations in various regions conduct real-time meteorological observations of their respective regions. Optimize the meteorological early warning mechanism, optimize the meteorological and hydrological collection mechanism, conduct scientific early warning, reasonable planning, especially pay attention to the early warning of dense fog and strong wind weather, do a good job in early warning, and ensure that the maritime managers work in the far sea area can be carried out in a reasonable and orderly manner. Faced with the shortcomings of emergency response for sudden maritime accidents in the far sea area, it is necessary to plan and build a comprehensive far sea search and rescue base, improve infrastructure and equipment strength, optimize resource allocation and force deployment, enhance the comprehensive supply capacity of far sea search and rescue, optimize emergency plans, strengthen linkage among various departments, and establish cooperation mechanisms. In addition, it is necessary to strengthen technological innovation and improve the level of modern search and rescue, such as introducing drone "beyond the line of sight" technology, which greatly saves search and rescue time and saves manpower and material costs.

6.2.3. Improve Policy Systems

At present, the facilities of the base are not sound enough. To ensure the management of far sea area, it is necessary to improve the infrastructure construction and actively expand the scope of maritime business. We need to increase investment in remote sites, improve relevant settings, improve the living conditions of managers personnel, and ensure long-term duty. We need to improve facilities such as communication, transportation, water and electricity, and culture, in order to create a sense of belonging to remote sites. In addition, the construction of the base also requires support from industry research and technological innovation. In response to the current theoretical gap in far maritime safety management, a cooperation and exchange system should be established to strengthen cooperation and exchange with scientific research institutions and institutions, track the development of new theories and trends, focus on hot issues, learn from others' strengths, explore new development models, and provide theoretical and technical support for far maritime safety management pilot area.

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