Original article

On the Analysis of Relation between Marine Accidents and Traffic Conditions in Korean Narrow Waterways Areas using Regression Analysis

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Abstract

In recent year, marine safety has been one of top concerns in Korea. In this paper, general statistics of ship in 159 waterways in Korea from 2007 to 2017 were considered. Main objective of this research is to investigate the relationship between the number of marine accidents and traffic conditions in narrow waterways by multiple regression analysis method. The result shows that the number of vessels, the width, the length and the depth of narrow waterway have an influence on the number of maritime accidents in corresponding area. Additionally, the number of vessels sailing has the most significant impact on the number of accidents in narrow waterway area.

Keywords: Marine accidents, narrow water way, multiple regression analysis

1. Introduction

Korea is mostly surrounded by water, has many small islands around and a large number of successive mountain ranges that crisscross the peninsula and running deep below sea level to create a gentle coastal terrain. This natural condition has created various narrow waterways and made the characteristics of the South Korean coast to become quite complex. Annually, the number of accidents occurring in narrow waterways is not too many but serious causing huge losses in people, vessels and cargoes. According to the data of Statistical Yearbook of Marine Accident Incident of Korean Marine Security Safety Division (2017), the number of marine accidents occurred in the narrow waterways was one of the highest sea areas due to the fact that the narrow waterways have features of narrow access width, strong and frequently changed tidal speed as well as the traffic is relatively dense.
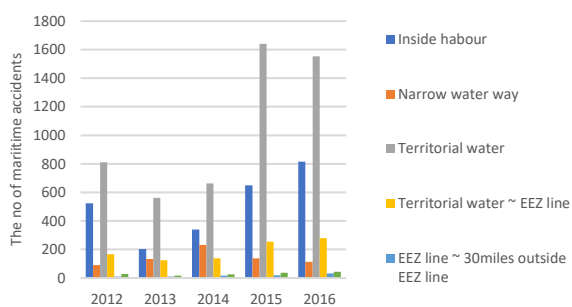

Figure 1. The number of accidents by sea areas in recent 5 years

Source: Marine Accident Incident, 2017

The narrow waterways in Korea can be divided into 6 regions, including Gyeongiman, Cheosuman-Anmagundo, Mokpo Port and the nearby, Wando-Thongyoung, Thongyoung-Ulsan and Jeju Island.
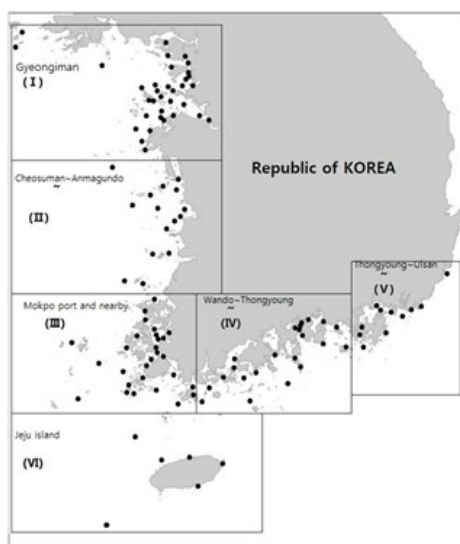

Figure 2 Korean narrow waterways map

Source: National Oceanographic Research Institute

For maritime traffic situation in the narrow waterway, as the data collected in specific days in 2017 and 2018, it indicated that most of marine traffic concentrated in Gyeongiman area, in which large ports such as Incheon port, Pyengtaek port, Seosan-Daesan port are present. Figure 3 describes the difference in the number of ships operating in distinct waterway areas in specific days.
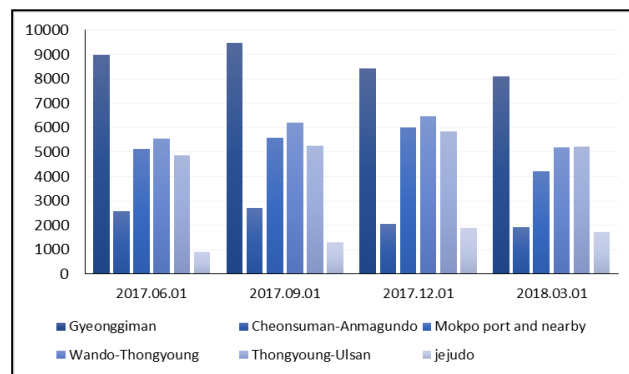

Figure 3 The number of passing vessels through narrow waterways by areas in specific days

Source: Compiled by Author

On the other hand, when classified by the type of vessels passing the narrow waterways, the data is divided into 2 types, one includes the large vessels recorded by AIS (automatic identification system) transceiver type A, and the other one includes small vessels recorded by transceiver type B. Figure 4 shows the quantity of two vessel types sailing in narrow waterways in specific days.
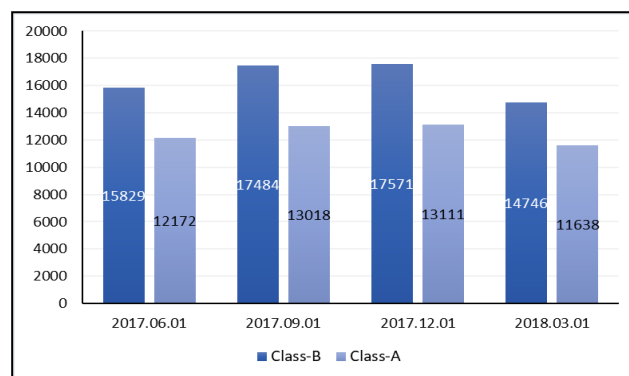

Figure 4 The number of passing vessels through narrow waterways by vessel types in specific days

Source: Compiled by Author

For the accident classification, marine accident can be classified into 7 major types which was shown in Figure 5. Therein, engine malfunction is the most common cause

of marine accidents with approximately 600 cases occurred in 5 years, followed by Collision and Safety Disturbance.
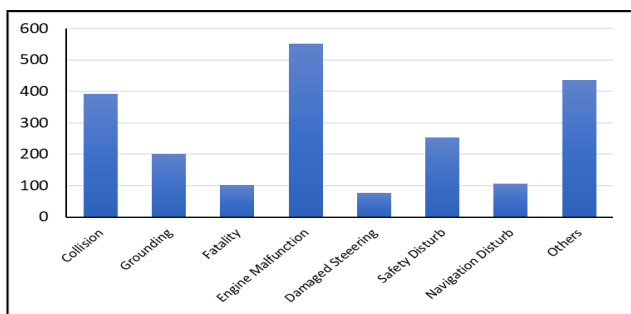

Fig 5 The number of marine accidents by types

Source: Compiled by Author

Figure 6 shows that fishing vessels are the most common casualties in the narrow waterways area with more than 1800 cases, compared with other types of vessels.
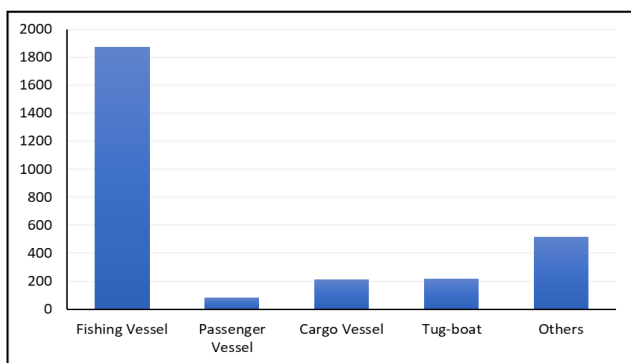

Fig 6 The number of marine accidents by vessel types
Source: Compiled by Author

It was also surveyed in Kim et al. (2014)'s paper that the highest tidal speed waterways in Korea were Myeongnayang, Maenggol, Geocha, Heonggan, Northern of Jeongdeung-hae, Jangjuk, Daebang waterways. In particular, the maximum tidal speed of Myeongnayang waterway was 10.3~11.5 knot (KHOA, 2013). In the recent 9 years (2008-2016), there were 99 marine accidents in the high current speed waterways, including 16 collision accidents, 21 grounding accidents, 20 engine troubles and the losses of cargoes was enormous (Korean annual overview of maritime casualties, 2017).

Therefore, by multiple regression analysis method, this paper aims to verify the impact of traffic factors on marine accidence in Korean narrow waterways.

The article is organized as follows. Section 2 reviews generally previous researches on this study topic and then explains the necessity of current work. Section 3 discusses an illustration of used methodology and section 4 presents data analysis and results. The last section summarizes the empirical findings with some concluding remarks.

2. Literature Review

Marine accidents have been occurring ever since the dawn of maritime industry. There are various researches attempt to improve maritime safety and reduction of marine accidents by analyse impact of constituent elements (Corovic, 2013; Oluseye and Ogunseye, 2016; Mousavi and Jafari, 2017; Chauvin *et al*, 2013). By far, there are few researches on maritime safety or marine accident in narrow waterway. Hasanspahic *et al* (2018) analysed the safety of tanker navigation in narrow waterways based on influential probability factors that taken into consideration comprise the narrow waterway category, meteorological and oceanological conditions, traffic density and VTS coverage of the navigable area. Most of the literature consider human behaviour as the most influential factor to marine accident. However, for maritime operations on narrow waterway, external factors such as geographical conditions and traffic density should be considered (Yao Yu, 2015). Therefore, it is necessary to pay more attention to the importance of external factors. In particular in Korea there are no previous researches on this field. This paper seeks to fill the research gap by providing a statistical analysis on relationship between marine accident and traffic conditions. Thence, it is possible to assess the safety level of each area in each specific period.

3. Methodological Approach

3.1 Research method

The research methodology applied in this study is multiple regression analysis, a statistical analysis-based method. The multiple regression analysis method is an extremely extension of simple regression analysis (Priyadarshinil and Chandra Babu, 2012), by describing the relationship between a dependent variable and several independent ones (David Garson, 2014). It is a very useful tool that can be used for predicting and forecasting (Uyanik and Guler, 2013).

The general multiple regression equation is

$$Y = a + b_1 x_1 + b_2 x_2 + \cdots + b_n x_n + \varepsilon \qquad (1)$$

Where

Y– dependent variable

x_i –independent variable

a – parameter

ε – random variable error or residue

3.2 Research Procedure

The procedure of Regression analysis includes following steps:

Step 1: Define Objectives. In this step we define and clarify purpose of the research, to identify and describe the measurement of the dependent variable.

Step 2: Select variables. Possible independent variables will be identified.

Step 3: Estimate Model. Regression coefficients of the model will be estimated

Step 4: Test model. The purpose of this step is to test to see if all coefficients are significant (reliability) and establish validity.

Step 5: Final model. In final step we explain the meaning of the obtained model

4. Data analysis and results

In this section of the paper we use as explanatory multivariate method multiple regression analysis to analyse correlations between variables and establishing the validity of the multiple regression model. Using SPSS kit – Statistical Package for Social Sciences, in case of multiple regression we obtained following results:

Step 1: Define Objectives

To see the characteristics of marine accident occurred in narrow waterways, the research team has collected data from 159 areas along South Korea coastal. In each area, we collected the number of marine accidents, the number of ships passing in specific days, the characteristics of narrow waterway (the length, width and depth). The objective of the research team is to model the relationship between marine accident and related factors in maritime traffic. Since the research team is interested in decreasing the

number of accidents, the dependent variable for this model should be the number of accidents.

Step 2: Selecting variables

Dependent variable: the dependent variable in this study is the number of marine accidents that was observed at 159 narrow waterways in Korea for 10 years (from 2007 to 2017).

Independent variable: the number of passing ships which measured total number of ships crossing each area for 72 hours (from 8 am 29th May 2017), the narrow waterway width, the narrow waterway length and the minimum depth.

Step 3: Estimating Model

In Step 3 by using SPSS, estimated coefficients of regression model were determined. Table 1 shows result of regression analysis by SPSS which indicates unstandardized and standardized coefficient of variables in regression model.

Table 1 Regression Coefficients

Model	Unstandardized Coeff	Std. Error	Standardized Coeff	t	Sig.	VIF
Const	1.477	3.412		0.433	0.666	
X_1	0.082	0.011	0.538	7.482	0.000	1.633
X_2	2.509	0.473	0.352	5.310	0.000	1.386
X_3	-9.004	5.122	-0.121	-1.758	0.041	1.506
X_4	-1.000	0.601	-0.105	-1.663	0.049	1.269

Where:

Y - the number of marine accidents

X1 - the number of passing ships; X2 - waterway length; X3 - waterway width; X4 - minimum depth

Independent variables have statistical significance at 5% level because sig values of its are smaller than 0.05,

Based on the Unstandardized coefficients we have the following regression model.

$$Y = 1.477 + 0.082x_1 + 2.509x_2 - 9.004x_3 - x_4$$

(2)

Step 4: Testing Model

- Test the coefficients

Parameter Sig. (or p-value) in Table 1 is the possibility of the hull hypothesis that the coefficient is 0. If the Sig

value is a small value, we can reject the hull hypothesis. From Table 1, Sig of X1 and X2 both are 0.000 which are less than 0.01. Therefore X1, X2 has statistical significance at 99% confidence level. Sig of X3 and Sig of X4 are less than 0.1, it means X3, X4 ¬have statistical significance at 90% confidence level. Meanwhile, Sig of constant variable is higher than 0.1, thus constant variable has no statistical significance.

- Test the validity of the model

Table 2 Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
0.790	0.623	0.611	11.538	1.804

The Adjusted coefficient of determination (Adjusted R^2) indicates how much of the total variation in the dependent variable can be explained by the independent ones. Table 2 shows results of validity test of the model, therein adjusted R^2 = 0.611. It means independent variables explain 61.1% of the variability of dependent variable, the 38.9% remaining were explained by external variables and random errors.

Table 3 shows results of analysis of variance test, which reports how well the regression equation fits the data.

Table 3 ANOVA test

	Model	Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	26220.962	4	6555.241	49.241	0.000
	Residual	15841.965	119	133.126		
	Total	42062.927	123			

The Sig. value indicates the statistical significance of the regression model that was run. In Table 3, Sig = 0.000 which is less than 0.01. It indicates that regression model is a good fit of the data.

- Test of Multi-collinearity

To see whether there was any multicollinearity between variables, the Pearson Correlation, the Variance increase factors (VIFs) were examined. Table 4 shows Pearson correlations coefficient between variables and its corresponding significant correlations.

If significant correlation between two independent

variables is less than 0.05 and Pearson Correlation coefficient is more than 0.5, it is doubt that there is multicollinearity between them. Nonetheless, there were none of correlation coefficients (R) are more than 0.50.

To assure more certain, we checked VIFs, if VIF equal or more than 2, there is multicollinearity between dependent variables. According to Table 1, all VIFs are less than 2. Therefore, it is no doubt to say that there was no multicollinearity between dependent variables.

Table 4 Correlations

		Y	X_1	X_2	X_3	X_4
Y	R	1				
	Sig.					
X_1	R	0.693^{**}	1			
	Sig.	0.000				
X_2	R	0.602^{**}	0.407^{**}	1		
	Sig.	0.000	0.000			
X_3	R	-0.532^{*}	-0.486^{*}	-0.479^{*}	1	
	Sig.	0.000	0.014	0.062		
X_4	R	0.245^{*}	0.447^{*}	0.252^{*}	-0.176	1
	Sig	0.006	0.000	0.005	0.094	

*. Correlation is significant at the 0.01 level (2-tailed)

Step 5: Final Model

The final regression model between marine accident and traffic status based on unstandardized coefficients was obtained as follow:

The number of marine accidents = 0.082 the number of passing ships + 2.509 the narrow waterway length – 9.004 the narrow waterway width – 1.000 the narrow waterway depth

The final model indicates that if the number of passing ships increases 1 ship or the narrow waterway length increases 1 mile, the number of marine accidents will increase 0.082 and 2.509 cases respectively. By contrast, if the narrow waterway width increases 1 mile or the narrow waterway depth increase 1 meter, the number of marine accidents will decrease 9.004 and 1.000 cases respectively.

While the number of passing ships and waterway length have positive correlation with the number of marine accidents, the waterway width and minimum depth have negative correlation with the number of marine accidents. In other words, if the number of passing ships or the waterway length increases then the number of marine accidents will increase. In contrast, if the waterway width or the minimum depth increases the number of marine

accidents will decrease and vice versa.

Moreover, standardized regression coefficients in Table 1 indicate the order of important of the independent variables. It discovers that the number of passing ships is a most important factor for the number of marine accidents, followed by waterway length, waterway width and minimum depth.

5. Conclusion

This study analysed the relation between marine accident and the traffic conditions in 159 narrow waterways in Korea.

The study result indicates that all factors have an influence on marine accident. The number of passing ships and waterway length have positive correlation with the number of marine accidents. Conversely, the width and the minimum depth of narrow waterway have negative correlation with the number of marine accidents.

Additionally, the result also points out the order of importance of the independent variables. The most important factor is the number of ships passing observed area, the second one is the length of narrow waterway, the third factor is the width and the factor which has the least impact on marine accident is the minimum depth of narrow waterway. Results send a warning to ship operators about danger of high-density narrow waterway and from which to help them make sound route decisions.

In the future research, traffic factors can be applied as inputs in mathematical models in order to measure collision risk and vulnerability level of vessels in particular waterway area.

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