Mersin University Journal of Maritime Faculty

Mersin University Journal of Maritime Faculty (MEUJMAF)
Vol. 1, Issue 1, pp. 1-9, December 2019
Research Article

ANALYSIS OF MARINE ACCIDENTS IN THE STRAIT OF İSTANBUL USING QUALITATIVE&QUANTATIVE METHODS

Nur Jale ECE*[1]

[1] Mersin University, Maritime Faculty, Maritime Business Administration, Mersin, Turkey
ORCID ID 0000 – 0003 – 2048 – 5458
e-mail: jalenur@mersin.edu.tr

* Corresponding Author
Received: 20/11/2019 Accepted: 10/12/2019

ABSTRACT
The Turkish Straits are one of the most hazardous and crowded waterways in the world. This study has been performed to analyze the accidents occurred in The Strait of İstanbul by using the statistical methods such as frequency distribution, Chi Square Test and Cramer's V for the "right-side up" scheme period 1982-2018 and regression analysis, t and F tests for significance of regression model and Durbin Watson Test to test autocorrelation in residuals between the years 1982 and 2003. In the study, traffic of the Strait of İstanbul and literature have been reviewed and literature review has been conducted. The results of the analysis have given as follows; the cargo ships were the most involved in the accident; accidents are mostly collision and respectively grounding; the most accident has been occurred in the hours 20:00-24:00 and main reason of accidents is human error in the Strait of İstanbul. There is a moderate level of statistical relationship between the type of ship involved in the accident and type of the accident; the independent variables given in the regression model increase estimated accident rate in the Strait of İstanbul. High value R-squared value (R2=0.997) indicates that the model fits the data well by the independent variables. At the conclusion of the study further suggestions are proposed to provide safety of environment and navigation and the Strait of İstanbul.

Keywords: *The Strait of İstanbul, Marine Accidents, Accident Analysis, Collision, Maritime Pilot.*

1. INTRODUCTION

Turkish Straits which links the Black Sea and the Mediterranean Sea is one of the most congested, narrow and risky waterways in the world from the point of view geographical conditions, navigational constraints such as deep, narrowness, currents, etc. and bad weather conditions contributes to marine accidents in the Strait(Ece, 2012; Başar, 2003). Turkish Straits has a vital importance from the point of jeo-politic, jeo-strategic and commercially. The Strait of İstanbul has massively rich in historical and cultural heritage and serves as a biological corridor (Ece, 2012).

Increasing tonnage and number of ships increase the accident risk and pose a risk from the point of human life and environment (Ece, 2012). It is expected to increase the marine traffic in the Straits (Ece. 2008).

The purpose of the study is to analyze the accidents occurred in The Strait of İstanbul for the period 1982-2018 and between the years 1982 and 2003. The paper is organized as follows: The second section consists of literature review, the third section is a review of maritime regime and traffic in the Strait of İstanbul. The fourth section performs material and methods involving data collection and statistical methods such as frequency distribution, Chi Square and Cramer's V Tests for the period 1982-2018, regression analysis, t and F Tests for significance of regression model and Durbin Watson Statistic to test autocorrelation in residuals between the years 1982 and 2003. At the conclusion of the study further suggestions are proposed to provide safety of environment and navigation in the Strait of İstanbul.

2. LITERATURE REVIEW

Köse, Başar, Demirci, Güneroğlu ve Erkebay (2003) developed the model which searches the traffic to simulate the traffic within the The Strait of İstanbul. One of the result of the study shows that the most type of accident are grounding and collision in the Strait of İstanbul. The majority of marine accidents is collision occurred in The Strait of İstanbul in 1953–2002 (Akten, 2006). Ulusçu and et al (2009) have analyzed safety risks for transit ship traffic in the Strait of İstanbul. The results of finding of the study are pilotage and traffic density in the Strait of İstanbul. Yazıcı and Otay (2009) improved a simulation model for unique traffic conditions. The results of the study; the Traffic Separation Schemes restrictions increase grounding risk and navigation difficulty in the Strait of İstanbul.

Uğurlu et al. (2015) have analyzed serious marine accidents in the Turkish Straits in 2001-2010. The finding of the study, human error is main reason of marine accidents in the Turkish Straits. The most of the accidents are occurred due to human error which involves fatigue, lack of adequate experience and knowledge, proper attention, technical etc. (Akten, 2006). Koldemir (2009) has defined the risky regions in the Strait of İstanbul by using accident black points method. One of the results of the study, the region located in Ortaköy - Beylerbeyi and Ahırkapı Feneri – İnciburnu Feneri is the most risky region. Birpınar et al (2009) have examined oceanographic and geographic features and explanes the Strait of İstanbul has faced many casualties and serious environmental problems. Uçan ve Nas (2015) analysed the Marine Pilotage Service to find the required number of marine pilots for ship traffic flow in the Strait of İstanbul by using Rockwell Arena Simulation Software. The findings of the analysis show that discrete simulation technique is efficient and reliable way of solving complex techno-nautical service allocation problems.

Görçüna and Selmin (2016) analyzed the risks concerning marine traffic in the İstanbul Strait between the years 2001 and 2010. The result of the analysis shows that are personnel, weather conditions and machines etc. are the main reasons of accidents (Ece, 2012). Yılmaz and Önaçan (2019) has been carried out a SWOT analysis regarding the developments in autonomous ship technology and its effects on the Turkish maritime and shipbuilding sector. One of the result of findings as follows; the that the risk of marine incident caused by human factors will be minimized for a fully autonomous ship but taking into account new kind of risks such as cyber-attacks, software errors and local aspects of strait passages etc. in addition to that MSC.1/Circ.1604 on interim guidelines for autonomous ship trials was adopted by IMO, additional safety and security measures regarding the passage of autonomous ships through the Turkish Straits should be considered (Yılmaz and Önaçan, 2019:57-86).

3. MARINE TRAFFIC IN THE STRAIT OF İSTANBUL

The number of ships is 41.103 and total tanker traffic is 8.587 passed through the Strait of İstanbul in 2018. The rate of maritime pilot employed is 57% in 2018 (ubak, 2018).

Table 1.Marine Traffic in The Strait of İstanbul

Years	Total Traffic	Total Tanker Traffic	Ratio of Ships Proceeding a pilot (%)
2003	54.880	8.107	45
2004	56.606	9.016	41
2005	54.396	8.813	45
2006	54.880	10.153	48
2007	56.606	10.054	47
2008	54.396	9.303	50
2009	51.422	9.299	49
2010	50.871	9.184	51
2011	49.798	9.099	48
2012	48.329	9.028	47
2013	46.532	9.006	50
2014	45.529	8.745	49
2015	43.544	8.633	51
2016	42.553	8.703	52
2017	42.978	8.832	51
2018	41.103	8.587	57

Resource: Undersecretariat for Maritime Affairs, 2010; Ministry of Transport and Infrastructure of The Republic of Turkey (UBAK), The Turkish Straits Vessel Traffic Statistics, 2019.

According to the Montreux Convention "pilotage and towage" remain optional (Article 2) (Akten, N). The maritime traffic regulations for The Turkish Straits have been implemented and the new schemes have been in use since 01 July 1994. The regulations were revised and adapted in 1998. "The System of Turkish Strait Vessel Traffic Services (TSVTS)" was installed at 31 December 2003 to provide safety of navigation and environment (Akten, N., 2003; www.kiyiemniyeti.gov.tr, 2019).

4. MATERIAL AND METHODS

4.1. Data Collection

The accident historical data for the Strait of İstanbul contains 857 accident records involving ship name, year, hour, type and accident reason, type of ship involved in the accident during "right-side up" scheme period 1982 and 2018. The ships and marine vehicles have been reported in the accident reports such as container, general cargo, tanker, dry bulk, fishing ships, tugboat, fishing ships, Ro-Ro, passenger ships, yacht, boat and others. The accident data for the Strait of İstanbul has been acquired from the Undersecretariat for Maritime Affairs (Undersecretariat for Maritime Affairs, 2003); Ministry of Transport and Infrastructure of The Republic of Turkey Main Search-Rescue Coordination Center (aakkm.udhb.gov.tr); Turkish Pilots (ww.turkishpilots.org, 2004; http://www.turkishpilots), PhD thesis and LLyod's Maritime Information Service's traffic and the articles (Kornhauster and Clark, 1995) (Baş, M., 1999) related to the accidents in the Strait of İstanbul. The Meteorological data has been acquired from General Directorate Of Meteorology (General Directorate Of Meteorology, 2004). The current data has been gathered from Republic Of Turkey Turkish Naval Forces Office Of Navigation, Hydrography And Oceanography concerning the Strait of İstanbul; Republic Of Turkey Turkish Naval Forces Office Of Navigation, Hydrography and Oceanography, 2004).

4.2. Methods

The statistical analysis has been used to analyse the accidents occured in Strait of İstanbul during "right-side up" scheme period 1982-2018 and before installing TSVTS 1982-2003 by using SPSS 17.00 and EVIEWS 5.0. The parametric data which is 4,285 contains year, hour, type, type of ship, reason of accident and marine vehicles (ship) involved in the accident. have been proceed in the analysis. The following methods such as Frequency Distribution, the crosstabulations, Chi Square Test (χ^2), Cramer's V, regression analysis have been used to analyse the accidents occurred in the Strait of İstanbul.

4.2.1. Frequecy distribution

The Descriptive Statistics such as Frequency Distribution has been used for summarizing categorical variables. The frequency distribution of the marine accidents by type of accident, type of ships involved in the accident, hours of accident and reason of accident in the Strait of İstanbul have been given the following tables.

a) Frequency distribution of marine accidents by type of accident

A Total of 44.5% of the accidents occured in Strait of İstanbul were collision (44.5%) and respectively grounding/stranding (19.3%), contact (15.6%), fire/ explosion (7.2%), breakdown (4.0%) and foundering/capsizing (2.9%) in 1982-2018 as shown in Table 2 (Ece, 2019)

Table 2. The Marine Accidents By Type of Accident

Type of Accident	Frequency	Percentage (%)	Percentage of Total Cumulative (%)
Unknown	18	2,1	2,1
Collision	381	44,5	46,6
Grounding/ Stranding	165	19,3	65,8
Fire/Explosion	62	7,2	73,0
Contact	134	15,6	88,7
Foundering/ Capsizing	25	2,9	91,6
Breakdown	34	4,0	95,6
Others	38	4,4	100,0
Total	857	100,0	

A Total of 45.6% of the accidents occurred in Strait of İstanbul were collision and respectively grounding/stranding (20.4%), contact (16.2%), fire/ explosion (7.9%), and foundering/capsizing (2.3%) in 1982-2003. The map of types of accident occurred in The Strait of İstanbul in 1928-2003 is given in Figure 1 (Ece, 2005; Ece, 2019)

Collision caused by human errors is the most occurred accident type. The main cause of the accidents is human error.

b) The frequency distribution type of ships involved ın the accident

The cargo ships (dry bulk, general cargo refeer, container, Ro-Ro were the most involved in the accident (44.9%) and respectively passenger ships and boats (passenger ship&boat,sea bus, ferryboat etc.) (17.7%), marine vehicles (boat, yatch, tugboat, research ship, others) (15.8%) and tankers (9.9%) in 1982-2018 as shown in Table 3.

Table 3.The Type of Ships Involved In The Accident

Types of ships Involved In The Accident	Frequency	Percentage (%)	Percentage of Total Cumulative (%)
Unknown	99	11.6	11.6
Boat,yatch,tugboat,research ship,others	135	15.8	27.3
General cargo,	385	44.9	72.2
Tanker,Liquid bulk	85	9,9	82,1
Passenger ship&boat ferryboat etc.	152	17.7	99.9
Others	1	.1	100.0
Total	857	100.0	

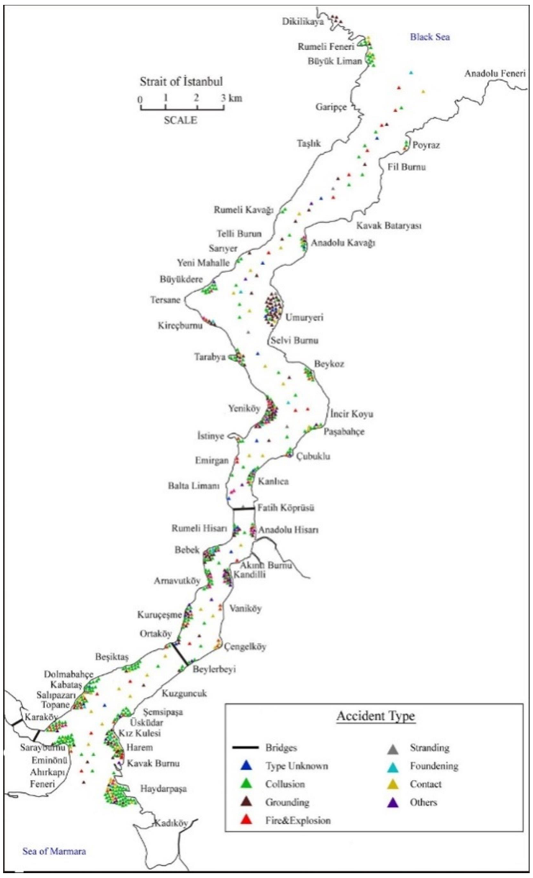

Figure 1. Map of Types of Accident Occurred in The Strait of İstanbul in 1928-2003
Resource: (Ece, 2015)

c) The Frequency Distribution of Marine AccidentsBy Accident Hours

The most accident were occured in the hours 20:00-24:00 (15.2%) and respectively 08:00-12:00 (13.9),12:00-16:00 (12.8%), 24:00-04:00 (12.3%), 16:00-20:00 (11.8%) and 04:00-08:00 (11.7%) in 1982-2018 as shown in Table 4 (Ece, 2019)

Table 4.Marine Accidents By Accident Hours

Accident Hours	Frequency	Percentage (%)	Percentage of Total Cumulative (%)
Unknown	192	22.4	22.4
24:00-04:00	105	12.3	34.7
04:00-08:00	100	11.7	46.3
08:00-12:00	119	13.9	60.2
12:00-16:00	110	12.8	73.0
16:00-20:00	101	11.8	84.8
20:00-24:00	130	15.2	100.0
Total	857	100.0	

d) Frequency Distribution of Marine Accidents By Reason of Accident

Human error is the major cause of accidents (25.4%), respectively bad wheather conditions and current (12.0%), breakdown (7.8%), contact fishing nets (7.6%) and traffic density (2.6%) in 1982-2018 as shown in Table 5.

Human error is the main reason of the accident (Ece, 2012; Ece, 2019).

Table 5.Frequency Distribution Of Ship Accidents By Reasons

Reason of Accident	Frequency	Percentage (%)	Total Cumulative (%)
Unknown	341	39.8	39.8
Human error	218	25.4	65.2
Traffic density	22	2.6	67.8
Bad whether conditions and Cur	103	12.0	79.8
Fire	18	2.1	81.9
Contact fishing net	65	7.6	89.5
Breakdown	67	7.8	97.3
Others	23	2.7	100.0
Total	857	100.0	

4.2.2. Chi Square Test

The Chi square (χ^2) Test has been used to analyze the relationship between the non parametric variables.

The formula for the Chi Square *Test* is given as follows:

$$\chi^2 = \sum_{i=1}^{k} \frac{(Observedvalue - Expectedvalue)^2}{Expectedvalue} \qquad (1)$$

Hypotesis; H_0: There is not a relationship between type of the accident and the type of ships involved in the accident, H_1: There is a relationship between type of the accident and the type of ships involved in the accident. The Table 6 shows that all type of ships were involved in the most collision in 1982-2018.

Table 7.Chi-Square Test Between Type Of Accident And Type of Ships Involved In the Accident

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	138.479[a]	24	0.000
Likelihood Ratio	127.184	24	0.000
Linear-by-Linear Association	1.433	1	.231
N of Valid Cases	857		

a. 7 cells (20,0%) have expected count less than 5. The minimum expected count is 1.79.

The Chi-Square Test result indicated that The Pearson Chi -Square value is 138.479, minimum expected count is more than 1 (1.79) as shown in Table 7. The null hypothesis (H_0) has been rejected and alternative hypothesis (H_1) is accepted. There is a statistical relationship between type ofthe accident and the type of ships involved in the accident (Ece, 2019).

4.2. 3. Cramer's V Test

Cramer's V Test has been used to describe the magnitude or association between categorical variables (nominal) between the variables.

Table 6. Cross-Tab Between Type Of The Accident And Type of Ships Involved In the Accident

Type of Accident	Count % within accident t ype	Unknown	Cargo ships	Tanker, liquid bulk	Passenger ships and boats	Others	Total
Unknown	Count	8	7	2	0	1	18
	% within accident t ype	44.4%	38.9%	11.1%	0.0%	5.6%	100.0%
Collision	Count	41	155	35	95	55	381
	% within accident type	10.8%	40.7%	9.2%	24.9%	14.4%	100.0%
Grounding/ Stranding	Count	8	99	25	14	11	165
	% within accident type	9.7%	60.0%	15.2%	8.5%	6.7%	100.0%
Fire	Count	6	20	4	16	16	62
	% within accident type	9.7%	32.3%	6.5%	25.8%	25.8%	100.0%
Contact	Count	29	66	12	19	8	134
	% within accident type	21.6%	49.3%	9.0%	14.2%	6.0%	100.0%
Breakdown	Count	3	17	3	5	6	34
	% within accident type	8.8%	50.0%	8.8%	14.7%	17.6%	100.0%
Others	Count	9	19	4	3	28	63
	% within accident type	14.3%	30.2%	6.3%	4.8%	44.4%	100.0%
Total	Count	112	383	85	152	125	857
	% within accident type	13.1%	44.7%	9.9%	17.7%	14.6%	100.0%

Table 8.Symmetric Measures Between Type Of The Accident And Type of Ships Involved In the Accident

Nominal by Nominal	Value	Approx. Sig
Phi	0.402	0.000
Cramer's V	0.201	0.000
N of Valid Cases	857	

The value of Cramer's V is 0.201 as shown in Table 8. Therefore, there is is a moderate level of statistical relationship between type of the accident and type of ships involved in the accident as shown in Table 9.

4.2.4. Regression Analysis &Unique Root Test

It is used regression analysiscovering the period 1982-2003 (N=21) for the accidents occurred in The Strait of İstanbul by using EVIEWS 5.0. Estimated accident rate in the Strait of İstanbul (Y) was considered as dependent variable for the linear regression model (Ece, 2005). Considered as dependent variable (Y) and potential independent variables (X_i) were given in Table 9.

Table 9. The Variables of Regression Analysis

Y = Ratio of Accidents estimated occurred in the Strait of İstanbul
X_1 = Maximum current velocity at the accident location (cm/sec/)
X_2 = Total number of days of wind blow (prevailing wind NNE)
X_3 = Average wind speed (meter/sec) (prevailing wind NNE)
X_4 = The number of average stormy days (wind speed>=17.2 m/sn.)
X_5 = The number of average strong stormy days (wind speed 10.8-17.1 meter/sec.)
X_6 = The number of average foggy days
X_7 = The number of average snowy days
X_8 = The number of average cloudy days (0-10)
X_9 = The number of average cloudyly days (bult. 8.1-10.0)
X_{10} = Average tonnage of the ships (GRT)
X_{11} = Total number of wind blow (prevailing wind SW)
X_{12} = Average wind speed (meter/sec. (SW)
X_{13} = Total number of wind blow (meter/sec.) (SSW)

It has been used The Least Squares Estimation in the study. The regression equation is given as follows (Dickey and Fuller, 1981).

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11+} + \beta_{12}X_{12} + \beta_{13}X_{13+}\varepsilon_i \quad (2)$$

where the values β_0. β_1. β_2. ………….. .β_{13} are called the regressions coefficients.

It has been used the Augmented Dickey-Fuller (ADF) test which is unit root test to test stationarity in the data. The following equations are used for ADF Test statistics (Çekerel, 2005).

$$\Delta y_t = \mu + \gamma y_{t-1} + \sum_{J=1}^{k} \alpha_J \Delta y_{t-j} + e_t \quad (3)$$

$$\Delta y_t = \mu + \delta_t + \gamma y_{t-1} + \sum_{J=1}^{k} \alpha_J \Delta y_{t-j} + e_t \quad (4)$$

Y_t: The variableused for the ADF Test at t time, μ : Average of the series, Δy_{t-j}: Difference operator, δ_t: Trend ofLineer time and e_t: Error term.

The regression equation (2) has been estimated in the study. It is assumed that ratio of accidents estimated occurred in the Strait of İstanbul in 1982-2003 as dependent variables and other variables as independent variables as shown in Table 10(Ece, 2005).

All variables are at the level of stationary as shown in Table 10. Hence. the equation (2) has been estimated by using The Least Squares Method. The Least Squares Method was applied to the estimated accident rate (dependent variable) and independent variables such as waterway characteristics as like current velocity, ship tonnages (GRT) and meterorological conditions for the Strait of İstanbul. The resulting linear regression model has been applied for data (1982-2003) (Ece, 2005).

Table 10.The Results of Unit Root (ADF) Test

Variables	ADF	Critical value	Lag Length	Probability
Y				
X_1	-4.881	-3.832	2	0.0011
X_2	-4.617	-3.809	0	0.0018
X_3	-4.067	-3.788	0	0.0054
X_4	-5.005	-3.788	0	0.0007
X_5	-8.373	-3.809	0	0.0000
X_6	-5.102	-3.832	1	0.0007
X_7	-5.893	-3.788	0	0.0001
X_8	-4.377	-3.887	3	0.0038
X_9	-3.169	-3.788	0	0.0366
X_{10}	-3.896	-3.788	0	0.0079
X_{11}	-3.929	-3.788	0	0.0074
X_{12}	-3.437	-3.788	0	0.0211
X_{13}	-4.809	-3.832	1	0.0013

Y = -13.65296 + 0.004942 X_1 - 0.002380 X_2 - 1.763056 X_3 - 0.387087 X_4 - 0.585795 X_5+ 0.016573 X_6 + 0.014126 X_7
(0.726335) (0.001679) (0.000351) (0.163392) (0.030382) (0.090135) (0.001893) (0.003796)

\+ 4.736643 X_8 - 0.003684 X_9 + 0.360814 X_{10}+ 0.005281 X_{11}+ 0.302605 X_{12} + 1.175667 X_{13}
(0.314160) (0.001439) (0.045299) (0.002060) (0.127618) (0.078551)

The results of regression were reported in the Table 11.

Table 11.The Result of Regression Analysis

Variables	Coefficient	Standart Error	t-Statistics	Probability
C	-13.65296	0.726335	-18.79706	0.0000
X_1	0.004942	0.001679	2.943306	0.0216
X_2	-0.002380	0.000351	-6.779653	0.0003
X_3	-1.763056	0.163392	-10.79037	0.0000
X_4	-0.387087	0.030382	-12.74071	0.0000
X_5	-0.585795	0.090135	-6.499074	0.0003
X_6	0.016573	0.001893	8.754637	0.0001
X_7	0.014126	0.003796	3.720964	0.0074
X_8	4.736643	0.314160	15.07715	0.0000
X_9	-0.003684	0.001439	-2.560621	0.0375
X_{10}	0.360814	0.045299	7.965090	0.0001
X_{11}	0.005281	0.002060	2.563503	0.0374
X_{12}	0.302605	0.127618	2.371173	0.0495
X_{13}	1.175667	0.078551	14.96695	0.0000
R-squared	0.996891	F-statistics		172.6814
Adjusted R-squared	0.991118	Prob (F-statistic)		0.0000
Durbin-Watson (DW) stat	2.390393			

R-squared ($R^{2)}$ = 0.997 F-statistics = 172.6814
Prob (F-statistics = 0.0000)

Adjusted R-squared ($\overline{R}^2$)= 0.991
Durbin-Watson stat (DW) = 2.390393

The coeffient of determination (R^2) has been used to measure the amount of variation in the dependent variable. High value of R^2 (0.997) indicates that the model fits the data well because the amount of total variance explained by the independent variables in the model as shown in Table 11 (Ece, 2005).

As the result of the estimation; the variables which increase the ratio of accidents estimated occurred in the Strait of İstanbul (Y) are maximum current velocity at the accident place (X_1); the number of average foggy days (X_6); the number of average snowy days (X_7); the number of average cloudy days (X_8); average tonnage of the ships (X_{10}); total number of wind blow (prevailing wind SW) (X_{11}); average wind speed (SW) (X_{12})andtotal number of wind blow (SSW) (X_{13}) (Ece, 2005)

On the other hand; The variables which decrease the If DW statistic is around 2 there is no autocorrelation. According to DW statistics (2.390) there is no autocorrelation in the equation as shown in Table 11 (Ece, 2005). It means that successive values will not tend to be close to each other.

5% level and the regression equation have a higly significant F-value according to the results of the model.

Improvement of navigation aids, encouraging the use of pilots on board, diversification of navigation equipments, minimizing human errors and establishment of pipelines for transport of dangerous goods will contribute to provide safety of navigation and environmment of the Strait of İstanbul.

Ratio of accidents estimated occurred in the Strait of İstanbul (Y) are total number of days of wind blow (prevailing wind NNE) (X_2). average wind speed (prevailing wind NNE) (X_3). the number of average stormy days (X_4). the number of average strong stormy days (X_5) and the number of average cloudyly days (X_9) (Ece, 2005).

4.2.5. t Tests For Independent variables (Significance Test)

It has been used t-tests (significance test) which is a type of inferential statistic to determine if there is a significant difference between the means of two groups (Uriel, 2003). The F-test for linear regression tests whether any of the independent variables in a multiple linear regression model are significant (http://facweb.cs.depaul.edu; (Ece, 2005).

$H_0 : \beta_i = 0$ if level of significance $<\alpha = 0.05$, H_1 is accepted
$H_1 : \beta_i \neq 0$ Otherwiswe H_0 is accepted

All independent variables given in Table 11 are significant at the below 5% level .

4.2.6. Hypotheses About β's and F Test For Overall Significance Test

There are several types of hypotheses about the β's (the partial slopes or coefficients) in a multiple regression model. F statistic is a value you between two populations are significantly different by using regression analysis (Uriel, 2003; (Ece, 2005).

H_0: $\beta_1 = \beta_2 = \ldots\ldots\beta_p = 0$ if level of significance $<\alpha=0.05$
H1 is accepted.
H_1: at least of of the $\beta_j \neq 0$ otherwise H_0 is accepted

The regression equation have a higly significant F-value according to the results of the model as shown in Table 11.

4.2.7. Durbin Watson Test

Durbin Watson Test (statistic) has been used to test for the presence of first-order autocorrelation in the residuals of the regression equation. Durbin Watson Test equation is given as follows (Johnston and Dinardo, 1997; (Ece, 2005).

$$\Delta = \frac{\sum_{t=2}^{n}(e_t - e_{t-1})^2}{\sum_{t=1}^{n} e_t{}^2}$$

e = y - Xb (error vector)

If DW statistic is around 2 there is no autocorrelation. According to DW statistics (2.390) there is no autocorrelation in the equation as shown in Table 11 (Ece, 2005). It means that successive values will not tend to be close to each other.

5. CONCLUSION

The Strait of İstanbul is one of the most narrow, congested and risky waterways in the world from the point of view navigational constraints, geographical features and several meteorological factors. of the Strait of İstanbul. The increasing of the number of the ships and expecially tankers passing through The Strait of İstanbul have become a serious threat for human life, safety of navigation, historical and cultural heritage and environment. The Strait of İstanbul faced 857 ship accidents during the “right-side up” scheme period 1982-2018.

In the study accident analysis has been performed for the accidents occured in The Strait of İstanbul by using the statistical methods such as frequency distribution, Chi Square Test, Cramer’s V Test in 1982-2018 and regression analysis, t and F tests for significance of regression model and Durbin Watson Test for testing autocorrelation in residuals from a regression analysis between the years 1982 and 2003. This paper’s findings consist of the following:

The most common type of accident is collision and respectively grounding in The Strait of İstanbul; the cargo ships were the most involved in the accident and respectively passenger shipss. The most accident has been occured in the hours 20:00-24 and respectively 08:00-12:00, 12:00-16:00 and 24:00-04:00. Human error is the main reason of the accidents. There is a moderate level of statistical relationship between type of the accident and the type of ships involved ın the accident.

According to the results of regression analysis; the variables which increase estimated accident rate occurred in the Strait of İstanbul are maximum current velocity at the accident place, the number of average foggy days, the number of average snowy days, the number of average cloudy days, average tonnage of the ships, total number of wind blow, average wind speed (SW), andtotal number of wind blow (SSW). High value R-squared value (R^2=0.997) indicates that the model fits the data well because the amount of total variance explained by the independent variables in the model. According to the result of t Test, all independent variables given in the study are significant at the below 5% level and the regression equation have a higly significant F-value according to the results of the model.

Improvement of navigation aids, encouraging the use of pilots on board, diversification of navigation equipments, minimizing human errors and establishment of pipelines for transport of dangerous goods will contribute to provide safety of navigation and environmment of the Strait of İstanbul.

REFERENCES

Akdi, Y. (2003)., *Zaman Serileri Analizi*, Bıçaklar Kitabevi, Yayın No:4, Ankara.

Akten, N. (2003) “The Strait of İstanbul (Strait of İstanbul): The seaway separating the continents with its dense shipping traffic”, *Turkish Journal of Marine Sciences*, Vol. 9, No. 3, pp. 241.

Akten, N. (2006).“Shipping accidents: a serious threat for marine environment, *J. Black Sea/Mediterranean Environment,* Vol. 12, pp. 269-304.

Baş, M. (1999).Türk Boğazları’nda Risk Analizi ile Güvenli Seyir Modeli, Doktora Tezi, T.C. İstanbul Üniversitesi, Fen Bilimleri Enstitüsü, İstanbul.

Birpinar, M.E., Talu, G.F. And Gönençgil, B. (2008). “Environmental Effects Of Maritime Traffic On The İstanbul Strait”, *Environmental Monitoring And Assessment*, Vol. 152, pp.13.

Çekerel K. ve Gürbüz H. (2005). “Reel döviz Kuru Değişimleri ile Sektörel Dış Ticaret Fiyatları Arasındaki Uzun Dönem İlişki”, http://www.econturk.org/Turkiyeekonomisi/odtu_kamil.pdf[Accessed 06 June 2005].

Dickey D.A. and Fuller W.A.. (1981) . “Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root”. *Econometrica*. Vol. 49, No. 4, pp. 1057-1072.

Directorate of General Coastal Safety, https://www.kiyiemniyeti.gov.tr/vessel_traffic_and_pilotage_services . [Accessed 18 October, 20].

Ece, N. J. (2005). The accident analysis of the Strait of Istanbul from the points of navigation andenvironment and evaluation of innocent passage. PhD Thesis, Gazi University, Ankara, Turkey.

Ece, N.J. (2012). “Analysis Of Ship Accidents In The Strait Of İstanbul”, *Dokuz Eylül Üniversity, Maritime Faculty Journal,* Vol. 4, No. 2, pp.1-25.

Ece, N.J. (2019). “Lessons Learned From the wreck of the Independența in its 40th year (40. Yılında İndependenta Kazasından Alınan Dersler)” Panel, *Koç* University *Maritime Forum (KUDENFOR*), İstanbul.

General Directorate Of Meteorology (2004). “Meteorological data for the Strait of İstanbul”.

Görçüna, Ö.,F. and Selmin, Z.B. (2016). “Formal Safety Assessment for Ship Traffic in the Istanbul Straits”, *Procedia - Social and Behavioral Sciences,* pp. 207-255.

Johnston, J. and Dinardo, J. (1997). *Econometric Methods, Heteroscedasticity and Autocorrelation, Testing for Autocorrelatde Disturbances*, McGraw-Hill, Fourth edition, Singapure.

Koldemir, B. (2009). “Determination Of Risky Regions In Strait Of Istanbul From The Aspect Of Navigational Safety; Updating Of The Accident Black Points”, *Dokuz Eylül Üniversity, Maritime Faculty* Journal, Vol. 1, No. 1, pp.22.

Kornhauster, A.L., Clark W.A. (1995). “Quantitative Forecast of Vessel Casualties resulting from Additional Oil Tanker Traffic Through the Bosporus”, *ALK Associates Inc. Princeton, NJ*, England, pp. 15-17, 3, 25-26, 38, 40, 42-45.

Köse, E., Başar E, Demirci, E.; Güneroğlu, A., Erkebay, Ş. (2003) Simulation of maritime traffic in İstanbul Strait, *Simulation Modelling Practice and Theory*, Vol. 11, pp. 606.

Republic Of Turkey *Turkish Naval Forces* Office Of *Navigation*, Hydrography And Oceanography, 2004.

The Republic of Turkey Ministry of Transport and Infrastructure of (UBAK) Main *Search-Rescue* Coordination *Center*(2019). General Directorate of Maritime Trade The Turkish Straits Vessel Traffic Statistics. http://aakkm.udhb.gov.tr/[Accessed 10 July 2019].

T.C. Başbakanlık Denizcilik Müsteşarlığı (Undersecretariat for Maritime Affairs) (2003). Seyir Güvenliği Daire Başkanlığı, “İstanbul Boğazı Deniz Kazaları İstatistikleri ve trafiği 2003-2004”, Ankara.

The F-Test For Linear Regression, http://facweb.cs.depaul.edu/sjost/csc423/documents/f-test-reg.htm[Accessed 10 Sept.2019].

Türk Deniz Araştırmaları Vakfı (TÜDAV). (2003). “İstanbul Boğazı Deniz Kazaları İstatistikleri”, İstanbul. Turkish Maritime Pilots Association, “List of Casualties Which Occured in the Strait of İstanbul During the Period 01/07/1994 to 31/08/2000”, http://www.turkishpilots.org.tr/DOCUMENTS, 1-10 (17.06.2004). [Accessed 06 June 2005].

Turkish Maritime Pilots Association /2004). “List of Accidents Occured in the Strait of İstanbul 1948-01.05.1982, http://www.turkishpilots. org./CASUALTY/accidents.html, [Accessed 06 Dec.2004].

Uçan, E. And Nas, S. (2015). “Analysing Istanbul Strait Maritime Pilot Capacity By Simulation Technique”. *The Journal Of Navigation*,Vol. 69, No. 4, pp. 815-827.

Uğurlu, Ö, Erol, S. and Başar, E. (2015). “The analysis of life safety and economic loss in marine accidents occurring in the Turkish Straits”, *Maritime Policy&Management*, Vol. 43, No. 3, pp.356-370.

Ulusçu, Ö. S, Özbaş, B, Altıok T. ve Or, İ. (2009). “Risk Analysis of the Vessel Traffic in the Strait of İstanbul”, *Risk Analysis*, Vol. 29, No.10, pp.1454-1455, 1471.

Uriel, E. (2003). Hypothesis testing in the multiple regression model, Universidad de Valencia Version: file:///C:/Documents%20and%20Settings/Hp/Belgelerim/Downloads/4Hypothesistestinginthemultipleregressionmodel.pdf [Accessed 06June 2003].

Yazıcı M A, Otay E N. (2009) A Navigation Safety Support Model for the Strait of İstanbul, *Journal of Navigation*, Vol 62, Issue 04, 609-630.

Yılmaz F. and Önaçan. M.B.K. (2019). A Qualitative Research on Developments in Autonomous Ship Technology and Effects on Turkish Maritime & Shipbuilding Sector. *Dokuz Eylül Üniversitesi Denizcilik Fakültesi Dergisi*, 11(1):57-86.