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A Comparative Study of Ship Risk Profile According to Port State Control Regime: A Case Study of Turkish Straits

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Abstract: The implementation and supervision of international regulations are crucial to ensure maritime safety. Port State Control (PSC) regimes make a great contribution to this by inspecting the safety standards and compliance with international regulations of ships arriving at ports. In PSCs, due to a lack of personnel for inspection and an excess number of ships to be inspected, risky ships are selected by ship risk profile and inspected, and substandard ships are detected. In this study, detention data along with non-conformities of PSC were combined with ships' data passing through the Turkish Straits to compare the PSC regime's effect on the navigational safety of a narrow waterway passage. Furthermore, exploratory analysis has been provided in order to reveal the maritime traffic structure of the Turkish Straits regarding PSC measures. The results have offered promising evidence that PSC regime implementation provides a valuable indicator to discriminate ship risk profile for narrow waterways.

Keywords: Maritime safety; Narrow waterways; Ship Risk Profile; Port State Control; Turkish Straits

1. Introduction

Maritime safety is crucial considering 90% of world trade is being carried out by maritime transportation (AGCS 2021), and is being ensured by putting international regulations and measures into practice. The supervision of international regulations and measures is just as vital as the implementation of those. Whereas the implementation and supervision of international regulations are primarily the responsibility of the flag state, these controls and inspections are carried out by the classification societies or inspectors authorized on behalf of the flag state (IMO 2017). However, due to the nature of the maritime environment, the fact that ships cannot frequently visit the ports of flag states and that there are not enough resources/personnel in flag states for ships that implement Flag of Convenience (FOC) has caused weaknesses in ensuring and inspecting the safety standards of ships. These resulting vulnerabilities have brought PSC to life (Heij et al. 2011). PSC regimes make a great contribution to the implementation and supervision of international regulations by inspecting the safety standards and compliance with international regulations of ships arriving at ports in support of Flag State Controls (FSC) (IMO 2017). In PSCs, due to a lack of personnel for inspection and an excess number of ships to be inspected, risky ships are selected by ship risk profile and inspected, and substandard ships are detected (Paris MoU 2021). Once the historical data of these inspections are evaluated, it is revealed that there are significant improvements in the establishment of life, property, and environmental safety (Li et al. 2008). PSC is the last safety step, which is generally accepted as a measure to consolidate the old maritime safety net created by FSCs and classification societies (Emecen Kara 2016).

In this study, detention data along with non-conformities of PSC were combined with ships' accident data passing through the Turkish Straits to compare the PSC Regime effect on the navigation safety of a narrow waterway passage. Then, in respect of maritime safety, a comparative study was conducted between ships passing through the Turkish Straits that had accidents and those that did not in order to reveal the significance of PSC audits. Furthermore, exploratory analysis has been provided in order to reveal the maritime traffic structure of the Turkish Straits regarding PSC measures. The results have provided promising evidence that PSC results/indicators have a significant effect on the navigation safety of narrow waterways. The correlation between PSC data and ship accidents has been revealed to provide insights into future studies.

Within the scope of the aforementioned information, this study is organized as follows. In Section 2, the literature review and info about the Turkish Straits are expressed. Data examination is introduced in Section 3. In Section 4, results are assessed. In the last section, the conclusion is presented. Sailing Plan (SP)-1 reports data between the years 2005 and 2021, which are reported by ships passing through the Turkish Straits, and the accidents data that occurred in Straits between the years 2004 and 2021 were obtained from the Turkish Directorate General of Coastal Safety. In addition, Paris MoU, Tokyo MoU, Mediterranean MoU, and Black Sea MoU detention data were extracted from the website of the relevant MoU.

2. Background

2.1 Turkish Straits

The Turkish Straits, composed of the Istanbul Strait, the Canakkale Strait, and the Sea of Marmara, are among the riskiest and most congested narrow waterways in the world with their unique structure in the aspect of navigational safety. Given that the Turkish Straits connect the Mediterranean and the Black Sea, its importance in world trade is apparent. The increasing ship sizes and traffic density in parallel with world trade on this waterway has escalated existing risks in the Straits (Köse et al. 2003), and safety measures have become highly necessary. Due to this need, many measures and regulations are continuously being put into practice. Therefore, academic studies are concentrated on safety in these waters as well.

Whilst the current state of the Turkish Straits is reviewed, it can be seen that the straits are being monitored by Turkish Straits Vessel Traffic Service (TSVTS) in order to mitigate accident risks, and a variety of precautions are taken by evaluating meteorological conditions, sea states, and traffic density. In addition, ships passing through straits are obliged to follow the traffic separation scheme and to inform TSVTS with SP-1 reports, which contain a wide variety of data about ship characteristics.

2.2. Literature Review

Maritime accidents are more common in ports, inland waters, or narrow waterways than on open seas (Ozbas 2013) and PSC plays an important role in mitigating sub-standard ships in the waterways. Therefore, studies on PSC focusing on maritime safety specific to narrow waterways are crucial. A literature review on PSC inspections was conducted by Yan and Wang (2019), and after examining 43 articles, it is declared that the introduction of PSC has helped to improve maritime safety, especially by reducing accident risks. This fact has been demonstrated once again by this study and made PSC's efficiency apparent.

In the study by Sage (2005), it has been stated that the sub-standard ship risk profiles set by the targeting factors used by the Paris MoU and the risk situation of the sea area where the ship is located, can be utilized in the identification of high-risk ships. With the help of this, high-risk vessels could be followed more precisely and proactive measures can be taken effectively by VTSs in order to mitigate possible accident risks or the consequences of accidents. Degré (2007) put forward the necessity of applying the ship risk profile in a risk-based way with a statistical approach including accident risk as a new targeting method by the Paris MoU. As a regional study, maritime risk assessment of the Istanbul Strait regarding the risk level of ships' flags according to Black Sea MoU data was conducted by Emecen Kara (2016). In parallel with these studies, a static ship risk profile model was introduced with a probabilistic approach using the ship risk profile parameters of the Paris MoU by Dinis et al. (2020). In addition, it has been stated that environmental, geographical, and other dynamic risk factors related to navigation can be added to the model developed in the sea region.

As abovementioned, PSC inspections escalate maritime safety. However, the PSC impact on narrow waterways has not been evaluated in studies related to PSC. In this study, a comparative analysis of the data on narrow waterways, specific to the sea region, was conducted with the PSC data.

3. Data Examination

Sea regions are unique due to the complexity of the maritime environment, and international regulations and measures can be introduced specifically for the region. The Turkish Straits are one of the most important narrow waterways in terms of regulations and measures introduced specifically to the region. In this respect, data on ships passing through the Turkish Straits between the years 2005-2021 and marine accidents in the Straits between the years 2004-2021 were obtained. As PSC data, Tokyo MoU between the years 2000-2021, Black Sea MoU between the years 2002-2021, Paris MoU between the years 2009-2021, and Mediterranean

MoU between the years 2016-2021 were acquired from related MoU websites. General information regarding ship passages from the Turkish Straits has been provided in Figure 1.

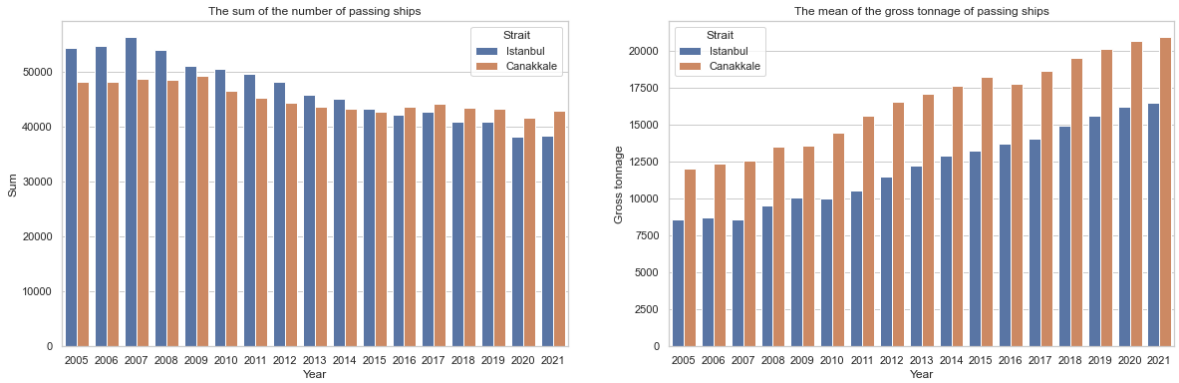

Figure 1. Ships passing through the Turkish Straits between the years 2005-2021.

In Figure 1, it is seen that the number of ships passing through the Turkish Straits has decreased over the years, but the gross tonnage of the ships passing through the Straits has highly increased compared to the decreasing number of ships passing. Considering the unique geographical structure of the Turkish Straits and current traffic density in the Straits, there is a serious increase in the size of ships and that poses potential accident risks. While reviewing PSC detention data with ships passing through the Turkish Straits, it is noticed that detention and deficiency number increased proportionally similarly (see Figure 2) and the yearly ratio of ships with detentions passing through the Turkish Straits increased as well (see Figure 3).

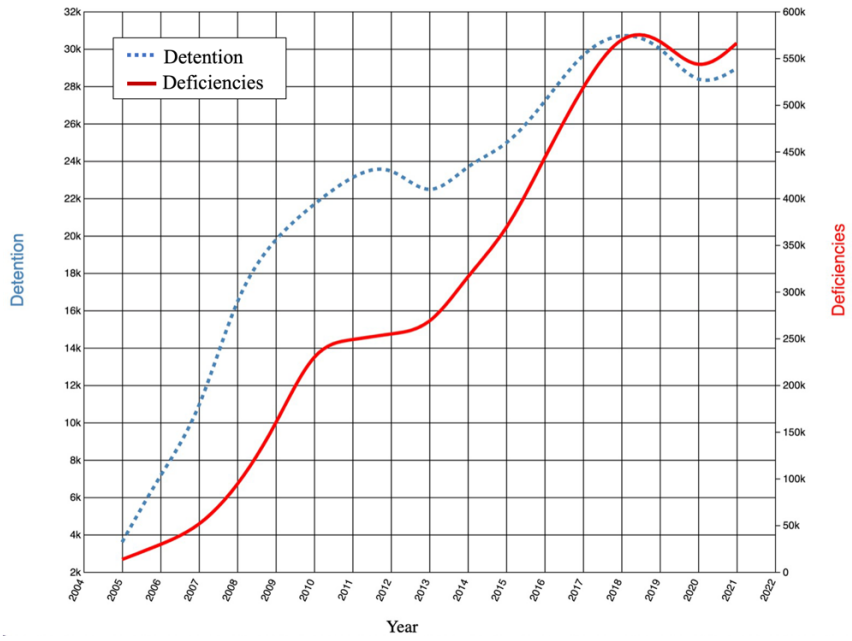

Figure 2. The deficiency and detention number of ships passing through the Turkish Straits

Length, gross tonnage, draft, flag, and pilot on board were selected as ship characteristics from the Turkish Straits data. Ship flag and pilot on board data are not numerical. To transform these data into numerical data, the pilot on board was assigned as “0” when false and “1” when true, and for ship flag categorization, the relevant year Paris MoU excess factor was used. Latter, the number of deficiencies and detention data from the PSC data were merged with the Straits data. Data cleaning is conducted; ship types are categorized as Tanker, Cargo, Container and Passenger ships, and other types of ships are excluded. Ship data passing through the Turkish Straits with PSC data and ship accident data in the Turkish Straits with PSC data are demonstrated respectively in Table 1 and in Table 2.

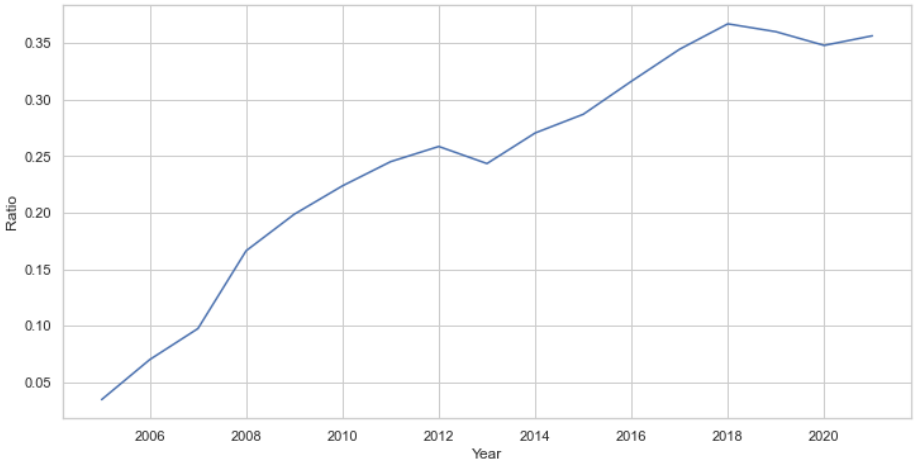

Figure 3. The ratio of ships with detentions passing through the Turkish Straits (non-dimensionalized)

In Table 1, duplicated data of ships passing through the Turkish Straits are dropped according to passage year, IMO number, and detention sum. Whilst examining data in Table 1, it is detected that the mean age of the ships passing through the straits is 16,25, the mean flag factor is -0,35 which indicates that ships, passing through Straits, are above the standard safety level (White flag), the mean detention number is 0,59, and the mean deficiency number is 4,11.

Table 1. Ship data passing through the Turkish Straits between the years 2005-2021.

	Count	**Mean**	**Std**	**Min**	**25%**	**50%**	**75%**	**Max**
Length	119414	157.27	57.05	34.84	108.40	151.55	189.99	399.99
Gross Tonnage	119414	20585.92	22549.24	142.00	3952.00	12226.00	29688.00	232618.00
Age during Passage	119414	16.25	11.65	0.00	6.00	14.00	25.00	60.00
Pilot on Board	119414	0.73	0.44	0.00	0.00	1.00	1.00	1.00
Draft	119414	6.94	2.73	3.01	4.90	6.50	8.40	19.28
Flag Factor	117741	-0.35	1.57	-2.00	-1.42	-0.86	0.00	10.60
Deficiency Number	119414	4.11	12.32	0.00	0.00	0.00	2.00	265.00
Detention Number	119414	0.59	1.31	0.00	0.00	0.00	1.00	20.00

In Table 2, owing to the fact that marine accidents are rare events, duplicated data of ship accident data in the Turkish Straits are dropped according to date of accident, and IMO numbers. While analyzing data in Table 2, it is noticed that the mean age of the ships passing through the Straits is 26,55, the mean flag factor is 0,98 which indicates that ships, passing through the Straits, are below the standard safety level (Gray flag), the mean detention number is 0,87, and the mean deficiency number is 8,08.

Table 2. Ship accident data in the Turkish Straits between the years 2004-2021.

	Count	**Mean**	**Std**	**Min**	**25%**	**50%**	**75%**	**Max**
Length	719	119.55	46.41	30.80	84.38	113.35	143.08	299.94
Gross Tonnage	719	8659.24	12945.10	148.00	1995.00	3712.00	9912.00	104729.00
Age during Passage	719	26.55	11.38	1.00	20.00	28.00	34.00	75.00
Pilot on Board	719	0.04	0.19	0.00	0.00	0.00	0.00	1.00
Draft	574	5.73	2.71	1.80	3.70	5.02	7.20	18.42
Flag Factor	699	0.98	2.16	-1.78	-0.55	0.44	2.27	12.68
Deficiency Number	719	6.08	15.73	0.00	0.00	0.000	5.00	202.00
Detention Number	719	0.87	1.57	0.00	0.00	0.000	1.00	12.00

Eventually, a comparison analysis was conducted on both the data in Table 1 and Table 2. As a prerequisite, the Levene test for checking variance equality, and the Shapiro-Wilk test as a normality test were applied to both data. According to the results, the variance of the data was not equal, and due to sample sizes, the variables were not well fitted to normal distribution. Notwithstanding these shortcomings, Welche's T-test was selected as a proper test and was conducted to descriptive statistics of data.

4. Results and Discussion

Whilst assessing the results, it is observed in Figure 1 that the size of ships passing through the Turkish Straits is increasing significantly even though the number of ships passing is decreasing less in comparison. This poses a serious potential hazard in the case of the occurrence of an accident. In addition to that, deficiency and detention numbers act correlatedly as depicted in Figure 2. The ratio of ships with detentions, which indicates these ships are sub-standard and vulnerable to accident occurrence, passing through the Straits in Figure 3 is approximately 0,35 for the last 5 years. These imply that potentially sub-standard ships prone to accident risk are passing through the Straits as well.

Comparing data of ships passing through the Turkish Strait in Table 1 with accident data in the Straits in Table 2, it is apparent that PSC data (Flag factor, detention number, and deficiency number) of accident data is significantly higher. This situation indicates that PSC data can be used as ships' factors prone to accident risk in maritime safety risk assessment in the Turkish Straits. In addition, the mean age of ships in accident data is older than expected. Contrary to expectations, the mean length of ships in accident data (Table 2) is less than the ship passage data (Table 1). When the data is thoroughly inspected, it is evaluated that this situation may be related to the building of new ships in larger sizes by the effect of new technological and economic developments, and needs.

Table 3. Welch's t test results

	Statistics	p-Value
Length	21.710	0.000
Gross Tonnage	24.504	0.000
Age during Passage	24.196	0.000
Pilot on Board	10.583	0.000
Draft	93.253	0.000
Flag Factor	-16.379,	0.000
Deficiency Number	-3.354	0.001
Detention Number	-4.865	0.000

The results of Welch's test have been presented in Table 3. As can be seen from the results, most of the features of accident and ship passage data are significantly different. Particularly, deficiency number and detention number results have shown that PSC regime implementation provides a valuable indicator to discriminate ship risk profiles.

In the example of the Turkish Straits, maritime authorities are utilizing the ship characteristics such as ship length, ship age, draft, etc. for determining ship risk profile. In this study, it is observed that the flag factor, deficiency and detention number may also be employed in ship risk assessment.

5. Conclusion

In this study, it is aimed to reveal the maritime traffic structure of the Turkish Straits, which is one of the most dangerous narrow and congested waterways in the world, with its economic and geopolitical importance, regarding PSC measures. Understanding the maritime traffic structure in the Turkish Straits may provide insight into risk assessment approaches in narrow waterways and congested waters, and determine what needs to be done for safe passage with the help of the PSC data. It has been seen that PSC data is a valuable indicator to determine risky ships for the narrow waterways in example of the Turkish Straits. For further studies, taking into account other features such as geographical and meteorological features could provide more insightful results for risk assessment in narrow waterways.

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