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ARDL Bound Testing Approach for Turkish-Flagged Ships Inspected under the Paris Memorandum of Understanding

Selen Uygur[1], Fırat Bolat[2]

[1]Oceangoing Watchkeeping Officer, İstanbul, Turkey, İzmir, Turkey
[2]İstanbul Technical University Maritime Faculty, Department of Marine Engineering, İstanbul, Turkey

Abstract

The Paris Memorandum of Understanding (MoU) publishes a white, gray, and black list, presenting the full spectrum from quality flags to flags with poor performance that are considered high or very high risk every year. At this point, increasing the flag's performance can be achieved by eliminating the deficiencies and detentions in the ships. In this context, the aim of this study is to examine the performance of Turkish-flagged ships under the Paris MoU port state control (PSC) to determine the deficiencies of the ships and to make suggestions for measures that may be taken by the Republic of Turkey as a relevant flag state. Accordingly, the PSC data of Turkish-flagged ships between 2013 and 2020 in the EMSA THETIS have been analyzed. Comparison and descriptive distributions for the data of Turkish-flagged ships have been performed by creating cross tables of the distribution of ship type, inspection type, age of ships, detention ports, and detention decisions. An autoregressive distributed lag bound test has been carried out to understand whether the deficiencies and age of the ships can significantly affect the detention decision of ships at the port under the Paris MoU. Consequently, while deficiencies on the ships are found to significantly affect the decision of the detention of ships, the age of ships doesn't have a significant effect under the Paris MoU.

Keywords

Flag performance, Port state control, Paris memorandum of understanding

1. Introduction

Flag performance has become an important issue in maritime, especially after the signing of the regional memorandums of understanding. Ships belonging to states with low flag performance become targets of the regional Memorandum of Understanding (MoU) regimes wherein ships can wait at the port during the port state control (PSC) or after the control if they have any deficiencies. This waiting process causes delays in the workflow and, accordingly, money losses arising from port fees. This also causes the ship operator to lose money and reputation due to the ship's loss of the next load.

Increasing the flag performance is the responsibility of the relevant flag state as well as ship operators such as the crew, captain, marine company, and shipowner. Corres and Pallis [1] stated that the flag states are primarily responsible for the safety and environmental protection performance of their ships and that they fulfill these duties through international conventions and national law. According to Mansell [2], each flag state must take measures to ensure the safety of ships carrying its flag in terms of construction, equipment, and seaworthiness. International conventions require each ship to be inspected by an authorized auditor at regular intervals before and after the registration of the ship registry. However, inspections made by the flag states and international maritime authorities failed to eliminate the sub-standard ships in the sector, and the heavy maritime traffic and related accidents, especially since the 1960s, have threatened the safety of life and property at sea and marine environment [3]. In addition, after the 1970s, maritime regulations began to diverge from the ideal situation with debatable practices of some flag states [4].

Address for Correspondence: Fırat Bolat, İstanbul Technical University Maritime Faculty, Department of Marine Engineering, İstanbul, Turkey
E-mail: bolatf@itu.edu.tr
ORCID ID: orcid.org/0000-0001-9807-7089

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Despite the complex and comprehensive legal framework in the maritime sector, the implementation of these laws could be insufficient due to the international nature of the sector and could vary widely at the level of flag states [5]. This situation has pushed the port states, which were affected by the pollution that emerged after the marine accidents (Torrey Canyon 1968 and Amoco Cadiz 1979) involving ships carrying foreign flags, and those that did not have a connection with the relevant ship to seek new searches. Hence, the PSC has been developed to control the ships entering their own ports or coastal facilities. Inspections by PSC have been carried out to determine whether the ships meet the safety and pollution prevention requirements and whether they comply with the standards in relevant international conventions [6]. Under the PSC, a port state can take administrative measures such as keeping the ship at the port until corrective measures are taken or directing it to the nearest shipyard for repair. Since its emergence, PSC has played an important role in protecting the marine environment and in improving safety. Moreover, PSC has contributed to issues such as protecting international maritime standards, preventing pollution, ensuring property and life safety in the scope of international conventions such as SOLAS, MARPOL, STCW, LOADLINES, COLREG, TONNAGE 69, and ILO147. The Paris MoU, which is signed by 13 European countries in 1982, is the first regional PSC regime. After the Paris MoU, 8 other regional PSCs are developed, which include the Tokyo MoU, Indian Ocean MoU, Mediterranean MoU, Acuerdo de Viña del Mar, Caribbean MoU, Abuja MoU, Black Sea MoU and Riyadh MoU, and the US Coast Guard for United States region. These regional MoUs apply international rules and form a second line of defense against non-standard shipping [5]. Each PSC audit generates an inspection report, which includes detailed information on the deficiencies, including the flag, International Maritime Organization (IMO) ship number, ship type, construction year, and inspection date [7]. These reports are made into annual reports and published by each MoU regime. In this direction, the regional memorandums of understanding try to ensure that the ships that do not meet the standards will not be able to trade in any region of the world through cooperating and exchanging inspection data [2]. In this context, PSC regimes do not replace the unit that controls the inspections of the flag states on ships, but they are a body that inspects the compliance of ships with maritime conventions. A supportive practice to flag states for the inspections of the ships [8,9].

PSC detention rates of ships have been used for many years to measure the performance of flag states [2]. The issue of measuring the flag state performance was first initiated by the oldest PSC regime, Paris MoU, and was subsequently adopted by the Tokyo MoU [5]. These statistics are compared with the detentions in the entire PSC regime region, and flag states below a certain average can be identified and become targets for future inspections [2]. Since 1999, PSC regimes have been creating and publishing black, gray, and white lists by examining and processing the audit data they obtain every year, and by placing the flag states under these lists according to their performance [2,5]. Accordingly, the PSC's data is a powerful measure of the performance of a flag state. Through these PSC performances, most people who are associated with the maritime industry gain views on the value of flags. Theoretically, a high PSC inspection rate for a particular flag decreases the attractiveness of the flag as it degrades the performance of that flag and thus causes delays and loss of time and money [4].

The detailed reporting of the inspections within the scope of PSC, the inclusion of lots of information about the ship in the reports, and the processing and sharing of this information with other regional MoUs aim to reduce the non-standard practices in the global maritime system. The presence of deficiencies on the ship during these inspections causes the inspection to take longer, and the serious deficiencies cause the ship to be kept. These detention periods cause financial losses for the operator and loss of reputation for the flag state. Control and detention rates are considered indicators of the performance of a flag state, and low performance in an MoU regime can reach other MoUs due to information sharing between MoU regimes. In this way, low-performance flags become the primary control target of other MoU regimes. By operating the legal rights and responsibilities of the flag state arising from international conventions, seriously taking the mandatory inspections that are carried out at regular intervals prevent the ships from detention by the regional MoU regimes. Decreasing ship detention rates increases flag performance, prevents ship operators from losing time and money, and ensures that the relevant flag is off the radar of regional MoU regimes.

In this context, the aim of this study is to examine the performance of Turkish-flagged ships under the Paris MoU PSC to determine what the deficiencies of the ships are and to make suggestions for measures that may be taken into consideration by the Republic of Turkey as the relevant flag state. Comparison and descriptive distributions of data have been performed for Turkish-flagged ships under the Paris MoU by creating cross tables of distribution of ship type, inspection type, age of ships, detention ports, and detention decisions. An autoregressive distributed lag bound (ARDL) time-series analysis has been carried out to understand whether the average number of deficiencies that have been found on the ships and the average age of ships that have been inspected under the Paris MoU significantly affect the average number of detention decision of ships at port.

2. Literature Review

Life, property, and the environment are the most important issues in international transportation in the maritime world. Although the maritime industry is comparatively safe, it also includes a huge cost of accidents related to humans, the economy, and the environment. To measure these cases, the IMO, which is the prescriptive body in the maritime industry, has enhanced approximately 50 conventions that are as the legislative framework. Coastal states and flag state authorities take preventive actions in the light of the IMO conventions and national rules due to the high costs of accidents. However, inspections and controls of flag states on the vessels are not effective because of ships working in long distances, lack of experience, deployment of flags of convenient applications, fast growth in world navigation fleet, and lack of sources [1]. Therefore, PSC was additionally established for ensuring navigation safety to prevent maritime environment pollution and to correct the problems of flag state controls. PSC inspects foreign ships in national ports to verify the condition of the ship. In this context, the purpose of PSC is to contribute to flag state inspection results that were inadequate for inspecting compliance of the vessels to international standards, and to impose enforcement measures to vessels violating these standards. PSC inspections benefit the coastal state by providing safety of life, property, and environment while measuring the performance of the flag state of ships.

There are various studies in the literature about PSC inspection and its benefits that support the measurement of the performance of vessels. For example, Heij et al. [10] analyzed the effect of PSC inspections on the topic of safety to lower the accident victim risk by associating the inspection data with the accident victim. They also researched the probable safety achievements that can arise from luculently including the vessel's particular risk for future accidents to planning vessel inspection strategies.

Aydemir [11] analyzed the defects identified at the vessels under a ship inspection report program. In his study, 393 inspections between 2006 and 2014 for 16 maritime companies have been examined in the scope of 9 different MoUs and 40 different ports. The results of the study revealed that the percentage of deficiencies of the firms taken under control were quite close to each other. Deficiency items for these companies have been aligned as sections of safety management, petroleum, chemical, LPG and LNG, and the machinery and steering system.

Bayram [12] investigated the reasons for the detention of Turkish-flagged vessels as a result of PSC in the Paris, Mediterranean, and Black Sea Memorandums. In this context, all the deficiencies of the Turkish-flagged ships detained in 2005-2008 were determined, and the detected deficiencies were examined under 19 headings. In all three MoU inspections, it was determined that Turkish-flagged ships were weak in fire safety and precautions, lifesaving appliances, and MARPOL, and the detention reasons were more intense on these issues.

According to the Paris MoU inspections report in 2019 [13], 17908 inspections actualized in the coast of the Paris MoU member and 9320 deficiencies, 526 detentions, and 27 bannings were found. Forty-one flag countries including the Turkish flag have been in the white list, while 16 and 13 flag countries have been in the gray and black list, respectively. The top five categories of deficiencies consist of the safety of fire (13%); safety of navigation (11%); lifesaving appliances (8%); labor conditions, welfare and social security protection, medical care, health protection (8%); and emergency systems (7%). In accordance with inspections in 2019 specifically for Turkish-flagged ships, 252 number of inspections have been carried out in which 159 of them were with deficiencies, 4 of them included detention, and 30 of them involved detainable deficiencies. As a result, 63.1% of inspections were with deficiencies and 1.6% of them comprised detention.

Fan et al. [4] established a statistical analysis for modeling the dynamic relationships between the PSC inspection rate and flag-out decision of the vessel operator. They made a binary choice logit model, which suppose maximization efficacy on the decision of the operator's flagging out, to understand the effect of PSC inspection on the flag-out decision. Accordingly, the main attributes for flagging out were the ship type, ship age, operator's nationality, and the determinants of the operator's characteristics, such as the GDP per capita and rate of income tax. In addition, if a vessel has a ship classification services from International Association of Classification Societies members, the ship is then less probably to flag out. The essential attributes for the rate of PSC inspection included the vessel tonnage, type, age, and operator's characteristics. Consequently, if a vessel flies a flag of convenience, it is more likely to be inspected.

Piniella et al. [14] made a comparative study for the ships detained in the scope of Viña del Mar, Tokyo, and Paris regional PSC. They found that the regional agreements on the PSC of Paris and Tokyo are in major cooperation with common directives and trainings of PSC inspectors in more internationally uniform ways.

Emecen Kara et al. [15] carried out a similarity analysis of PSC regimes on the strength of the flag state's performance. Similarities of the PSC regimes have been assessed by the hierarchical clustering method that utilized the risk levels similarity matrices of flag states, the deficiency and rates of detention similarity matrices, and the mixed similarity matrix.

Chung et al. [16] applied data mining for the time-wise assessment of the PSC inspection data in Taiwan's important ports to provide possible substantial data for PSC vessel inspections. This model determined various beneficial association rules through PSC deficiencies in the sense of particular vessel properties, such as vessel societies, flags, and types via the apriori algorithm. According to the analysis, there is a significant relationship between the watertight and weathertight conditions and fire safety items. The comparison analysis of vessel societies and vessel types reveals that the association rules for the particular vessel types have better impact than those for individual vessel societies.

There are some studies suggesting that the ship's age is an important factor for the detention of ships or deficiencies finding onboard. For instance, Cariou and Wolff [17] found that a ship's age, type, and flag of registry are significant predictors. They used quantile regression analysis with a sample of 249,140 initial inspections. These inspections were carried out between January 2000 and December 2011 by 19 participating maritime administrations of the Tokyo MoU. Graziano et al. [18] made an ordinary least square regression model for determining that the differences in detecting at least one deficiency or detaining a vessel are significant among the member states. For that purpose, they used 32,206 PSC inspections that were carried out by the European Union and European Free Trade Association Member States within the Paris MoU region from 1 January 2014 to 31 December 2015. According to their results, there is a significant difference in some member states that the ship with at least one deficiency or detention is 40 percent less likely to be inspected than those with zero deficiency or detention. They also discovered that age is positively related to the deficiencies or detention. However, there is difference in the effect of the coefficient between the age levels. With the reference age, which is less than 5 years old, the probability of having a vessel detained increases by 4.7 percentage points when the vessel is more than 30 years old and by 2.1 percentage points for the number of deficiencies. In addition, according to their results, there are correlations between the role of the inspectors and PSC outcomes. Yılmaz and Ece [19] examined the inspection results of the Turkish-flagged ships inspected under the Paris MoU between 2011 and 2016. In this study, it has been aimed to examine the relationships between the types of inspected ships, the season of the inspection, the type of inspection performed, and the ages of the ships under inspection with the chi-square test (χ^2) method. According to the findings of the research, while the rate of detention was at the level of 3 percent in the comprehensive inspections carried out in the period between 2011 and 2016 under the Paris MoU inspection, it was observed that the average for Turkish-flagged ships was 4.7 percent. In conclusion, there was a statistically significant relationship between the number of deficiencies, age of ships, and the audit result. The difference of this study from Yılmaz and Ece's [19] study is the examination of the effect of deficiencies and age of ships on the detention of ships via an ARDL test. Besides that, this study presents comparatively descriptive information about the Turkish-flagged vessels inspected under the Paris MoU and shows the performance of Turkish-flagged vessels. On the other hand, the Paris MoU has forced a new regime of inspections (NIR) in 2011. According to the NIR, the "ship risk profile" has been taken instead of the "ship target factor" in the system and ships have been classified in different risk groups such as low-risk ships and high-risk ships. In this context, Piniella and Rodriguez-Diaz [20] made a statistical analysis to find which factors are the most significant for the Paris MoU officers in determining which ships to inspect in the NIR. The variables used in their study were the flag state, classification society, type of vessel, age of the ship, and ship risk profile. According to their results, while the flag state, type of vessel, and ship risk profile were important factors in the NIR, the classification society and the age of the ship were not important variables on the degree of risk that the ship presents. As a result, this study is one of the papers that suggested that the ship's age does not have a significant effect on detention.

Similarly, there are other studies with unexpected results for the effect of the ship's age and contrary to the industrial perception. For instance, Knapp and Franses [21] showed that the basic ship profiles given by age, size, flag, class, and ownership did not vary significantly across the regimes with respect to the probability of detention. The deficiencies have the most differences across the regimes for detention and port states. They made binary logistic regression using the data of 183,819 port state inspections from various PSC regimes for the interval of 1999 to 2004. In accordance with their results, only the differences in port states and the treatment of deficiencies significantly affect the probability of detention while flag, owner, age, class, or size as perceived by the regulators and industry do not have significant effect on the detention of ships. Li et al. [22] provided an improved quantitative safety index for each international sea-going vessel based on their condition information and safety records. The safety index involves static and dynamic information of merchant vessels around the world and produce a risk score via binary logistic regression. The safety index can be used by port authorities to determine whether an onboard inspection is needed for vessels calling at their ports to prevent oil pollution and accidents within their territorial waters. For that purpose, they initially determine the parameters constituting the safety risk. As a result, they discovered that increasing the vessel age is related to increasing the level of vessel safety. Although the relationship has a fractional coefficient (0.001) in their result, this may be a reflection of the fact that the survival vessels are proved to be quality or well-maintained ones.

On the other hand, there are many studies stating that the ship's profile determines the scope, frequency, and priority of inspections instead of the outcomes of inspections [23-25].

Compared with existing research, our study has two distinctive features. The first feature is to demonstrate that unlike the industry's point of view and the conclusion of traditional studies, the age of the ship does not have a significant effect on the detention of the Turkish-flagged ship within the scope of the Paris MoU inspections and that the ship's deficiencies have a significant effect on the detention of the ship. The second feature is the use of time-series analysis based on ARDL method in determining whether the parameters of ship's age and deficiencies affect the detention of Turkish-flagged vessels.

3. Methodology

3.1. Auto Regressive Distributed Lag Bound (ARDL)

A linear combination of non-stationary series can be considered stationary. Such variables are called cointegrated variables. The linear composition is generally related to economic theory. According to the economic interpretation of cointegration, if two or more series are related to each other in such a way as to form an equation of equilibrium that extends over a long period, they move closely with each other over time and the difference between them is stable even if the series contain a stochastic trend (not stationary). In this case, the concept of cointegration means that the economic system converges in time and a long-term equilibrium relationship exists [26].

Although the concept of cointegration has been introduced in the literature by Engle and Granger [27], there are many cointegration tests based on the application of unit root tests to residues that are calculated from the cointegration model. In this study, the ARDL boundary test method was used to investigate the existence of cointegration relationships. In the selection of the ARDL bounds test, it was taken into consideration that the test could detect the existence of a cointegration relationship without taking into account the stationary characteristics of the variables. To put it more clearly, the ARDL boundary test method becomes more useful than the Engle and Granger [27] and Johansen [28] tests because it allows the examination of a cointegration relationship between the differentially integrated series. Since the variables in the research model are integrated to different degrees, ARDL bounds test approach was adopted in the study.

ARDL test is one of the cointegration tests that enables the examination of the relationships between non-stationary variables in econometrics. The ARDL limit test method has some advantages over other cointegration tests, which include the following: It gives the coefficient for the long-term relationships. It can be applied to variables that are equally non-stationary and integrated of different order at most I [1]. Trend and constant specifications are quite wide. It is based on error corrections and works with the condition of balancing long-term deviations. It is not enough to only have the long-term equilibrium. It also requires balancing the deviations from the long term in addition to the equilibrium by the error correction term [26].

The ARDL limit test approach consists of two stages. In the first stage, the existence of long-term relationships between variables is tested. In the second stage, the short- and long-term coefficients of the series that are determined to be cointegrated in the first stage are calculated. For better understanding, the following equation is estimated to test the long-term relationship in the boundary test approach for a bivariate research model [29]. Formula 1 is below:

$$\Delta Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 X_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-1} + \sum_{i=0}^{q} \lambda_i \Delta X_{t-i} + \mu_t \quad (1)$$

Symbols in Equation (1) are expressed as follows;

p=optimal lags in the dependent variable

q=optimal lag number in the independent variable

β0, β1 β2, δi, and ⋋i: coefficients

Δ=difference of the variable.

The null hypothesis for the cointegration relationship between variables is as in Equation (2) below;

$$H\_0: β\_1 = β\_2 = 0 \quad (2)$$

If the calculated test statistic is less than the specified lower critical limit, the null hypothesis, which states that there is no cointegration relationship, cannot be rejected. If the test statistic is greater than the specified upper critical limit, the null hypothesis is rejected and it is decided that the cointegration has been established. If the test statistic is between the lower and upper limit values, no decision can be made regarding the cointegration [29].

After determining that there is cointegration between the series, the ARDL (p, q) model is estimated as shown in Equation (3) below [29].

$$Y_t = \beta_0 + \sum_{i=1}^{p} \delta_i Y_{t-i} + \sum_{i=1}^{p} \lambda_i X_{t-i} + \mu_t \quad (3)$$

In the ARDL (p, q) model, the long-term coefficients for the independent variable are estimated as in Equation (4) below.

$$\frac{\lambda_0 + \lambda_p + \cdots . \lambda_p}{1 - \delta_1 + \delta_2 + \cdots \delta_q} \quad (4)$$

After estimating the long-term coefficients, the short-term coefficients are obtained by establishing an error correction model (Equation 5 as below).

$$\Delta Y_t = \beta_0 + \beta_1 EC_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i} + \sum_{i=1}^{q} \lambda_i \Delta X_{t-i} + \mu_t \quad (5)$$

The “EC” in the Equation (5) refers to the error correction term. To test the existence of the causality relationship from the independent variables to the dependent variable, the error correction term must be meaningful and must be between 0 and -2.

To determine the optimal lag lengths for the ARDL (p, q) model, the Aike information criterion has been taken into account. Many different lag length specifications can be created and compared according to the Aike information criterion, but recent econometric package programs determine the optimal lag length according to the comparison criteria, saving the researcher from this effort.

3.2. Application of ARDL Test for Turkish-Flagged Ships in the Scope of Paris MoU

In this study, the data frequency distribution of ship type, inspection type, construction year of the ship, detention port, and detention decisions are shown by creating cross tables on the data. This gives the comparison and descriptive information for the data on the Turkish-flagged ships that have been inspected in the scope of the Paris MoU. Besides that, the ARDL test is carried out to determine whether the average number of deficiencies that have been found on the ships and the average age of ships that have been inspected under the Paris MoU significantly affect the average number of detention decisions of ships at the port. Cross tables are created via the SPSS program and the ARDL test is performed via the E-views program.

Cross tables of data are then presented and the summary statistics of the variables in the research model (ARDL test) is given. The variable time course charts are examined to determine the trend and structural break properties of the variables. The seasonality of the variables is then examined using the F and Kruskal-Wallis H tests, which reveal no observed seasonal effects.

The variables in the time-series regression models have conditions for being stationary. A pseudo-regression model is established between two or more non-stationary variables. The predicted models generally give good results in the case of pseudo-regression. However, despite the high R^2 and statistically significant models in pseudo-regression, the predicted parameters are generally insignificant because the non-stationary variables randomly move in the same direction. Pseudo-regression can occur between two completely unrelated non-stationary variables and in interrelated macroeconomic and financial series [30].

Augmented Dickey-Fuller (ADF) unit root tests are applied to determine the stationary states of the variables. The ADF unit root test determines whether the series is stationary or not. This method is an improvement of the Dickey-Fuller (DF) unit root test by taking into account the autocorrelation problem in contrast with the DF unit root test. The ADF proposes the solution of three equations [Equations (6, 7, 8)] to answer whether a Yt series is stationary at the level with the unit root test [31].

For $Y_t \sim I(0)$;

Equation without constant term and trendless:

$$\Delta Y_t = \beta_1 Y_{t-1} + \sum_{i=1}^{p} \sigma_i \Delta Y_{t-i} \quad (6)$$

Equation with constant terms:

$$\Delta Y_t = \beta_0 + \beta_1 Y_{t-1} + \sum_{i=1}^{p} \sigma_i \Delta Y_{t-i} \quad (7)$$

Equation with constant and trend:

$$\Delta Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 \, \text{Trend} + \sum_{i=1}^{p} \sigma_i \Delta Y_{t-i} \quad (8)$$

The ADF test requires the estimation of one, more, or all of the regression specifications in equations (6), (7), and (8) with the least square values. Two conditions must be met for the stationarity of the series: (1) The coefficient of β1 should be negatively signed. (2) The coefficient should be statistically significant [31].

The null hypothesis and the alternative hypothesis for the ADF test are as follows;

H0: There is a unit root in the series.

H1: There is no unit root in the series.

Throughout the specifications, the deterministic process is the constant and the trend. Unnecessarily adding a constant or trend variable will reduce the strength of the test, which may end up concluding that the stationary series is not stationary. The dependent variable delays in the equation are intended to overcome the possible autocorrelation problem in the error terms. A decision is made if the test results indicate that all three specifications point to the unit root in the same place or if the unit root is absent [31].

In the case where the variables to be used in the regression models are non-stationary, a frequently used method is to make the variables stationary by taking their differences. However, Granger and Newbold explained that it is not appropriate to use non-stationary variables in this way because it eliminates the information about the long-term relationship [32]. For this reason, the ARDL test is performed in this study.

3.2.1. Data Collection

The data used for this study are obtained from EMSA THETIS, which is the Paris MoU database [33]. In this context, the data collected include the detention port, detention date, ship age, number of deficiencies, and type of ship belong to Turkish-flagged ships that have been inspected between 2013 and 2020 in the scope of the Paris MoU. Two thousand seven hundred-2779 sample observations from 2013 to 2020 are acquired from the EMSA THETIS. These data are then transformed into monthly data sets to obtain the time series by averaging the information of related variables. The data are categorized according to the average age of the ships that have been inspected every month, average number of deficiencies that have been found in the ships every month, and the average number of detentions for each month under the Paris MoU. Hence, longitudinal data is created for the time-series analysis. Longitudinal data are those data where the same variable or variables have been measured at different time points. Based on the analysis of longitudinal data, the development of individuals over time can be observed by comparing them within themselves and with each other. To determine if the examined variables are affected by different variables to reach the result of interest in the analysis of longitudinal data, the data can also be examined with multi-level analysis methods [34]. For the ARDL test, the data of all variables are collected at a monthly frequency between the 2nd month of 2013 and the 12th of 2020. A time-series data set containing 95 observations is then created. Frequency data distributions of the variables are also shown as cross tables.

3.2.2. Analyses and Findings

Step 1 - Cross tables for Performance Analysis

Cross tables are created to see the frequency distribution and descriptive features of the detained Turkish-flagged ships under the Paris MoU according to other variables. While these tables provide us the opportunity to interpret the data distribution by comparing the variables, the distribution table including the ship's age provides preliminary information during the hypothesis phase for ARDL test.

In this context, the distribution of the detention situation of ships according to the ship type between 2013 and 2020 years is shown in Table 1. In general, it is seen that the general cargo (1331) is the most inspected Turkish-flagged ship type under the Paris MoU between 2013 and 2020. However, commercial yachts (31.8%) have the highest detention rate among the ship types.

In Table 2, the distribution of detention situations of ships according to the type of inspection is presented. It is seen that ships are less likely to be detained during initial inspection in the scope of the Paris MoU. Vessels are most often detained during a more detailed inspection. However, only approximately 4.4% of the inspected ships are detained at the same time in total.

Data distribution of detention situations of ships according to the ship's age is given in Table 3. According to the data distributions, it is seen that more detained vessels at the port have ages of 30 years and older and the fewer detained vessels have ages of 10 year and below. This distribution shows the possibility that there may be a positive relationship between the ship's age and the detention of the ship. Therefore, the ARDL test is applied to prove whether the Turkish-flagged ship's age has a significant effect on the Turkish-flagged ship detention under the Paris MoU.

The distribution of detention situations of ships according to country in which the ships have been detained is shown in Table 4. It is seen that the countries with the most number of decisions of detention for ships include Canada, Slovenia, Poland, Germany, Belgium, and Italy.

Step 2 - ARDL

Within the scope of the research, an econometric model is established to examine whether the average number of deficiencies that have been found on the ships under the Paris MoU and the average age of ships that have been inspected under the Paris MoU significantly affect the average number of detention decisions of ships at port using Equation 9.

$$T_t = \alpha_t + \beta_1 Y_t + \beta_2 E_t + \varepsilon_t \quad (9)$$

In Equation (9), α is the constant term, ε is the error term, and t subscript indicates the time dimension. β_1 and β_2 express the effect of age and deficiency variables on the detention variables, respectively. The definitions of the variables in the equation are summarized in Table 5.

The descriptive statistics of the variables used in the ARDL test are shown in Table 6. The average number of detentions of ships (T) per month between 2013 and 2020 reaches a maximum of 0.160 and has a minimum of 0.000. The average

Table 1. *Frequency distribution of detention situation of ships according to ship type*

	2013		2014		2015		2016		2017	
Type of ships	Detained ships	Not detained ships	Detained ships	Not detained ships	Detained ships	Not detained ships	Detained ships	Not detained ships	Detained ships	Not detained ships
General cargo	10 (4.3%)	223 (95.7%)	13 (5.3%)	232 (94.7%)	16 (8%)	183 (92%)	13 (6.9%)	175 (93.1%)	7 (5.2%)	128 (94.8%)
Container	2 (5.3%)	36 (94.7%)	3 (7.9%)	35 (92.1%)	0 (0.0%)	27 (100%)	1 (2.9%)	33 (97.1%)	0 (0.0%)	32 (100%)
Bulk carrier	1 (1.7%)	57 (98.3%)	3 (5.6%)	51 (94.4%)	3 (5.4%)	53 (94.6%)	0 (0.0%)	49 (100%)	2 (5.3%)	36 (94.7%)
Ro-Ro cargo	0 (0.0%)	16 (100%)	0 (0.0%)	11 (100%)	0 (0.0%)	14 (100%)	0 (0.0%)	20 (100%)	0 (0.0%)	21 (100%)
Commercial yacht	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (22.2%)	7 (77.8%)	4 (36.4%)	7 (63.6%)
Chemical tanker	1 (1.7%)	59 (98.3%)	0 (0.0%)	48 (100%)	5 (11.1%)	40 (88.9%)	2 (3.4%)	57 (96.6%)	1 (2.3%)	43 (97.7%)
Passenger ship	0 (0.0%)	24 (100%)	4 (10.5%)	34 (89.5%)	0 (0.0%)	33 (100%)	1 (3.0%)	32 (97.0%)	0 (0.0%)	27 (100%)
Tug	0 (0.0%)	1 (100%)	0 (0.0%)	5 (100%)	0 (0.0%)	3 (100%)	0 (0.0%)	1 (100%)	0 (0.0%)	3 (100%)
Oil tanker	0 (0.0%)	14 (100%)	0 (0.0%)	7 (100%)	0 (0.0%)	9 (100%)	2 (16.7%)	10 (83.3%)	0 (0.0%)	10 (100%)
High speed passenger craft	0 (0.0%)	1 (100%)	0 (0.0%)	1 (100%)	0 (0.0%)	2 (100%)	0 (0.0%)	2 (100%)	0 (0.0%)	3 (100%)
Gas carrier	0 (0.0%)	3 (100%)	0 (0.0%)	3 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	6 (100%)	0 (0.0%)	3 (100%)
Combination carrier	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100%)	0 (0.0%)	0 (0.0%)
Offshore supply	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (100%)	0 (0.0%)	0 (0.0%)
Other special activities	0 (0.0%)	0 (0.0%)	0 (0.0%)	8 (100%)	0 (0.0%)	3 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Total	14 (3.1%)	434 (96.9%)	23 (5.1%)	431 (94.9%)	24 (6.1%)	367 (93.9%)	21 (5.0%)	395 (95.0%)	14 (4.3%)	313 (95.7%)

	2018		2019		2020		Total	
Type of ships	Detained ships	Not detained ships	Detained ships	Not detained ships	Detained ships	Not detained ships	Detained ships	Not detained ships
General cargo	2 (1.4%)	140 (98.6%)	2 (1.85%)	108 (98.2%)	0 (0.0%)	79 (100%)	63 (4.73%)	1.268 (95.27%)
Container	0 (0.0%)	15 (100%)	0 (0.0%)	10 (100%)	0 (0.0%)	17 (100%)	6 (3.3%)	205 (96.7%)
Bulk carrier	1 (2.9%)	34 (97.1%)	0 (0.0%)	26 (100%)	0 (0.0%)	18 (100%)	10 (3.4%)	324 (96.6%)
Ro-Ro cargo	0 (0.0%)	22 (100%)	1 (4%)	24 (96%)	1 (4.35%)	22 (95.6%)	2 (0.0%)	150 (100%)
Commercial yacht	1 (50.0%)	1 (50.0%)	0 (0.0%)	0 (100%)	0 (0.0%)	0 (0.0%)	7 (31.8%)	15 (68.2%)
Chemical tanker	1 (2.2%)	45 (97.8%)	1 (3.22%)	31 (100%)	0 (0.0%)	22 (100%)	11 (3.3%)	345 (96.7%)
Passenger ship	1 (3.8%)	25 (96.2%)	0 (0.0%)	26 (100%)	0 (0.0%)	3 (100%)	6 (3.3%)	204 (96.7%)

Table 1. Frequency distribution of detention situation of ships according to ship type (Continued)

	2018		2019		2020		Total	
Type of ships	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**
Tug	0 (0.0%)	6 (100%)	0 (0.0%)	3 (100%)	0 (0.0%)	1 (100%)	0 (0.0%)	23 (100%)
Oil tanker	0 (0.0%)	12 (100%)	0 (0.0%)	9 (100%)	0 (0.0%)	11 (100%)	2 (3.1%)	82 (96.9%)
High speed passenger craft	1 (14.3%)	6 (85.7%)	0 (0.0%)	5 (100%)	0 (0.0%)	0 (0.0%)	1 (6.3%)	20 (93.8%)
Gas carrier	0 (0.0%)	1 (100%)	0 (0.0%)	3 (100%)	0 (0.0%)	1 (100%)	0 (0.0%)	20 (100%)
Combination carrier	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (100%)
Offshore supply	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (100%)
Other special activities	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (100%)
Total	7 (2.2%)	307 (97.8%)	4 (1.62%)	247 (99.3%)	1 (0.57%)	174 (99.4%)	108 (4.4%)	2.670 (95.6%)

Table 2. Frequency distribution of detention situations of ships according to type of inspection

	2013		2014		2015		2016		2017	
Type of inspection	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**
Initial inspection	0 (0.0%)	144 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
More detailed inspection	13 (5.3%)	231 (94.7%)	17 (4.4%)	367 (95.6%)	22 (6.7%)	304 (93.3%)	17 (5.0%)	325 (%95.0)	12 (4.7%)	244 (95.3%)
Expanded inspection	1 (1.7%)	59 (98.3%)	6 (8.6%)	64 (91.4%)	2 (3.1%)	63 (96.9%)	4 (5.4%)	70 (94.6%)	2 (2.8%)	69 (97.2%)
Total	14 (3.1%)	434 (96.9%)	23 (5.1%)	431 (94.9%)	24 (6.1%)	367 (93.9%)	21 (5.0%)	395 (95.0%)	14 (4.3%)	313 (95.7%)

	2018		2019		2020		Total	
Type of inspection	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**
Initial inspection	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	144 (100%)
More detailed inspection	7 (2.8%)	243 (97.2%)	4 (2.09%)	187 (97.91%)	1 (0.67%)	148 (99.3%)	93 (4.9%)	2049 (95.1%)
Expanded inspection	0 (0.0%)	64 (100%)	0 (0.0%)	61 (100%)	0 (0.0%)	27 (100%)	15 (3.7%)	497 (96.3%)
Total	7 (2.2%)	307 (97.8%)	4 (2.63%)	248 (97.3%)	1 (0.56%)	175 (99.4%)	108 (4.4%)	2.670 (95.6%)

Table 3. *Frequency distribution of detention situations of ships according to ship's age*

	2013		2014		2015		2016		2017	
Age of ships	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**
10 year and below	2 (1.1%)	185 (98.9%)	1 (0.7%)	148 (99.3%)	4 (3.1%)	125 (96.9%)	4 (3.6%)	107 (96.4%)	3 (3.3%)	89 (96.7%)
11-20 year	4 (5.8%)	65 (94.2%)	7 (7.2%)	90 (92.8%)	6 (6.7%)	83 (93.3%)	7 (5.9%)	111 (94.1%)	5 (5.2%)	91 (94.8%)
21-30 year	4 (4.0%)	95 (96.0%)	4 (3.8%)	101 (96.2%)	6 (6.3%)	89 (93.7%)	3 (3.0%)	97 (97.0%)	2 (2.5%)	77 (97.5%)
30 year and older	4 (4.3%)	89 (95.7%)	11 (10.7%)	92 (89.3%)	8 (10.3%)	70 (89.7%)	7 (8.0%)	80 (92.0%)	4 (6.7%)	56 (93.3%)
Total	14 (3.1%)	434 (96.9%)	23 (5.1%)	431 (94.9%)	24 (6.1%)	367 (93.9%)	21 (5.0%)	395 (95.0%)	14 (4.3%)	313 (95.7%)

	2018		2019		2020		Total	
Age of ships	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**
10 year and below	3 (3.8%)	76 (96.2%)	1 (2.0%)	49 (98.0%)	0 (0.0%)	17 (100%)	18 (2.3%)	796 (97.7%)
11-20 year	2 (2.0%)	100 (98.0%)	1 (1.2%)	82 (98.8%)	1 (1.25%)	79 (98.7%)	33 (5.4%)	701 (94.6%)
21-30 year	2 (2.4%)	81 (97.6%)	2 (2.7%)	72 (97.3%)	0 (0.0%)	47 (100%)	23 (3.7%)	659 (96.3%)
30 year and older	0 (0.0%)	50 (100%)	0 (0.0%)	45 (100%)	0 (0.0%)	32 (100%)	34 (7.2%)	514 (92.8%)
Total	7 (2.2%)	307 (97.8%)	4 (1.58%)	248 (98.4%)	1 (0.57%)	175 (99.4%)	108 (4.4%)	2.670 (95.6%)

Table 4. *Frequency distribution of detention situations of ships according to the country in which the ships have been detained*

	2013		2014		2015		2016		2017	
Country	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**
Belgium	1	9	0	6	1	9	0	5	0	4
Bulgaria	1	54	1	54	0	37	0	50	0	31
Canada	1	5	1	4	1	4	0	3	0	3
Croatia	0	18	0	20	1	14	1	14	1	12
Cyprus	0	1	0	2	0	0	0	0	0	1
Denmark	0	1	0	1	0	2	0	1	0	0
France	0	19	0	25	0	15	0	16	0	15
Germany	1	2	0	6	1	7	0	5	1	2
Greece	1	64	7	93	5	86	3	84	5	82
Ireland	0	1	0	1	0	1	1	1	0	2
Italy	4	64	9	42	4	56	3	63	4	51
Latvia	0	1	0	3	0	2	0	0	0	2
Lithuania	0	2	0	3	0	1	0	1	0	0
Malta	0	2	0	1	1	2	0	1	0	1
Netherlands	0	10	0	6	0	7	0	6	0	4
Norway	0	1	0	0	0	1	0	1	0	1

Table 4. *Frequency distribution of detention situations of ships according to the country in which the ships have been detained*

	2013		2014		2015		2016		2017	
Country	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**
Poland	0	1	0	2	1	2	0	2	0	1
Portugal	0	9	0	11	0	11	1	19	0	11
Romania	1	88	2	86	3	58	9	55	2	38
Russian	0	21	0	15	2	12	0	27	0	10
Slovenia	2	7	0	8	1	4	0	0	0	6
Spain	2	45	2	36	1	32	2	32	1	30
Sweden	0	0	0	0	0	0	0	0	0	1
United Kingdom	0	9	1	5	2	4	1	10	0	5
Finland	0	0	0	1	0	0	0	4	0	0
Total	14	434	23	431	24	367	21	400	14	313

Country	2018		2019		2020		Total	
	Detained ships	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**	**Detained ships**	**Not detained ships**
Belgium	1	7	0	2	0	1	3	43
Bulgaria	0	23	0	20	0	14	2	283
Canada	0	2	0	2	0	1	3	24
Croatia	0	13	0	11	0	6	3	108
Cyprus	0	1	0	0	0	0	0	5
Denmark	0	0	0	0	0	2	0	7
France	1	7	0	14	0	12	1	123
Germany	0	4	0	1	0	1	3	28
Greece	3	73	2	68	0	30	26	580
Ireland	1	2	0	1	0	0	2	9
Italy	0	56	1	36	1	31	26	399
Latvia	0	0	0	0	0	1	0	9
Lithuania	0	1	0	0	0	1	0	9
Malta	0	0	0	2	0	1	1	10
Netherlands	0	6	0	4	0	2	0	45
Norway	0	0	0	1	0	0	0	5
Poland	0	4	0	2	0	1	1	15
Portugal	0	13	0	6	0	3	1	73
Romania	1	41	0	30	0	32	18	428
Russian	0	14	0	16	0	11	2	126
Slovenia	0	3	0	3	0	1	3	37
Spain	0	30	1	21	0	17	9	243
Sweden	0	1	0	1	0	0	0	3
United Kingdom	0	6	0	7	0	5	4	51
Finland	0	0	0	0	0	0	0	7
Total	7	307	4	248	1	173	108	2670

ship age (Y) variable has a maximum of 28 and a minimum of 11. The average number of deficiency (E) variable has a maximum of 4,714 and a minimum of 0.000. While T and Y variables do not fit the normal distribution according to the test statistics (Sig.<0.10), the E variable fits the normal distribution (Sig.>0.10). On the other hand, when the skewness coefficients of the variables are examined, it can be said that there is no significant skewness for all variables (|S|<1) [35,36].

The time course charts of the variables used in the study are presented in Figure 1, which reveals that all variables are time series that do not have a clear trend and do not show distinct structural break features. On the other hand, it can be said that the seasonal increases and decreases in the variables cause suspicion of seasonal effects. For this reason, seasonality tests are performed.

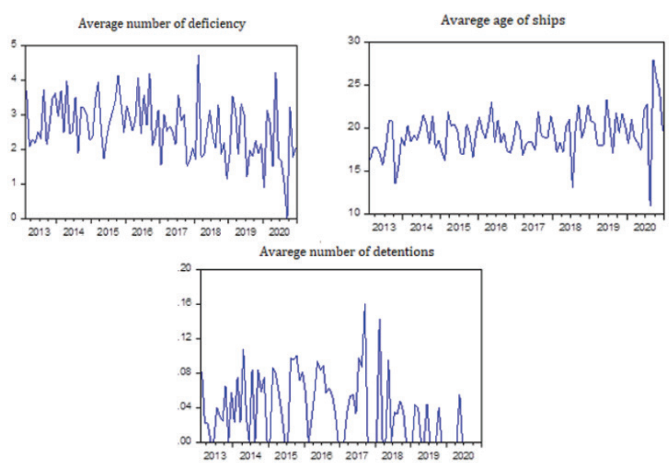

Figure 1. *Variable time course charts*

To prevent the pseudo-regression phenomenon originating from seasonality, the seasonality conditions of the variables should be examined with the seasonality test, and seasonal adjustments should be made if deemed necessary. The seasonality test result in Table 7 shows that there is no seasonal effect for any variable according to the F and Kruskal-Wallis H seasonality test findings, which test the difference between the monthly averages (Sig.>0.10).

Table 8 shows the statistics of the ADF unit root test that was performed to determine the stationarity status of the variables. As evident in the table, the T variables are stationary at the level of 1% significance (Sig.<0.01). On the other hand, while the Y and E variables are not stationary in the level values, they become stationary in the first cyclic differences. When the stationarity states of the variables are examined together, T≈I (0), Y≈I (1), and E≈I (1) definitions can be made. In other words, it can be said that the variables in Equation (9) are stationary in different degrees.

Table 5. *Definitions of variables*

Variables	Symbol
Average number of detention	T
Average age of ship	Y
Average number of deficiencies	E

Table 6. *Descriptive statistics of variables used in the ARDL test*

Descriptive Statistics	T	Y	E
Mean	0.035	19.294	2.596
Maximum	0.160	28.000	4.714
Minimum	0.000	11.000	0.000
Standard deviation	0.038	2.463	0.839
Skewness	0.851	0.115	-0.049
Kurtosis	3.031	5.192	3.083
Jarque-Bera	11.479	19.238	0.065
J.B (Sig.)	0.003	0.001	0.968
Number of observations	95	95	95

J.B (Sig.): T: Average number of detention, Y: Average age of ship, E: Average number of deficiencies

Table 7. *Seasonality tests for variables*

Variables	F (11, 83)		Kruskal-Wallis (11)	
T	1.784	Sig.>0.10	22.854	Sig.>0.10
Y	0.789	Sig.>0.10	8.712	Sig.>0.10
E	0.536	Sig.>0.10	15.419	Sig.>0.10

(Values in the parentheses indicate the test degrees of freedom)

T: Average number of detention, Y: Average age of ship, E: Average number of deficiencies, F: Test for the joint significance of the coefficients

Table 8. *ADF unit root test*

Variables	Augmented Dickey-Fuller test statistics		
	Without constant	With constant	With constant and trend
T	-3.192 [1]***	-7.536 [0]***	-8.101 [0]***
	(0.002)	(0.000)	(0.000)
Y	0.549 [3]	-9.126 [0]***	-9.848 [0]***
	(0.833)	(0.000)	(0.000)
ΔY	-10.841 [2]***	-10.813 [0]***	-10.782 [2]***
	(0.000)	(0.000)	(0.000)
E	-0.645 [4]	-9.135 [0]***	-10.417 [0]***
	(0.435)	(0.000)	(0.000)
ΔE	-8.569 [3]***	-8.524 [3]***	-8.516 [3]***
	(0.000)	(0.00)	(0.000)

***represents stationarity at the significance level of 1%. Parentheses () include the value of probability (p) of the ADF unit root tests. Brackets [] contain the optimal ADF unit root test delay length selected according to the Schwarz Information Criteria. Maximum delay=8. Δ: The first cyclical difference of the variable

Since all the variables used in the research model are not stationary and the variables are seen to be stationary at different orders [I (0) and I (1)], it was decided that the appropriate econometric time-series estimation method to examine the relationship between variables is the ARDL boundary test method.

For the ARDL method, to select the optimal delay lengths for the autoregressive model, the Akaike information criterion gives the command to select the optimal delay, and the program determines the optimal variable delays as follows: 1 for T, 0 for Y, and 2 for E. In this case, the ARDL model can be expressed as ARDL (1, 0, 2).

For the ARDL (1, 0, 2) model, the autoregressive model, error correction model, F limit test statistics, long-term coefficients, and diagnostic test statistics are presented in Table 9. Upon examination, there is no variance problem

Table 9. *ARDL (1, 0, 2) model estimation results*

Results of autoregressive model				
Variables	**β**	**S.H**	**t**	**Sig.**
T_{t-1}	0.021	0.108	0.188	0.851
Y	0.001	0.001	0.321	0.748
E	0.028	0.004	7.633***	0.000
E_{t-1}	0.008	0.005	1.662	0.101
E_{t-2}	0.007	0.004	1.497*	0.076
Constant term	-0.085	0.035	-2.431**	0.017
Results of error correction model				
Variables	**β**	**S.H**	**t**	**Sig.**
ΔE	0.028	0.003	9.028***	0.000
ΔE_{t-1}	-0.007	0.003	-2.185**	0.031
ECM	-0.979	0.104	-9.393***	0.000
ΔE	0.028	0.003	9.028***	0.000
F limit test statistics				
F=2 1,323***		**Significance**	**I (0)**	**I (1)**
		1%	4.13	5.00
		5%	3.10	3.87
		10%	2.63	3.35
Long-term statistics				
Variables	**β**	**S.H**	**t**	**Sig.**
Y	0.001	0.001	0.324	0.747
E	0.044	0.006	7.164***	0.000
Constant term	-0.087	0.033	-2.609**	0.011
Diagnostic test				
F test		F (20. 72)=15.152***		Sig.=0.000
Determination		R2=0.465		D.R2=0.435
White heteroscedasticity test		F (20. 72)=0.709		Sig.=0.804
Breusch-Godfrey autocorrelation test		Lag (2)	F (2. 85)=0.069	Sig.=0.971
		Lag (4)	F (4. 83)=0.518	Sig.=0.723
		Lag (6)	F (6. 81)=0.481	Sig.=0.821
		Lag (8)	F (8. 79)=0.395	Sig.=0.921
		Lag (12)	F (12. 75)=0.651	Sig.=0.792
Error term	$\bar{X}\approx 0$	J.B=13.436	J.B (Sig.)=0.001	S=0.700 K=4.226

(*, **, and *** represent the significance level of 10%, 5%, and 1%, respectively. The parentheses include the test degrees of freedom.)

ARDL: Auto regressive distributed lag, T: Average number of detention, Y: Average age of ship, E: Average number of deficiencies, ECM: Error correction term, S.H: Standard error in the model according to the white heteroscedasticity test for the autoregressive model [F (20, 72)=0.709, Sig.>0.10]. This step is the first stage of the ARDL model. There is no autocorrelation problem up to the 12th delay in the model according to the Breusch-Godfrey autocorrelation test (Sig.>0.10). The model error terms are distributed with a zero mean without showing any significant distortion (|S|<1). Since the assumptions are provided for the autoregressive model, no loss of efficiency is expected in the model due to the assumption violations. For this reason, there is no need for a resistive standard error estimation.

Results from autoregressive model findings reveal that the Y variable does not have a statistically significant effect on the T variable for the short term (β=0.001, Sig.>0.10). It is seen that the short-term parameter of the E variable on the T variable is statistically significant and positive at the 1% significance level (β=0.028, Sig.<0.01). To be more precise, as the average number of ship deficiencies in the same period increases, the average number of their detentions in the port also increases. On the other hand, there is no statistically significant relationship between the average age of the ship and the average number of ship detentions in the port for the same period.

When the ARDL model F limit test is examined, the variables are found to be in a statistically significant long-term balance relationship at the 1% significance level (F=21,323> $F_{Tab,\ 0.01}$). To put it more clearly, the variables in the model have a statistically significant equilibrium relationship in the long-term.

As a result of the long-term equilibrium relationship being significant, it will be meaningful to interpret the long-term parameters. Upon examination, the Y variable does not have a statistically significant effect on the T variable in the long term (β=0.001 Sig.>0.10). The long-term effect of the E variable on the T variable is predicted to be statistically significant and positive at the 1% significance level (β=0.044 Sig.<0.01).

When the ARDL model error correction equation findings are examined, it is seen that the error correction model (ECM) term is statistically significant and negative at the 1% significance level and with an absolute value of less than 2 (ECM=-0.979, Sig.<0.01). In this case, it can be said that the error correction mechanism of the model works. To put it more clearly, it can be said that the deviations from the long-term balance are brought into balance by the error term throughout the periods and return to the long-term balance.

Cusum and Cusum square test graphs drawn for the long-term stability condition of the estimated model are presented in Figure 2. When the graphs are examined, both Cusum and Cusum square test statistics do not significantly exceed the 5% significance band during the period under consideration. For this reason, it can be said that the long-term statistics are stable at the 5% significance level.

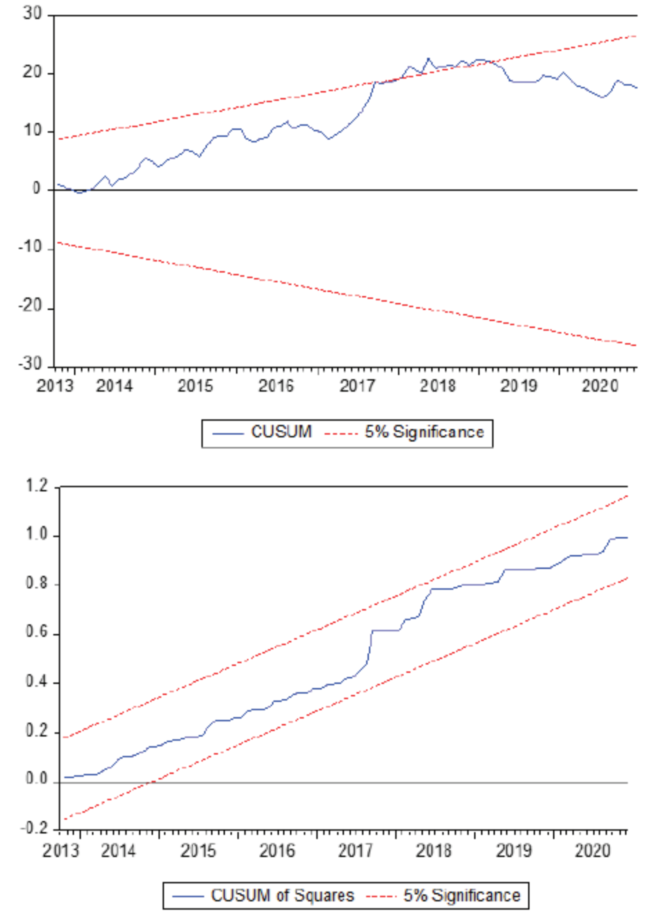

__Figure 2.__ Cusum and Cusum square test

4. Discussion

According to the data frequency distribution tables, although the most detained ship type is the commercial yacht (detention percentage=31.8%, number of detained ships inspected=7 out of 22 detained commercial yachts), the general cargo ships are the most detained ships with a detention percentage of 5.3% (total inspected general cargo is 61 out of 1,142 detained cargo ships). Vessels are generally detained during a more detailed inspection and ships that are 30 years and older are most likely to be detained as seen from the frequency data distributions. Although this is the case, the ARDL analysis reveals that the age of Turkish-flagged vessels does not significantly affect the detention of the Turkish-flagged vessels under the Paris MoU. Data frequency distributions, especially the data on the ship's age, help us create a hypothesis to understand the effect of variables on the ship's detention under the Paris MoU.

The ARDL test is performed to determine whether the variables that present data distribution, especially deficiencies that have been found on the ships and the age of ships, have a significant effect on the number of detentions of Turkish-flagged vessels under the Paris MoU. Results confirmed that the number of deficiencies of the Turkish-flagged vessels significantly affects the number of detentions of the Turkish-flagged vessels under the Paris MoU and the age of the Turkish-flagged vessels does not significantly affect the detention of the Turkish-flagged vessels under the Paris MoU.

According to the ARDL test result, Equation (10) is obtained. A one-unit increase in the number of deficiencies found on Turkish-flagged ships within the scope of the Paris MoU increases the probability of detention of the ship by 0.044 units.

$$T=-0.087+0.044*E \quad (10)$$

In accordance with Cusum and Cusum square tests, autoregressive model, error correction model, F limit test statistics, long-term coefficients, and diagnostic test statistics, the model is fit appropriately and reasonably.

Although there exist many studies that state that the ship's age can significantly affect the number of detentions of the vessels, the opposite result is found in this study, which could be caused by many reasons. One possible reason is the new inspection regime of the Paris MoU. According to the NIR, the company performance regime is treated as a new parameter in the Paris MoU inspections. The company performance formula accounts by taking into consideration items of ISM deficiencies, refusal of access, and risk profiles. Therefore, the company performance and flag states (black-white flag list) are also important factors for the ship's detention. Other possible reasons could be the regulations and conventions in maritime. Since these conventions and rules are developed to prevent any vulnerability of safety, security, and life in the maritime field, and since the PSCs mainly inspect the compliance with the rules of the ships, the vulnerabilities accompanying the increasing age of the ship is automatically removed thanks to these regulations. At this point, the deficiency item is more important than the ship's age. Furthermore, it is seen that multiple studies in the literature have employed binary logistic regression. However, this paper presents the results using an ARDL time-series analysis. This is the first time that the ARDL method is used to identify the effect of the ship's age and the number of deficiencies on the number of detentions of vessels under the Paris MoU. ARDL is a model for capturing long- and short-term causality relationships. Since the unconstrained error correction model is used in ARDL, it has better statistical properties than other time-series tests used to determine the causality between variables, and it gives more reliable results in even small samples. In addition, this paper presents the effective parameters for the detention of Turkish-flagged vessels under the Paris MoU. In this study, the results of the inspections of Turkish-flagged ships are evaluated using the data of the years after the new inspection regime of the Paris MoU. It is proved that the ship profile information affects the inspection frequency and scope rather than the inspection result as stated in many studies.

To summarize, this paper provides empirical results to determine whether the average number of deficiencies that have been found on the Turkish-flagged vessels under the Paris MoU and the average age of Turkish-flagged vessels that have been inspected under the Paris MoU significantly affect the average number of detention decisions of these ships at the port. For this purpose, the ARDL time-series analysis is carried out with recent Turkish vessel inspection data. Particularly, the effect of the number of deficiencies in vessels on the detention, which is among the findings of this study, is a common phenomenon found in almost all studies. Similarly, this study shows that this result has the same effect for Turkish-flagged ships. In contrast with other studies, this study reveals that the ship's age does not have a significant effect on the detention of Turkish-flagged ships. Table 10 summarizes the studies that show whether the ship's age has an effect on the detention or not.

5. Conclusion

This study aimed to analyze the performance measure of Turkish-flagged ships under the Paris MoU PSC. For this purpose, inspection data between 2013 and 2020 of the Paris MoU records are used. In this context, comparison and descriptive analyses are performed to see the data distribution of vessel detention situations according to ship type, age, flag, and inspection type.

It can be concluded that to make a significant contribution to reducing the deficiencies and detentions in PSC inspections, some actions can be performed. For instance, timely reporting of nonconformities detected on ships by the ship's captain and relevant officers to the operator company and the correction of the reported non-conformities by the company as soon as possible can be most important actions Besides, in parallel with the increase in the age of the ship, a tighter follow-up of the general structural condition and timely maintenance-attitudes within the scope of the International Safety Management System can be another significant process for dropping negative results of PSC

***Table 10**. The summary of comparing studies*

The Effect of ship' age on detention of vessels	Authors	Used data	Used method
There is significant effect of ship's age on detention of vessels	Cariou and Wolff [17]	Tokyo MoU inspections data between January 2000 and December 2011	Quantile regression analysis
	Graziano et al. [18]	32206 PSC inspections that are carried out by the European Union and European Free Trade Association Member States within the Paris MoU region from 1 January 2014 to 31 December 2015	Ordinary least square regression model
	Yılmaz and Ece [19]	Inspection results of the Turkish-flagged ships inspected under the Paris MoU between 2011 and 2016	Chi-square test
There is no significant effect of ship's age on detention of vessels	Piniella and Rodriguez-Diaz [20]	The most serious maritime accidents happened in the historical period from the Torrey Canyon incident in 1967 up to the present day in several databases	Descriptive statistics
	Knapp and Franses [21]	The data of 183,819 port state inspections from various port state control regimes for the interval of 1999 to 2004	Binary logistic regression
	Li et al. [22]	Inspection dataset comprising 370,000 inspection cases in 59 countries from January 1999 to December 2008	Binary logistic regression
MoU: Memorandum of Understanding, PSC: Port state control			

inspections. In addition, despite rejecting the hypothesis, which states that the age of the Turkish-flagged vessels significantly affect the number of detentions of the Turkish-flagged vessels under the Paris MoU, it is thought that the renewal of the Turkish maritime merchant fleet and the projects aimed at reducing the average age will contribute to the reduction of detention within the scope of Paris MoU, even if the age of the ship is not taken into account directly within the scope of maritime rules and regulations.

For future studies, it would be beneficial to carry out studies that will analyze factors that affect the detention in PSC inspections applied in other regional control regimes such as the Black Sea MoU, Indian Ocean MoU, Riyadh MoU, Abuja MoU, and the United States Coast Guard. Besides, it can also analyze the effect of other variables such as deadweight tonnage, gross tonnage, class, and company performance on the detention of vessels under both Paris MoU and other regional control regimes. A dynamic modeling system including the variables with a proven effect on the vessels' detention situation can be developed, enabling each company to estimate the probability of detention by entering the data of these variables into the model for each ship. Thus, the optimum benefit can be achieved with less cost since the point where the system is broken is clearly visible.

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Concept design: F. Bolat, Data Collection or Processing: F. Bolat, Analysis or Interpretation: F. Bolat, Literature Review: S. Uygur, Writing, Reviewing and Editing: F. Bolat

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