Global Port Detentions: Impact on Financial Performance in the Maritime Sector

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Abstract

Port State Control (PSC) is the authority overseeing vessel technical and safety compliance in accordance with IMO regulations. The number of detained vessels has been declining over the last decade, despite fleet growth and expanding trading routes, as shipowners responded in a receptive manner to the increasingly stringent regulatory framework. This study aims to delve into the relationship, between vessel detentions and the financial performance of the maritime sector, as evidenced by freight rates, within a progressively rigorous regulatory landscape. It is expected that during periods of higher earnings, shipowners would exercise heightened diligence, given that a potential detention could entail substantial revenue loss. To investigate this, monthly hand collected data is gathered from Paris MoU and Tokyo MoU– bodies representing European and Asian port state control authorities, respectively – spanning the years 2010 to 2021. Through the application of Generalized Method of Moments (GMM) estimation, we unveil intriguing insights: institutional factors such as class and flag, alongside the nature of ship deficiencies pertaining to safety at sea and environmental protection, emerge as the primary drivers elucidating vessel detentions sanctioned by port authorities. What is surprising though, is our finding of a strong, positive and bidirectional relationship between ship detentions and economic activity in the sector. This study unveils a compelling signal that diverges from conventional wisdom, holding the potential to reverberate across all stakeholders engaged in the sector.

1. *Introduction*

Shipping is a global industry engaging hundreds of thousands of people in its activities both on deck and onshore. The purpose of institutional regulation is to prevent accidents from occurring which would not only affect the safety of the vessels and those onboard but also the surrounding marine environment (Chen et al., 2017). The International Maritime Organization (IMO) has thus formed a set of standards implemented by flag registries worldwide (Li and Zheng, 2008), while port authorities are responsible for overseeing vessel compliance with the frequently evolving regulation towards ensuring safety and environmental protection.

More specifically, Port State Control (PSC) measures are designed to inspect vessels in areas such as their technical status, their operations, or their staffing and living conditions, in line with the standards under the relevant international conventions (Wan and Chen, 2018). The vessels failing to meet any of the standards are subject to port detention, an unfavourable and potentially costly 'punishment' for the vessel's owner in terms of causing delays and disrupting the schedule, as detained vessels are not released until the issues identified have either been improved or rectified (Heij et al., 2011). Indeed, since the introduction of PSC in 1982 through the Paris MoU, vessel detentions have been gradually falling (Kasoulides, 1995); for instance, the detention percentage in 2021 was 2.94% of the total fleet inspected contrary to 3.88% in 2019. Cariou et al. (2008) employed Poisson models to showcase that PSC inspections have indeed reduced significantly ship deficiencies. According to Paris MoU records, the most frequently recorded deficiency during that period involved breach of the International Safety Management Code (ISM).

Despite the falling numbers of detained vessels, due to the positive response of shipowners to regulation and the close supervision by port authorities, ship detentions remains a non-random event. In this study it is shown that institutional factors and ship specific characteristics are mostly responsible and continue to explain vessel detention by port authorities. What is surprising though is our finding of a positive and bidirectional relationship between ship detentions and economic activity in the sector. One would expect that in a booming period shipowners would exercise more care as a potential detention would deprive them of substantial revenues and hence the relationship between freights and detentions would be significant and negative. Our study extracts an important signal which is transmitted to all stakeholders involved.

Initially we investigate the impact of ship specific and institutional characteristics that detained vessels possess, on the number of ships detained. We employ monthly hand collected data from Paris MoU over 2010-2021 and find that the flag, port region, IACS membership, and type of deficiency are significant factors in explaining port detention. The stricter region as far as Port Control Inspection (PCI) is concerned, is Europe and European ports, especially in Spain and Italy. We also use monthly hand collected data from the Tokyo MoU from 2010 to 2021 and find that the type, the flag, the port region and the number of deficiencies burdening the vessels are all important factors explaining port detention. The strictest region as far as Port Control Inspection (PCI) is concerned, is Asian ports and more specifically, in China and Japan. Next, we proceed to investigate how these factors (outlined above) influence ship detention by category (dry-bulk, tankers). The contribution of this paper lies with the fact that we have been able to show in the context of a simultaneous system of equations, that ship detentions by category as well as total ship detentions are positively related to the economic activity in the sector. It appears that on the one hand PSC is stricter in applying IMO rules and regulations. On the other hand our finding shows that shipowners in booming periods might continue to evade, hoping deficiencies will not be captured and hence take the risk while trying to fully reap the rising market benefits . Our findings carry important policy implications for all stakeholders involved in the shipping sector.

Section 2 of this study surveys the literature on Port State Control inspections and outlines the main findings. Section 3 analyzes the Data and the Methodology employed. Section 4 discusses Model Specification and Section 6 presents the Empirical Work and discusses the results. Finally, Section 7 concludes and discusses future research paths.

2. Literature Review

There is a plethora of studies on vessel detention and PSC inspection. A strand of literature deals with factors influencing vessel detention. Chen et al. (2019) use the GRA (Grey Rational Analysis) model to quantitatively analyse ship detention factors under PSC inspection, using data collected from Tokyo MoU's Annual Reports during 2008-2017 regarding the Asia-Pacific Region. More specifically, through improved entropy weight they try to understand to what extent various factors affect the decision of ship detention while at the same time they present key factors of ship detainment to guarantee shipping safety and protection of the environment. They identify nine factors, including crew certificates, water/weathertight conditions or emergency systems (EM). All of them, following their findings have impacted both the schedule as well as the profits of the vessels in question. The trends observed show that the number of inspections has slightly increased, contrary to the number of detentions which has decreased. The general trend observed may showcase an improvement in the performance and quality of shipping within that region, but there are still substandard vessels operating within that region due to escaping inspection by the PSC authorities. Moreover, they proceed to provide effective means for government and shipping enterprises to identify ship detention factors. Indeed, the most significant factors identified through their GRA model are breach of the ISM code (International Safety Management Code for the Safe Operation of Ships and for Pollution Prevention), EM as well as Fire/Safety Measures. Yang et al. (2018) employs a Bayes-based network to conduct risk analysis on PSC inspection and identify factors that in turn predict the probability of a vessel being detained, based on data collected for bulk cargo ships across seven European countries during 2005-2008 from Paris MoU. Chen et al. (2022) using data from Paris MoU across six years (2014-2020) suggests that recognizing the detention risk of vessel deficiencies contributes to improving vessel safety and pollution, while decreasing the probability of detention altogether. Factors such as the number of PSCO (Port State Control Official) as well as their background have been found to have an impact on the results of the inspection of the vessel (Graziano et al., 2018). Furthermore, Yan et al.'s (2021) findings show that the flag's performance can also influence more accurately evaluating a vessel's detention risk. Ships' management also played a role, as it was more likely for ships to be detained when defects were found during previous inspections under the same management (Yan et al., 2021). Age was another factor, as ships older than six years were also more likely to possess more defects compared to younger vessels (Chen et al., 2022). Knapp and Franses (2007) demonstrate that the possibility for a vessel to be detained can be explained by a combination of variables including flag state (Perepelkin et al., 2010), classification society as well as the ship's size and age (Ji et al., 2015, Chen et al., 2017) rather than the type and the number of deficiencies. This analysis also indicates that there are significant differences in the possibility of detention across international ports. Groenleer et al. (2010) link the EU member status to the results of detention. Fan et al. (2014) showcase how PSC inspections increase the possibility of a vessel being stripped off its flag (also known as a flag-out), while Graziano et al.'s (2018) findings suggest that that the member state status of a vessel affects its potential detention. In contrast, factors that diminish the likelihood of a ship being detained include proper arrangement of shipping routes according to a vessel's condition as well as self-inspecting them prior to their departure (Yang et al., 2021).

A large part of the literature of PSC surveys focuses on ship safety deficiencies and inspection methodologies and effectiveness. For instance, Hanninen and Kujala (2014) used PSC inspection data to study the relationship between the types of deficiencies spotted in a vessel and the degree of its involvement in marine accidents and related incidents. Fan et al. (2014) employ a three-stage Least Square method by using a binary logit as well as a linear model to carry out PSC inspection analysis. Through analyzing the PSC inspection rates, they find that PSC inspections increase the probability of a flag-out, i.e. deregistration of a vessel from its national registry. Cariou et al. (2009) identify the most important factors that influence how PSC chooses which vessels to inspect: flag of registry, age at inspection and type of ship. Li and Zheng (2008) examine the usefulness of PSC and the ways adopted in regional PSC for selecting vessels for inspection. Their findings verify that the enforcement of PSC is effective relative to ship safety improvement in the maritime sector. Piniella et al. (2014) studied all the vessels detained under three MoU agreements, i.e. those of Paris, Tokyo as well as Vina del Mar. Their aim was to determine whether there are different treatments at play depending on the flag or the classification society of the vessel to certify their levels of safety. Their results show a similar trend observed both under the enforcement of the Paris and the Tokyo MoU agreements in contrast with the Vina del Mar agreement, where the level of efficacy in the control appears to be insufficient when compared to the other two. Ravira and Piniella (2016) examine the effect of PSC inspectors' professional profile by developing a case study on the Spanish Maritime Administration. Kara et al. (2019) try to assess the similarities between the PSC regimes based on the importance of flag registries as far as their PSC inspections are concerned.

Cariou et al. (2009) survey the number of deficiencies in addition to the determinants of detention identified in data collected from PSC inspections within the Indian Ocean MoU region during 2002-2006. They propose 'scrutiny' PSC standards to be adopted by port states to determine the detention of a 'defective' vessel. Furthermore, Cariou and Wolff (2015) improve upon this 'scrutiny' mechanism by employing Quantile regression to predict vessels' having several specific types of deficiencies, thus expanding the possibility of vessel detention beyond just 'defective' ships.

Overall, the focus has primarily been on the relevance of detention factors to determine vessel detention as well as the process through which ship selection for inspection is conducted.

Tsou (2019) in his study uses an extended data analysis to inspect the connection between detention deficiencies themselves as well as their relationship with external factors. His data is based on the ship detention database from the Port State Control inspections which have taken place for many years under the auspices of the Tokyo Memorandum of Understanding. He analyses every factor of the PSC detention database to examine the potential frequency of ship detention deficiencies. Tsou (2019) concludes that by using association rule mining techniques in data analysis we can derive with accuracy the regularity correlation between ship deficiencies themselves as well as between them and all the factors that are related to them. The techniques he suggests provide countermeasures and being used by the ship management personnel during inspection they can reduce significantly the detention rate of ships. The benefit of the above method on one hand improves the working efficiency of the staff while on the other hand reduces the disadvantageous effects on navigation safety caused by sub-standard vessels.

Osman et al. (2021) in their study used both GRP model and Entropy Weight Method to distinguish the various types of ships entering ports of Malaysia, reveal the “weakness” of each one of them and then identify the most preferrable vessel type for inspection. It took them five years to record, identify, examine, score and grade all types of ships entering selected ports of Malaysia to conclude that each port has a different type of vessel as the first in its ranking. For example, oil tankers were of the highest value in Bintulu port, passenger ships in Penang port, containers in Kuching port etc. Finally, they also analyze the sequence of types arriving at individual ports to help policymakers to set up a more effective inspection design.

The PSC inspections, relying on regional schemes, are implemented in line with the corresponding MoU or agreement with the goals of reducing substandard ships, ensuring shipping and personnel safety, preventing ship pollution, and safeguarding the maritime environment (Chen et al., 2019). Research on this topic has relied on various approaches. Also, researchers have started work on the standards or systems for PSC inspections that should be adopted by the port states to determine the detention of defective ships. Cariou et al. (2008) adopted Poisson models on surveyed data and found out that PSC inspection has significantly reduced ship deficiencies. At present, domestic and global researchers focus on relevance on detention factors and pattern study in their work on PSC detention in order to establish the ship detention decision-making mechanism and ship-selection mechanism. However, there are few evaluation methods with objective weight to identify the key factors of ship detention under Port State Control.

Even though the literature examines in depth and reveals reasons for vessel detention, there has been no attempt so far to examine ship detentions and economic activity in the sector, which unveils a behavioural perspective in the shipping reality.

3. Hypotheses

When ships are detained, it disrupts schedules and can lead to delays in cargo delivery. A decrease in detentions implies that vessels are operating more efficiently and reliably, which can attract more customers and lead to a higher level of economic activity in the shipping sector (UNCTAD, 2019). Ship detentions often result from safety deficiencies, non-compliance with international regulations, or environmental violations. When ships are detained, they are taken out of operation, causing delays in the transportation of goods and impacting supply chains. This can lead to increased costs and disruptions in trade activities (IMO, 2021). A study by Stopford and Cook (2014) found that shipping delays caused by detention can result in significant financial losses for both shipowners and cargo owners. On the other hand, during periods with higher freights and intense maritime activity, there may be resource constraints in terms of experienced crew, maintenance schedules, and compliance and as a result detentions rise, Wang et al.,(2020). It is also true that in booming periods the strong incentive of profit maximization might lead to a delay of necessary maintenance and repairs. Risk-taking behaviour can increase the likelihood of non-compliance and detentions, (Dominguez-Péry, et al., 2021).

We pose the hypothesis of a bidirectional relationship between the incidence of vessel detentions and economic activity in the maritime sector expecting to find a positive sign

H1: Vessel detentions are positively related with economic activity in the maritime sector.

The International Maritime Organization's (IMO) Safety of Life at Sea (SOLAS) convention set the safety at sea standards (IMO, 2021). Various safety violations, include inadequate maintenance, equipment failures, and deficient emergency preparedness. Non-compliance with these safety standards can lead to detentions. Detentions can also occur when ships fail to meet environmental standards, such as those outlined in the International Convention for the Prevention of Pollution from Ships (MARPOL). Common environmental violations leading to detentions include illegal discharge of pollutants, improper disposal of waste, and non-compliance with ballast water management regulations (IMO, 2021). The International Safety Management Code (ISM) includes all safety at sea and environmental protection standards. Chen et al. (2019) find among the most significant factors identified through their GRA model is the ISM code (International Safety Management Code for the Safe Operation of Ships and for Pollution Prevention. The following hypothesis is formed:

H2: The International Safety Management Code (ISM), exerts a strong and positive impact on the number of ship detentions.

Vessels that conform to the International Association of Classification Societies (IACS) and vessels registered under reputable flags (white flag vessels) are positively correlated with a lower likelihood of ship detentions because they indicate a commitment to rigorous safety, environmental, and regulatory standards (IACS, 2021). Vessels meeting these high standards are less likely to encounter detention by port state control authorities due to their reputation for compliance and adherence to best practices UNCTAD,2019. Yan et al.'s (2021) findings show that the flag's performance can also influence more accurately evaluating a vessel's detention risk. The following hypothesis is being formed.

H3: IACS classification and vessels under white flags exert a strong and negative impact on the number of ship detentions.

4. Data-Methodology

The data was hand collected from Paris MoU and the Tokyo MoU over the period 2010-2021 so information for each ship detained was gathered including, class, flag, detention port, as well as type of ship, type of deficiency and year built. We derived 144 monthly observations for each characteristic of interest for each one of the two MoUs in order to proceed with model specification. We also distinguished deficiencies arising from safety and environmental protection reasons. We further distinguished dry bulk and tankers detained out of the total. We have also collected from Clarkson database monthly observations over the period 2010-2021 for fleet growth, price of Brent as a proxy for bunkers' cost, price of iron ore reflecting demand in the dry bulk sector but also BDI which is an index of economic activity derived from sea born trade worldwide. Table 1, Panel A that follows, defines the variables employed in model specification. Panel B of Table 1 presents the descriptive statistics for the variables used. All variables are transformed into logs in order to account for scale differences. We observe that in total a larger number of ships is detained by Port authorities members of the Tokyo MoU. Also, Paris MoU detains a larger number of Dry-Bulk and a small number of tankers. Tokyo MoU detains more General Cargo vessels. Furthermore, it appears that more ships with white flags and members of the IACS are detained by Tokyo MoU authorities while Paris MoU authorities detained considerably more ships with deficiencies arising from safety and environmental protection reasons.

Table 1 – Variables

Panel A: Description of variables

Variable	Coding	Definition
Baltic Dry Index	$LBDI$	Natural Logarithm of the weighted average of freight rates over 26 routes issued by the Baltic Exchange
Price of Brent Oil	$LOIL$	Natural logarithm of the Price of Brent crude oil in $/bbl
Iron Ore	$LIRON$	Iron Ore Spot price CFR, N.China, in $/tonne
Fleet Growth	FG	Monthly increase in the total fleet
Fleet Growth in Dry-Bulk/Tanker/General Cargo	FGB	Monthly increase in the Dry-Bulk/Tanker/General Cargo fleet
IACS	$LIACS$	Natural logarithm of the number of ships detained with IACS classification
IACSB/IACST/IACSG	$LIACSB$	Natural logarithm of the number of Dry-Bulk/Tanker/General Cargo detained with IACS classification
Ships Detained	LSD	Natural logarithm of the number of ships detained across types
Dry-Bulk/Tankers/General Cargo	$LSDB/LSDT/LSDG$	Natural logarithm of the number of Dry-Bulk/Tankers/General Cargo ships detained
Asian Ports	$LPAS$	Natural logarithm of the Asian Detention Ports, all ships
	$LPASB/LPAST/LPASG$	Natural logarithm of the Asian Detention Ports, Dry-Bulk/Tanker/General Cargo ships

European Ports	*LPER*	Natural logarithm of the European Detention Ports all ships
	LPERB/LPERT/LPERG	Natural logarithm of the European Detention Ports Dry-Bulk/Tanker/General Cargo ships
Ships with White Flag	*LWF*	Natural logarithm of the detained Ships with White Flag
	LWFB/LWFT/LWFG	Natural logarithm of the detained Dry-Bulk/Tankers/General Cargo Ships with White Flag
Safety and Environment	*LISM*	Natural Logarithm of the Number of Deficiencies associated with Safety and Environment
Dry-Bulk/Tankers/General Cargo	*LISMB/LISMT/LISMG*	Natural Logarithm of the Number of Deficiencies Dry-Bulk/Tankers/General Cargo associated with Safety and Environment
Ships with Grey Flags	*GF*	Ships with Grey Flags
American Ports	*PAM*	Number of detentions by American Ports

Panel B of Table 1 presents the descriptive statistics for the variables used. All variables are transformed into logs in order to account for scale differences. We observe that in total a larger number of ships is detained by Port authorities who are members of the Tokyo MoU. Also, Paris MoU detains a larger number of Dry-Bulk and a small number of tankers. Tokyo MoU detains more General Cargo vessels. Furthermore, it appears that more ships with white flags and members of the IACS are detained by Tokyo MoU authorities while Paris MoU authorities detained considerably more ships with deficiencies arising from safety and reasons regarding the protection of the environment.

Panel B: Descriptive statistics

	Mean	Median	Max	Min	Std. Dev
PARIS MoU	**ALL SHIPS**				
LSD	3.741	3.773	4.644	1.098	0.380
LPER	3.678	3.701	4.454	0.000	0.426
LPAS	2.333	2.000	13.000	0.000	2.392
LWF	3.377	3.367	4.263	0.693	0.387
LIACS	3.877	3.892	4.290	3.496	0.190
LISM	6.265	6.359	7.360	3.583	0.522
PARIS MoU	**DRY-BULK**				
LSDB	3.556	3.583	4.466	1.098	0.399
LPERB	5.652	5.674	6.428	1.973	0.426
PASB	1.768	1.515	9.849	0.000	1.811
LWFB	3.068	3.059	3.954	0.385	0.387
LIACSB	3.478	3.450	4.04	0.303	0.690
LISMB					
PARIS MoU	**TANKERS**				
LSDT	1.333	1.386	2.398	0.000	0.554
LPERT	3.064	3.070	3.811	1.754	0.308
PAST	1.803	1.521	9.886	0.000	1.822
LWFT	3.100	3.070	3.965	1.900	0.324
LIACST	1.324	1.305	2.795	0.000	0.615
LISMT	5.061	5.136	5.945	2.895	0.422
TOKYO MoU	**ALL SHIPS**				
LSD	4.428	4.511	5.037	3.091	0.424
LPER	0.586	0.693	1.791	0.000	0.508
LPAS	4.405	4.499	5.010	2.990	0.437
LWF	4.125	4.277	4.779	1.609	0.489
LIACS	3.980	4.045	5.929	1.253	1.024
LISM	0.532	0.544	0.612	0.371	0.051
TOKYO MoU	**DRY-BULK**				
LSDB	3.338	3.401	3.912	2.398	0.312
LPERB	-0.474	-0.476	0.972	-1.544	0.591
LPASB	3.338	3.393	3.905	2.302	0.292
LWFB	3.045	3.144	3.625	0.726	0.377
LIACSB	3.850	3.818	4.090	1.867	0.707
LISMB					
TOKYO MoU	**GEN. CARGO**				
LSDG	3.423	3.496	4.344	1.609	0.59
LPERG	-0.371	-0.364	-0.909	-1.670	0.624
LPASG	3.409	3.492	4.337	1.514	0.591
LWFG	3.137	3.282	3.984	0.624	0.594
LIACSG	3.981	4.045	5.929	1.253	1.024
LISMG	4.289	4.444	5.464	2.514	0.701

SHIPPING	SECTOR	INDICATORS			
LBDI	7.090	7.042	8.480	5.726	0.527
LIRON	4.602	4.609	5.368	3.679	0.405
LBRENT	4.265	4.273	4.832	3.281	0.364
FG	4.097	3.600	9.800	2.300	2.339
FGB	6.673	4.300	17.600	1.900	4.902
FGT	2.090	1.873	12.373	-4.980	3.117
FGG	6.539	3.950	16.70	1.60	5.096

5. *Model specification*

Our simultaneous equations model is as follows

$$LSD = f[LBDI, LPER, LPAS, LWF, LIACS, LISM]$$
$$LBDI = z[LSD, LIRON, FG, LBRENT]$$

Where SD is the total number of ships detained but we run two more models with $LSDB$ (Dry Bulk) and $LSTA$ (Tankers). The variables LSD or $LSDB$ or $LSTA$ and $LBDI$ are endogenous but it might be the case that some more of the explanatory variables might also be endogenous and some predetermined. The next step would be to employ 2SLS or 3SLS but as robustness of standard errors is not guaranteed, we employ GMM.

Choice of appropriate instruments is essential with the General Method of Moments (GMM). An instrument needs to be highly correlated with the explanatory variables suspected to be endogenous and uncorrelated with the disturbance term. In the presence of heteroskedasticity and/or autocorrelation GMM estimation is more efficient than instrumental variables estimation.

Our choice of instruments is

$$X = [LPER, LPAS, PAM, FG(-1), LBRENT(-1), GF, LISM],$$

where $GF(Grey\ Flag)$ and $PAM(American\ Ports)$ are employed as external instruments, and FG and $BRENT$ are not explicitly modeled as dependent variables in our system of equations.

The system of equations is:

$$LSD_i = f[LBDI_i, LPER_i, LPAS_i, LWF_i, LIACS_i, LISM] + u_{i1}$$
$$LBDI_i = z[LSD_i, LIRON_i, FG_i, LBRENT_i,] + u_{i2}$$

Error terms can be correlated and heteroscedastic, therefore, we impose the following orthogonality conditions:

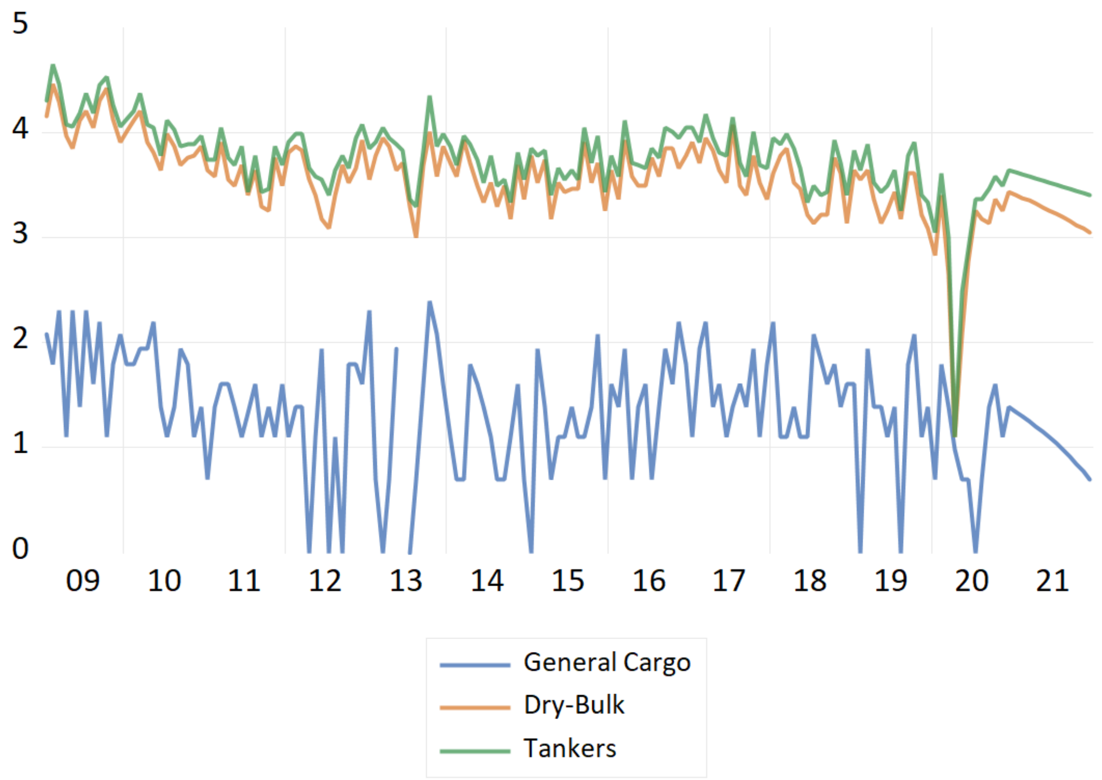
$$n^{-1}\sum_{i=1}^{n}(LSDi - f(LBDI_i, LPER_i, LPAS_i, LWF_i, LIACS_i, LISM_i; \theta)X_{ik})=0$$
$$n^{-1}\sum_{i=1}^{n}(LBDI_i - z(LSD_i, LIRON_i, FG_i, LBRENT_i, ; \theta)X_{ik}) =0$$

where n is the number of observations, θ is the vector of parameters and $k = 1,2, \ldots, K$ denotes the instruments which is 7 (K=7). We have $2K$ equations for the estimation of 12 parameters. In setting up our GMM model we need to deal with the issue of weak instruments for which Stock and Watson, (2017) suggest looking at the F-statistic of the first stage regression. The threshold of the F-statistic depends on the number of instruments, but, roughly, a value of 10 is considered as a reasonable benchmark.

6. Empirical Work

Graph I below shows the natural logarithm of the number of detentions by ship type over the period under investigation. It is apparent that tankers have a much lower number of detentions through time. This is because vetting inspections in tankers are

Graph I: Detentions by Ship-Type 2010-2021



much stricter and are undertaken both by the inspection institution 'Rightship' but also by major shipping companies.

Table 2 below shows our results with 3SLS and GMM, when our dependent variables are LSD and $LBDI$, for the entire period under investigation from 2010 to 2021. The columns (2) and (3) of the table highlight that economic activity in the shipping sector as proxied by $LBDI$ appears to be significantly and positively associated with overall ship detentions. During booming periods ship owners know that if their vessels spent time detained, instead of fully complying with IMO standards, will deprive them of valuable returns. So, they are expected to take good care of their vessel in order to avoid detention. The positive relationship that we have detected is justified by the greater activity during booming periods together with greater alertness of port authorities. Furthermore, the bidirectional relationship discovered, that is higher detentions in previous period, lead to an increase in LBDI, can be explained as follows: Detentions are recorded in the history record of each vessel. This affects, the selling price, insurance but also chartering of a vessel. It is highly likely that repeatedly detained vessels are scrapped, reducing fleet growth and positively affecting LBDI.As expected, European and Asian ports strongly affect ship detentions and white flag ships negatively impact detentions. Furthermore, LISM is on the other hand weakly but positively related with ship detentions as expected. Finally, the bidirectional relationship between LSD and $LBDI$ established, reveals that the large number of inspections across regions and ports, results to more ship detentions show that despite white flags or LIACS classification, shippers continue to not fully conform with safety and environmental protection standards.

TABLE 2: *The Bidirectional Relationship Between Ship Detentions (LSD) by TOKYO MoU and PARIS MoU and Seaborne Economic Activity as Proxied by LBDI*

	Estimation by GMM(TOKYO) (1)		Estimation by 3SLS(TOKYO) (2)		Estimation by GMM(PARIS) (3)		Estimation by 3SLS(PARIS) (4)	
Independent Variables	Dep.Var. *LSD*	Dep.Var. *LBDI*	Dep.Var. *LSD*	Dep.Var. *LBDI*	Dep.Var. *LSD*	Dep.Var. *LBDI*	Dep.Var. *LSD*	Dep.Var. *LBDI*
C	0.672*** (0.106)	-6.021*** (2.010)	0.652*** (0.193)	-5.715** (2.710)	1.111*** (0.242)	-2.283 (1.564)	1.137*** (0.365)	-2.223 (1.433)
LBDI (-1)	0.053** (0.024)		0.057 (0.042)		0.037*** (0.009)		0.047*** (0.016)	
LPER	0.028*** (0.003)		0.029*** (0.006)		0.734*** (0.036)		0.684*** (0.035)	
PAS	-		-		0.005*** (0.002)		0.006* (0.004)	

LPAS	0.984*** (0.005)		0.985*** (0.012)		-		-	
LWF	-0.075*** (0.009)		-0.074*** (0.020)		-0.193*** (0.033)		-0.224*** (0.046)	
LIACS	-0.093*** (0.016)		-0.089*** (0.031)		-0.067** (0.035)		-0.042 (0.061)	
LND	-		-		0.084*** (0.021)		0.098*** (0.023)	
LISM	0.073*** (0.026)		0.069 (0.069)		0.498*** (0.210)		0.527 (0.330)	
LSD (-1)		1.329*** (0.333)		1.221*** (0.465)		1.257*** (0.245)		1.237*** (0.232)
LIRON		2.714*** (0.406)		2.637*** (0.537)		1.699*** (0.303)		1.841*** (0.287)
FG (-1)		- 0.126*** (0.030)		-0.119*** (0.036)		-0.389*** (0.200)		-0.405** (0.179)
LBRENT		-1.045** (0.333)		-0.931*** (0.451)		-0.589*** (0.225)		-0.726*** (0.282)
Prob(J-Stat)		0.162				0.117		

Note:(*) sig.at 10%,(**)sig.at 5%,(***)sig.at 1%.

Next, we break down our sample into the three major detention categories: Dry-Bulk, General Cargo and Tankers. Dry bulk carriers and general cargo vessels face inspection failures, primarily related to issues like structural integrity, safety equipment, pollution prevention measures, and crew working conditions. The frequency of these failures depends on the specific conditions and operational practices of individual ships and companies. Dry-Bulk is the second most frequent detained category by both port authorities under consideration. Dry-Bulk was chosen as it is the largest number of operating vessels in the maritime industry. General cargo is the most frequently detained category by both port authorities. Tankers detention is of special interest. Historically, tankers have received significant attention from regulatory authorities and the industry due to the potential for catastrophic environmental and safety incidents in case of oil spills or other hazardous cargo-related accidents. Consequently, tankers, especially older ones, have often been subjected to stricter scrutiny, leading to a higher likelihood of inspection failures or detentions if they do not meet the required safety and environmental standards. Table 3 below shows empirical results with respect to Dry-Bulk detained ships. We observe from columns (2) and (3) that the impact of the included variables is strong and with the same magnitude as for the overall ship detentions. Also, the coefficient of $LIACS$ is negative as expected and significant for Paris MoU while insignificant for Tokyo MoU, so $LIACS$ dry bulk vessels have fewer detentions than other classification societies, but not a significant impact.

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***TABLE 3**: The Bidirectional Relationship Between Dry-Bulk Ship Detentions (LSDB) by TOKYO MoU and PARIS MoU and Seaborne Economic Activity as Proxied by LBDI*

Estimation by GMM(TOKYO) (1)			Estimation by 3SLS(TOKYO) (2)		Estimation by GMM(PARIS) (3)		Estimation by 3SLS(PARIS) (4)	
Independent Variables	Dep.Var. *LSDB*	Dep.Var. *LBDI*	Dep.Var. *LSDB*	Dep.Var. *LBDI*	Dep.Var. *LSDB*	Dep.Var. *LBDI*	Dep.Var. *LSDB*	Dep.Var. *LBDI*
C	0.991*** (0.209)	-1.880*** (1.242)	1.083*** (0.373)	-1.898 (1.763)	-1.259*** (0.337)	-1.068 (0.917)	-1.213*** (0.455)	-1.539 (1.249)
LBDI (-1)	0.599** (0.305)		0.471 (0.512)		0.081*** (0.025)		0.111*** (0.036)	
LPERB	0.029*** (0.003)		0.975*** (0.01)		0.729*** (0.032)		0.702*** (0.032)	

PASB	-		-		0.029*** (0.003)		0.031*** (0.008)	
LPASB	0.973*** (0.007)		0.029*** (0.007)		-		-	
LWFB	-0.12*** (0.021)		-0.128*** (0.04)		-0.004 (0.019)		-0.016 (0.023)	
LIACSB	-0.16*** (0.035)		-0.169*** (0.062)		-0.094* (0.057)		-0.143* (0.079)	
LISMB	0.124*** (0.031)		0.109* (0.065)		0.175*** (0.036)		0.209*** (0.055)	
LSDB (-1)		0.945*** (0.305)		0.879** (0.424)		0.957*** (0.097)		0.991*** (0.189)
LIRON		1.792*** (0.213)		1.785 *** (0.309)		1.545*** (0.250)		1.703*** (0.269)
FGB (-1)		-0.06*** (0.019)		-0.061*** (0.023)		-0.352** (0.153)		-0.447*** (0.130)
LBRENT		-0.498*** (0.262)		-0.418*** (0.307)		-0.404** (0.163)		-0.447 (0.295)
Prob(J-Stat)		0.158				0.127		

Note:(*) sig.at 10%,(**)sig.at 5%,(***)sig.at 1%.

Table 4 below presents General Cargo detentions by Tokyo MoU and Tanker detentions by Paris MoU. The bidirectional relationship between detentions and the level of economic activity in the maritime sector is reaffirmed for both categories General Cargo and Tankers. For the General Cargo category, our hypotheses on the impact of IACS, ISM and white flag is shown to be strong and with the expected sign. For Tankers though ISM has an insignificant impact and this may relate to the special scrutiny that tankers go through more than any other category with respect to safety and environmental pollution.

TABLE 4: *The Bidirectional Relationship Between General Cargo Ship Detentions (LSDG) by TOKYO MoU and Tanker Ship Detentions(LSDT) by PARIS MoU and Seaborne Economic Activity as Proxied by LBDI*

	Estimation by GMM(TOKYO) (1)		Estimation by 3SLS(TOKYO) (2)			Estimation by GMM(PARIS) (3)		Estimation by 3SLS(PARIS) (4)	
Independent Variables	Dep.Var. *LSDG*	Dep.Var. *LBDI*	Dep.Var. *LSDT*	Dep.Var. *LBDI*		Dep.Var. *LSDT*	Dep.Var. *LBDI*	Dep.Var. *LSDT*	Dep.Var. *LBDI*
C	0.049 (0.045)	-4.54*** (0.909)	0.013 (0.115)	-4.697*** (1.380)	*C*	-1.899** (0.802)	3.623*** (0.534)	-2.207 (1.728)	3.055*** (0.891)
LBDI (-1)	0.764** (0.305)		0.705 (0.539)		*LBDI (-1)*	0.294*** (0.084)		0.294** (0.149)	
LPERG	0.037*** (0.004)		0.036*** (0.007)		*LPERT*	2.214*** (0.541)		2.345** (0.996)	
PASG	-		-		*PAST*	0.004 (0.030)		0.019 (0.052)	

LPASG	1.059*** (0.020)		1.071*** (0.042)		*LPAST*			-	
LWFG	-0.056*** (0.017)		-0.059* (0.032)		*LWFT*	-1.612** (0.683)		-1.760 (1.145)	
LIACSG	-0.108*** (0.019)		- 0.123*** (0.041)		*LIACST*	-0.418*** (0.142)		-0.362 (0.246)	
LISMG	0.055** (0.023)		0.075 (0.065)		*LISMT*	0.188 (0.159)		0.213 (0.217)	
LSDG (-1)		1.106*** (0.115)		1.111*** (0.191)	*LSDT(-1)*		0.709*** (0.159)		0.810*** (0.220)
LIRON		2.579*** (0.225)		2.636*** (0.327)	*LIRON*		1.359*** (0.227)		1.624*** (0.209)
FGG (-1)		-0.117*** (0.017)		-0.115*** (0.024)	*FGT(-1)*		-		-
LBRENT(-1)		-1.003*** (0.170)		-1.034*** (0.279)	*LBRENT(-1)*		-0.807*** (0.239)		-0.988*** (0.241)
					FGT(-1)		-1.052*** (0.302)		-1.049 (0.420)
Prob(J-Stat)				0.135			0.122		

Note:(*) sig.at 10%,(**)sig.at 5%,(***)sig.at 1%.

In summary, ship detentions are positively correlated with economic activity in the shipping sector due to the increased regulatory scrutiny, expansion of the fleet (including older vessels), cost pressures in competitive markets, globalization of trade routes, and the diverse regulatory environments that ships operate in. While economic growth in the shipping sector is generally positive, it can also result in more detentions as a consequence of these interconnected factors. To mitigate these issues, shipowners and operators must prioritize compliance, safety, and maintenance practices to reduce the risk of detentions and their associated costs.

7. Concluding Remarks

Port state control authorities have ensured ship safety globally and contribute decisively in enhancing/reducing the good reputation of each shipping company in the sector. The detention record of each company affects the value of the vessel if and when put on the market. It will also affect ship insurance, acting as a picture for the good management of the ship, and the chartering of the vessel. Specifically, in dry-bulk there is an inspection institution 'Rightship' which classifies dry-bulk vessels according to their detention records. If a ship is classified with less than three stars then it will not be chartered. For tankers, major oil companies undertake vetting inspections which ensures safety.

Although the numbers of detentions have decreased over the last few years, a substantial number of detentions still take place in ports around the world. In this study, we attempted to reveal the impact of ship specific and institutional characteristics of vessels on detentions. The factors that were found to be significant in explaining a port's detention decision included: the flag (fewer white flagged ships compared to grey flagged ships are less detained as expected), port region (stricter regions include Chinese and Japanese ports), IACS membership, as well as the type of deficiency or ISM deficiencies impact detentions positively. More importantly, our findings show that economic activity appears to be significantly and positively associated with ship detentions overall. Overall it appears that white flag and IACS membership, do not suffice to mitigate the strong positive relationship between maritime sector economic activity and the number of vessel detentions. Therefore a closer cooperation of port authorities with vessel management is called for given the rising role of 'Rightship'. Our study assists various stakeholders of the maritime industry including owners, managers and agents in achieving compliance and prevent the unfavourable scenario of their ship being detained, while also assisting port state control officials in conducting their inspections more efficiently. Further research can focus on comparing results not only from the Paris and Tokyo MoUs but others also.

The port authorities are expected to play an important role in supervising the new regulation implementation with regards to the decarbonation of` the shipping sector which was the response to calls to address the issue of climate change. The regulation represents the response of the shipping sector's stakeholders to the goals set out in the Paris Agreement (December 2015), calling all industries to take steps to maintain a global average temperature increase to 'well below' 2 degrees Celsius and even aiming for 1.5 degrees. The regulation's final version was accepted as a resolution in April 2018, during MEPC 72 and entering into effect since January of 2023. Regarding the key terms, vessels will be required to report on two energy-efficiency specialized vessel operational indices, essentially a one-time certification for CO_2 emissions called the Energy Efficiency Existing Ship Index (EEXI) and an annual operational carbon intensity indicator (CII), a new addition to operational indices measuring how efficiently a vessel can transport cargo or passengers, given in CO2 grams/ton-mile. This regulation marks the IMO's first implementation of a formal vessels' GHG emissions rating system. Port authorities will again be called to supervise this regulation's implementation.

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