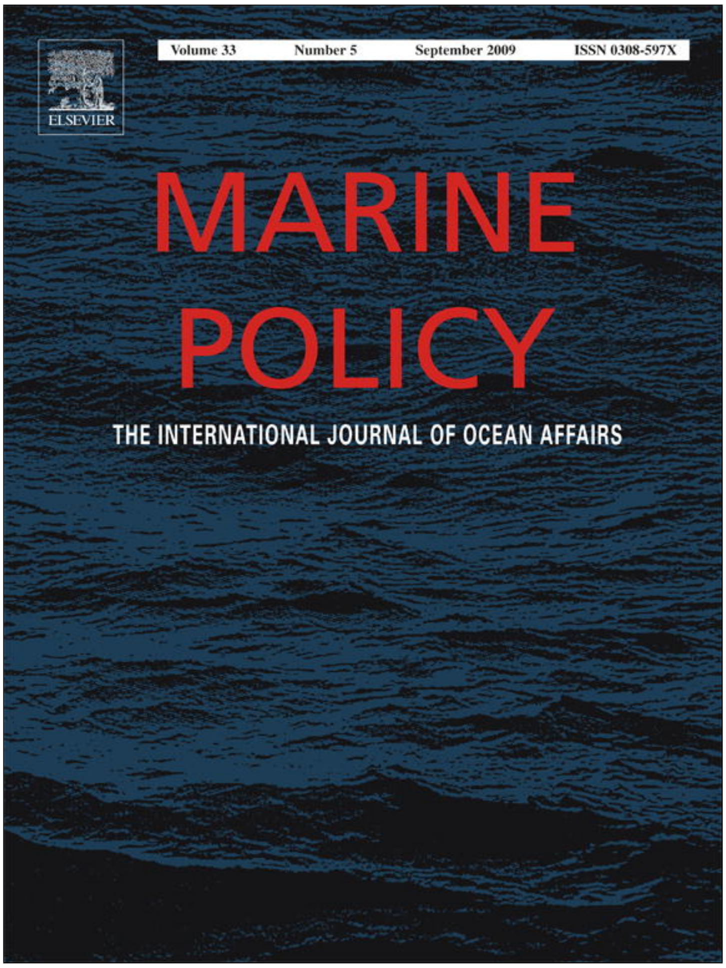
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Evidence on target factors used for port state control inspections ☆

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A B S T R A C T

Target factors aim at setting criteria to select foreign vessels that should be inspected by port state control authorities. Although a relative consensus exists on the main factors to consider in selecting vessels, the weight to be given to these factors is still unclear. Using data on 26 515 PSC inspections that took place within the Indian Ocean MoU region from 2002 to 2006, we investigate the determinants of the number of deficiencies and of the probability of detention. Our results show that the main contributors to detention are the age of the vessel at inspection (40%), the recognised organization (31%) and the place where the inspection occurs (17%). Also, differences in detention rates amongst various inspecting authorities are essentially explained by differences in the characteristics of vessels calling in a specific country rather than by differences in the way inspections are done.

1. Introduction

Port state control (PSC) inspection regimes were created on the ground that maritime safety should not be used by shipowners as a competitive tool. In that sense, unique standards and procedures must apply worldwide in order to verify that when a foreign vessel calls in a national port, the ship and its equipment comply with the requirements of international regulations and that the ship is manned and operated in compliance with these rules.[1] To achieve these goals, PSC inspections are a complement to flag state controls. They are legitimated by the fact that a ship rarely (if ever) visits its port of registry in its service life, a factor that in conjunction with the limited resources of some maritime administrations hampered their ability to check the conformity of vessels flying their flag.

If the selection of vessels to be inspected remains under the prerogative of sovereign states, it was obvious from the beginning that a degree of coordination should take place in order notably to avoid unnecessary multiple inspections. Knapp [1] estimates the cost per PSC inspection at 759 USD, when deficiencies are noted, and 509 USD, when no deficiency is found. It is in that vein that nine regional Memoranda of Understanding on Port State Control covering virtually all of the world's seas[2] (also called "MoU on PSC", or simply "MoU") were created aiming at, inter alia, centralising information and coordinating actions amongst MoU's members.[3]

One of the objectives of MoUs is to set criteria, commonly referred to as "target factors" to help identify what priority a

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[1] PSC inspection procedures apply mainly to ships that come under the provisions of the International Convention for the Safety of Life at Sea, 1974, as amended (SOLAS), the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended (STCW), the International Convention for the Prevention of Pollution from Ships, 1973, as amended (MARPOL), the International Convention on Load Lines, 1966 (Load Lines), and the International Convention on Tonnage Measurement of Ships, 1969 (Tonnage 69), hereafter referred to as the applicable conventions.

[2] The different MoUs are: Paris MoU—Europe and the North Atlantic; Tokyo MoU—Asia and the Pacific; Acuerdo de Viña del Mar—Latin America; Caribbean MoU—Caribbean Sea region; Abuja MoU—West and Central Africa; Black Sea MoU—Black Sea region; Mediterranean MoU—Mediterranean Sea region; Indian Ocean MoU—Indian Ocean region; Gulf Cooperation Council (GCC) MoU—Arab States of the Gulf.

[3] The present regime of PSC traces its origins from a memorandum of understanding signed in The Hague between eight North Sea states in 1978 that "laid down a general surveillance procedure aimed at verifying that a number of requirements derived from various international agreements were met and that conditions on board ships were not hazardous to safety or health" Kasoulides [2, p. 142].

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particular foreign vessel should be given for inspection in the region. However, if a consensus exists amongst various MoUs on which factors should be considered in the selection of vessels for inspection [1,3,4], few empirical investigations have tried to estimate the weight that should be given to these various factors [5,6].

This paper tackles this issue using data from around 26 000 PSC inspections conducted within the Indian MoU region from 2002–2006 to analyse the occurrence of two events, namely the probability for a vessel to be detained and the probability to record a given number of deficiencies during an inspection. The first objective is to investigate if the factors that explain the occurrence of the two events are significantly different. To do so, the paper uses several regressions and recent decomposition methods in order to measure the contribution of various explanatory variables such as age of the vessel, flag of registry, inspecting authority, recognised organisation and type of vessel. The second objective is to investigate if the inspecting authority, i.e. the country where the inspection took place, proves to have a significant impact on detention records. This issue is analysed estimating if the controls carried out by Australian PSC authorities that represent 56% of the total number of controls in our dataset are significantly different from results by other inspecting authorities.

The paper is organized as follows. The next section reviews the variable used in targeting systems by the Paris MoU, by the Indian MoU and by the Australian Maritime Safety Administration. In Section 3, descriptive statistics are presented on 25 615 PSC inspections carried out from January 2002 to December 2006 by countries belonging to the Indian MoU. In Section 4 estimates on the contribution of different vessels' characteristics when explaining the number of deficiencies detected during a PSC inspection using Probit models and count data models are done. It also compares the results with the probability for a vessel to be detained. In Section 4, the paper investigates if the place where the inspection took place (inspecting authority) plays a significant role on the probability for a vessel to be detained. Finally, Section 5 includes policy recommendations and conclusions.

2. Background information on target factors

While the choice on vessels to be inspected remains under the responsibility of states, a degree of coordination exists at a regional level within MoUs. MoUs usually set requirements on the minimum number of inspections to be carried out by individual member states[4] as well as recommendations on criteria on vessels to inspect (for a complete overview [1]).

Looking first at the factors to consider in the selection process, a relative consensus exists amongst various MoUs. Three main types of information are usually considered: firstly, the vessel's characteristics such as the type of vessels and their age; secondly, the performance of the flag of registry, the classification society, and the shipowner; and thirdly, records from previous inspections for a specific vessel.

The Paris MoU (2007[5]) states for instance that each member state should inspect at least 25% of foreign vessels calling at their ports and calculates at the end of each day generic and historical factors to reach an overall target factor for a specific ship (see Appendix A). If the overall target point is more than 50 points, the inspection becomes mandatory. Generic factors are based on the past performances of the ship's flag of registry, vessel type, age at inspection, and the performance of its class society. History factors are related to whether the vessel is entering the region for the first time, has been inspected during the last six months, has been detained, the number of deficiencies recorded during last inspection, and actions taken to correct outstanding deficiencies.[6]

The target system used by the Indian MoU[7] created in 1998 is representative of practices used by more recent MoUs that are not initially relying on a comprehensive dataset such as the Paris MoU. Its secretariat[8] states that members of the Indian MoU should inspect 10% of foreign vessels calling at their ports and that focus should be given to ships that enter for the first time or that have not entered during the last 12 months in the region; ships with deficiencies noted during former inspections that still need to be rectified; ships that have been reported by pilots or port authorities as having deficiencies which may prejudice their safe navigation; ships whose statutory certificates on the ship's construction and equipment have not been issued in accordance with the relevant instruments; ships carrying dangerous goods or pollutants which have failed to report to the competent authority of the port and coastal State all relevant information concerning the ship's particulars, the ship's movements, and details concerning the dangerous goods cargo being carried; and ships which have been suspended from their class for safety reasons in the last six months. Finally, the Indian MoU stresses that in selecting vessel to inspect, authorities should seek to avoid inspecting ships that have been inspected by other authorities within the previous six months, unless clear grounds for inspection exist.

To conclude, it appears that while the factors retained by MoUs to target vessels are fairly similar (age at inspection, vessel type, previous records, etc.), disparities still exist. Investigating the differences across various PSC regimes, Knapp [1] and Knapp and Franses [3] use Probit and Logit models applied to data on detentions from five different MoUs (Paris MoU, Caribean, Vino del Mar, Indian, USCG and Australia), split into six different ship types (general cargo, dry bulk, container, tanker, passenger, other ship type) and eight categories of deficiencies. Authors conclude that the ship profiles given by age, size, class and ownership would not vary significantly across various PSC regimes and those differences would come from the use of deficiencies in determining detention.

Furthermore, it appears that comparing the various targeting systems, the weight that should be given (Indian MoU for instance) or the reasons for the weight that has been given to the various factors (Paris MoU for instance) are also difficult to understand. On that last issue, the targeting system used by the

[4] For instance, 25% of foreign ships entering the area per year for Paris MoU, 15% for Caribbean MOU, 15% for Vina del Mar, 10% for Indian Ocean MOU or 75% of all vessels calling in the region for Tokyo MoU.

[5] See http://www.parismou.org/ for additional information.

[6] Within the Paris MoU, a new inspection regime (NIR) is expected to replace the current system in the near future to correct two main issues. Firstly, the targeting system does not set criteria on the total percentage of vessels to be inspected within the Paris MoU region. Secondly, multiple inspections exist for vessels having fairly good records. The NIR sets a goal for 100% of vessels entering the region to be inspected and for a hierarchy to be developed amongst High Risk Ships (HRS) inspected every 5–6 months, standard/Medium Risk Ships (MRS—every 10–12 months) and Low Risk Ships (LRS—every 24–36 months). The NIR also proposes a simplified target system for HRS based on the type of vessel (tankers, chemicals, gas carriers and passengers, +2 points), age at inspection (+2 if more than 12 years), flag of registry (if black list and HRS=+2 while if MRS=+1), recognised organisation (+1 if low performance), shipowner (+2 if low or very low performance), and on the number of detentions recorded during last 36 months (if at least 1, +1). For an individual vessel, if the total number of points is equal to or greater than 5, it would then be classified as HRS and inspected by one of the Paris MoU members no later than 5–6 months from the last inspection.

[7] The members of the Indian MoU in 2007 are: Australia, Bangladesh, Djibouti, Eritrea, Ethiopia (observer), India, Iran, Kenya, Maldives, Mauritius, Mozambique, Myanmar, Oman, Seychelles, South Africa, Sri Lanka, Sudan, Tanzania, and Yemen.

[8] See http://www.iomou.org for additional information.

Australian Maritime Safety Authority (AMSA[9]) represents a notable exception.

AMSA developed its own targeting system in 2001[10] and uses a generalized additive modelling to offer a hierarchy amongst the various factors. It relies on a dataset of 29,500 inspections that took place in Australia from 1996 to 2005 to identify the factors that explain the probability for a vessel to be detained and to rank them according to their relative influence (from important 1 to marginal 4, see Appendix B). Results suggest that for bulk carriers (around 60% of foreign vessels calling at Australian ports) the age of the vessel is the most important factor (1), followed by the number of deficiencies at the previous inspection and the time elapsed since the previous inspection (2), and the recognised organisation and the flag the vessel is flying (3). On the other hand, the fact that the ship is undergoing its first inspection plays only a marginal role (4). For the other ship types, age still represents the most important factor (1), followed by the type of ship and the gross tonnage (2), the number of deficiencies at previous inspection, the time since previous inspection and the flag of registry (3) while the recognised organisation and the fact that the ship is undergoing its first inspection play significant, but marginal roles. These conclusions are similar to Cariou et al. [5]. Using a decomposition model applied to the number of deficiencies recorded during PSC inspections carried out by the Swedish Maritime Administration (1996–2002), these authors identify the age of the vessel (36.8%) as the first explanatory variable, followed by the flag of registry (33.7%), and the ship type (28.3%).

This article tries to contribute to the former studies and literature on two issues that were partially covered. Firstly, is there a difference in the contribution (weight) of the factors towards the probability to record a given number of deficiencies and the probability to be detained? Secondly, does the inspecting authority play a role in explaining the probability to be detained? Before proceeding to the econometric analysis, the following section presents descriptive statistics from the Indian MoU dataset.

3. Descriptive statistics

The initial sample comes from 26 515 PSC inspections carried out within the Indian MoU region from January 1, 2002 to December 31, 2006. Every PSC boarding generates a detailed inspection report containing the following information: ship's name, International Maritime Organization (IMO) vessel number, flag of registry, recognised organization, vessel type, gross tonnage, deadweight tonnage, year built, type of inspection, date of inspection, date of detention, date of release from detention, place of inspection, inspecting authority, and nature of deficiencies. Table 1 provides descriptive statistics on the main variables used in the sequel.

The sample concerns 10 236 vessels, the average number of inspections by vessel being equal to 2.6. The average age of vessels subject to inspection is 14.4 years old with a fairly equal distribution amongst various age categories (15.4% of vessels are between 0 and 4 years old, 20.6% between 5 and 9, 15.3% between 10 and 14, 15.7% between 15 and 19, 19.5% between 20 and 24 and 13.4% are more than 25 years). Australia carried out the majority of controls (56.6%) followed by India (18.2%) and Iran (12.6%). Panama is the first flag of registry subject to inspection (26.7%) followed by Liberia (6.6%) and Hong Kong China (5.9%). Bulk carriers represent 46.3% of vessels inspected followed by general cargo/multi-purpose ships (18.4%) and oil tankers (10.3%). Finally, the Nippon Kaiji Kyokai classification society is the first recognised organisation inspected (30%) followed by Lloyd's Register (14.9%) and Det Norske Veritas (9.7%).

Table 1
Description of the sample.

Variables		Distribution (%)
Age at PSC inspection	0–4	15.4
	5–9	20.6
	10–14	15.3
	15–19	15.7
	20–24	19.5
	25+	13.4
Inspecting authority	Australia	56.6
	Iran	12.6
	India	18.2
	South Africa	8.8
	Others	3.6
Flag of registry	Panama	26.7
	Liberia	6.6
	Hong Kong, China	5.9
	Bahamas	4.9
	Cyprus	4.7
	Singapore	4.6
	Russian Federation	4.4
	Malta	4.4
	Greece	3.3
	Others	34.5
Type of ship	Bulk carrier	46.3
	General cargo/multi-purpose ship	18.4
	Oil tanker	10.3
	Containership	8.2
	Chemical tanker	3.2
	Vehicle carrier	2.9
	Woodchip carrier	1.5
	Refrigerated cargo carrier	1.3
	Ro-ro cargo ship	1.3
	Gas carrier	1.2
	Others	5.4
Recognised organization	Nippon Kaiji Kyokai	30.0
	Lloyd's Register	14.9
	Det Norske Veritas	9.7
	American Bureau of Shipping	8.7
	Germanischer Lloyd	7.9
	Bureau Veritas	7.8
	Russian Maritime Register of Shipping	6.1
	China Classification Society	3.7
	Korean Register of Shipping	3.6
	Others	7.7
Number of observations		26515

Source: Indian MoU (2007).

A key feature of these data is that they include information both on the number of deficiencies and on detentions. Three dependent variables were defined in the following manner. The first one, called *DEF*, is a binary variable equal to one when a specific vessel has at least one deficiency (0 otherwise). The second one is the number of deficiencies recorded, *DEFN*, ranging from 0 to *n*. The last one, *DET*, is a binary variable which takes the value of one when the vessel is detained (and 0 otherwise).

Fig. 1 presents the mean values of *DEF* and *DET* over the 2002–2006 periods. The mean number of deficiencies is 2.7 for the entire sample ranging from 2.3 in 2002 to 3.12 in 2006. The mean number of controls with at least one deficiency detected is 53.1% and the number of controls leading to detention is 7.7% ranging from 5.6% in 2002 to a maximum of 9.1% in 2003. On average, about 53% of the inspected vessels were found to have at

[9] Although Australia is part of two distinct MoUs (Indian MoU and Tokyo MoU), it still uses its own criteria to select vessels to inspect. See http://www.amsa.gov.au/Shipping_Safety/Port_State_Control/ for additional information.

[10] The system was implemented in cooperation with the Commonwealth Scientific and Industrial Research Organisation (CISRO).

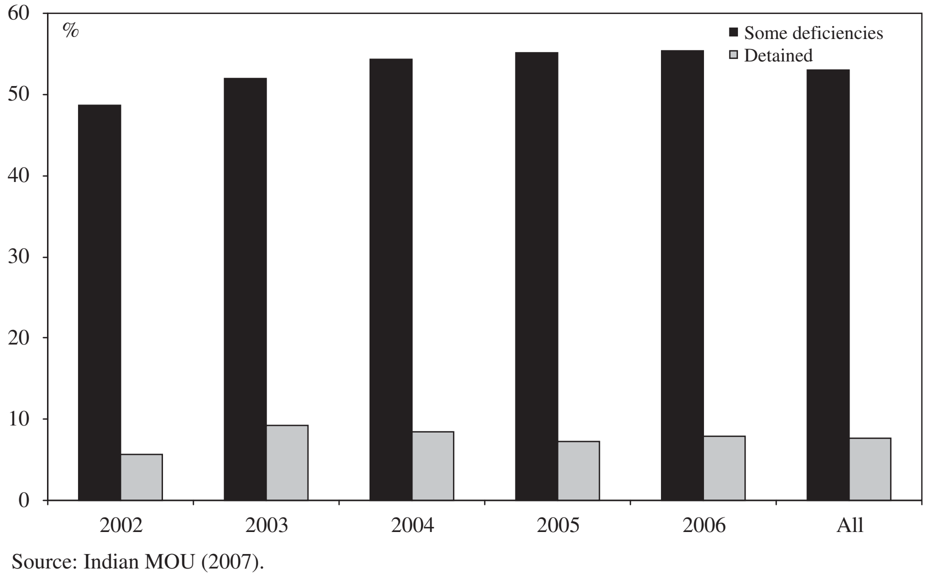

Fig. 1. Frequencies of having at least one deficiency and of being detained.

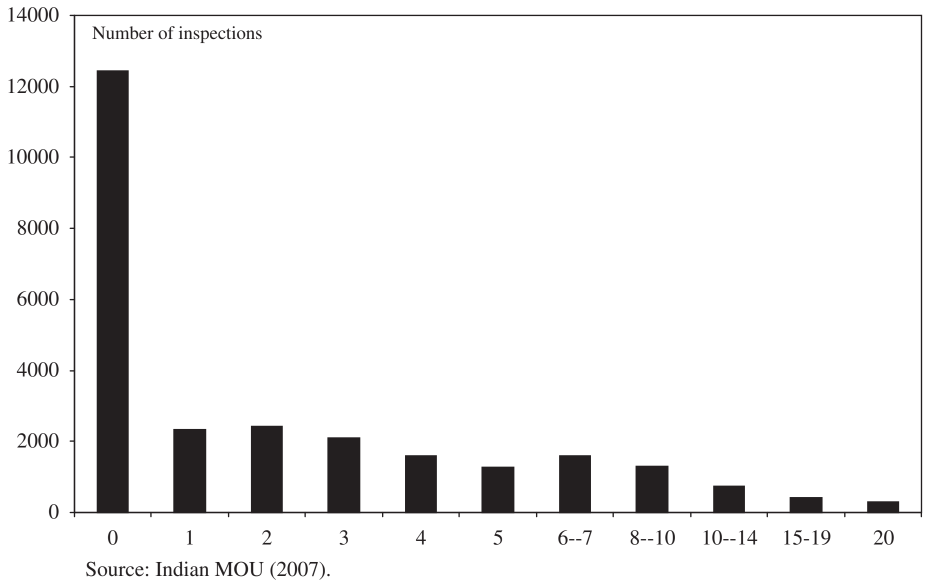

Fig. 2. Distribution of the number of deficiencies.

least one deficiency. This proportion of vessels with deficiencies is slightly increasing over the period, as *DEF* is equal to 48.7% in 2002, 51.9% in 2003 and 54.4% in 2004 (55% in 2005 and 2006%). On the other hand, the proportion of vessels detained averaged 7.7%, ranging from 5.6% in 2002 to 9.2% in 2003.

Fig. 2 provides the distribution of *DEFN*, i.e. the number of deficiencies per inspection. The mean number of deficiencies is 2.7 for the entire sample, with a minimum of 2.3 in 2002 and a maximum of 3.1 in 2006. Amongst the subsample of vessels with at least one deficiency, the mean number of deficiencies is much higher, around five, and the median number of deficiencies is four. There are more than five deficiencies in 16.4% of the inspections, and more than 10 deficiencies in 5.5% of the cases. Finally, among the 26 515 inspections, seven have more than 50 deficiencies detected.

Table 2 indicates the magnitude of deficiencies and detention by vessel's characteristics. Turning first to age at inspection, statistics show as expected a constant increase in the average number of deficiencies detected with vessel age, from 1.0 for less than 5 year old vessels to 5.1 for vessels older than 25 years old. A similar finding exists for controls with at least one deficiency detected (from 30.4% of the category for vessels less than 5 year old to 67.2% for vessels older than 25 years old) or detentions (from 1.6% of controls leading to detention for vessels less than 5 years old to 20.0% for vessels older than 25 years old).

Regarding the inspecting authority, Iran is the country for which the average number of deficiencies detected is the highest (5.3 deficiencies on average) followed by India (2.8) and Australia (2.6). A similar finding can be found for the percentage of detentions (Iran with 15.6% followed by India 12.5% and Australia with 5.5%). Concerning the flag of registry, a high number of deficiencies is detected for Singapore (3.0) and Malta (2.9). At the same time, vessels flying the Russian Federation flag have at least one deficiency detected in 68.2% of the cases, followed by

55.5% of the cases for Malta. Finally, the ''other flag'' category[11] records the poorest performances in terms of detention (10.3% of controls on vessels flying ''other flags'').

The average number of deficiencies is 3.8 for general cargo/multi-purpose vessels, the number of inspections with at least one deficiency being equal to 62.1% and the number of detentions 13.3%. Chemical carriers also record poor results with an average of 2.9 deficiencies detected and 10.2% of controls leading to detentions. Finally, regarding classification societies, the other category[12] contains the highest proportion of vessels with 5.7 deficiencies on average and 25% detentions in the category, followed by Bureau Veritas (3.1 deficiencies and 10.0% of detentions) and the Russian Maritime Register of Shipping (2.8 deficiencies on average and 9% of detentions).

For each inspection, an analysis was done on the type of deficiencies detected (if any). As there are more than 350 different types of deficiencies, the various deficiencies codes were grouped in eight categories using a similar classification to Knapp [1]. The deficiencies related to safety and fire appliances are the most frequent type of deficiencies detected during inspections (29.3% of the cases), followed by deficiencies related to stability and structure (20.5%), navigation and communication (16.6%) and ship and cargo operations (11.5%). The four other categories—certificates, working and living conditions, equipment and machinery, and management—are detected less frequently. Table 3 presents the results for various vessels' characteristics.

An interesting element to note is that the type of deficiencies detected is influenced by the main characteristics of the vessel, i.e., age, inspecting authority, flag of registry, and type of ship. For instance, relatively new vessels are more likely to be deficient on either navigation/communication or management related deficiencies. Conversely, for older vessels, deficiencies are more likely to occur for stability or structure. Furthermore, the types of deficiencies reported seem to be influenced by where the inspection took place.

In Australia, deficiencies are essentially related to safety and fire appliances, and to navigation and communication, while problems of stability or structure are less frequent. Conversely, in India, problems are more often concerned with certificates and stability and structure problems than in the other countries. In South Africa, inspections also lead to frequent detection of deficiencies in stability and structure (31.3% instead of 20.5% in average). Concerning flag of registry, vessels from Russia have more often deficiencies related to stability and structure (27.5%) and certificates (10.1%), while problems of navigation and communication are more common for Greek vessels.

Finally, significant differences exist between ship types. Safety and fire appliances are more likely to occur among vehicle carriers, woodchip carriers and gas carriers. Problems of structure and stability more often concern general cargo and multi-purpose

Table 2
Occurrence of deficiencies and detention, by vessels' characteristics.

Variables		Mean nb of deficiencies	Any deficiency % in category	Detained % in category
Age at PSC inspection	0–4	1.0	30.4	1.6
	5–9	1.7	46.0	2.8
	10–14	2.3	52.7	5.2
	15–19	2.9	59.0	7.6
	20–24	3.7	64.3	11.1
	25+	5.1	67.2	20.0
Inspecting Authority	Australia	2.6	56.3	5.5
	Iran	5.3	75.9	15.6
	India	2.8	51.7	12.5
	South Africa	0.7	19.0	1.5
	Others	0.5	13.9	4.9
Flag of registry	Panama	2.6	52.2	7.3
	Liberia	1.7	41.7	4.7
	Hong Kong, China	2.3	50.8	3.4
	Bahamas	1.8	45.4	5.0
	Cyprus	2.8	54.6	8.7
	Singapore	3.0	54.4	6.8
	Russian Federation	2.1	68.2	4.7
	Malta	2.9	55.9	7.4
	Greece	1.7	46.2	4.5
	Others	3.3	55.5	10.3
Type of ship	Bulk carrier	2.7	56.3	6.1
	General cargo/multi-purpose ship	3.8	62.1	13.3
	Oil tanker	2.0	38.0	8.3
	Containership	1.8	42.7	5.5
	Chemical tanker	2.9	53.1	10.2
	Vehicle carrier	1.5	42.1	2.8
	Woodchip carrier	1.7	55.9	3.9
	Refrigerated cargo carrier	2.1	36.4	5.7
	Ro-ro cargo ship	1.9	38.3	6.3
	Gas carrier	1.1	37.8	2.2
	Others	3.0	55.5	8.3
Recognised organization	Nippon Kaiji Kyokai	2.2	50.4	4.4
	Lloyd's Register	2.7	53.2	7.4
	Det Norske Veritas	2.1	45.8	5.0
	American Bureau of Shipping	2.5	50.0	6.8
	Germanischer Lloyd	2.2	45.6	7.0
	Bureau Veritas	3.1	57.9	10.0
	Russian Maritime Register of Shipping	2.8	70.2	9.0
	China Classification Society	2.6	54.1	4.5
	Korean Register of Shipping	2.6	53.7	5.6
	Others	5.7	64.6	25.0
Mean		2.7	53.1	7.7

Source: Indian MoU (2007).

[11] Other Flags of Registry are Saint Vincent and the Grenadines; China; Marshall Islands; Norway; Korea, Republic of; Philippines; Antigua and Barbuda; Malaysia; Isle of Man (UK); India; Netherlands; Japan; Thailand; United Kingdom (UK); Turkey; Korea, Democratic People's Republic; Denmark; Italy; Taiwan, China; Azerbaijan; Bermuda (UK); Vanuatu; Germany; Cayman Islands (UK); Iran; Cambodia; Indonesia; France; Sweden; Bangladesh; Belize; United Arab Emirates (UAE); Sri Lanka; Papua New Guinea; Saudi Arabia; Vietnam; Egypt; Croatia; Georgia; Switzerland; Myanmar; Comoros; Kuwait; Netherlands Antilles; Tonga; Jordan; Qatar; Belgium; Syrian Arab Republic; Gibraltar (UK); Turkmenistan; Mongolia; Ethiopia; Pakistan; Bolivia; Lebanon; United States of America; São Tomé and Príncipe; New Zealand; Bahrain; Ukraine; Dominica; Saint Kitts and Nevis; Honduras; Algeria; Sudan; Barbados; Luxembourg; Mauritius; Ireland; Portugal; Samoa; Seychelles; Ghana; Sierra Leone; Slovakia; Bulgaria; Maldives; Fiji; Eritrea; Brazil; Morocco; Tuvalu; Jamaica; South Africa; Tunisia; Spain; Lithuania; Chile; Colombia; Cook Islands; Tanzania; Dominican Republic; Kiribati; Namibia; Somalia; Costa Rica; and Nigeria. This category also includes vessels listed as being registered under unspecified ''other'' flags.

[12] Other Recognized Organizations are Registro Italiano Navale; Indian Register of Shipping; China Corporation Register of Shipping; International Register of Shipping; Korea Classification Society; International Naval Survey Bureau; Hellenic Register of Shipping; Polski Rejestr Statkow; Croatian Register of Shipping; Biro Klasifikasi Indonesia; Turkish Lloyd; Viet Nam Register of Shipping; Register of Shipping, Albania; Isthmus Bureau of Shipping; Honduras International Surveying and Inspection Bureau; Panama Register Corporation; Panama Maritime Documentation Services; Panama Shipping Registrar Inc.; Global Marine Bureau; Panama Maritime Surveyors Bureau Inc; RINAVE Portuguesa; Bulgarski Koraben Registar; Shipping Register of Ukraine; INCLAMAR; Honduras Maritime Inspection; Panama Bureau of Shipping; Belize Register Corporation; Ceskoslovensky Lodin Register; Seefartsaht Helsinki; Honduras Bureau of Shipping; Russian River Register; Marconi International Marine Company Ltd; Registro Internacional Naval S.A.; Compania Nacional de Registro e Inspeccion de Naves. This category also includes vessels listed under ''Other,'' ''No Class,'' and ''Class Withdrawn''.

Table 3
Type of deficiencies by vessels' characteristics.

Variables		Certificates	Working and living conditions	Safety and fire appliances	Stability and structure	Ship and cargo operations	Equipment and machinery	Navigation/ communication	Management
Age at PSC inspection	0–4	6.1	5.0	24.1	10.9	15.9	2.9	27.3	7.9
	5–9	4.0	5.4	30.2	13.7	13.6	3.3	23.9	6.0
	10–14	4.6	6.1	30.5	17.7	12.0	3.9	19.8	5.5
	15–19	4.6	7.6	32.0	20.3	10.5	4.7	16.1	4.3
	20–24	4.5	8.5	30.5	22.9	10.7	5.8	13.7	3.4
	25+	8.8	8.6	26.1	24.8	10.9	6.2	12.4	2.3
Inspecting authority	Australia	3.0	6.6	31.9	17.0	11.3	3.8	20.6	5.9
	Iran	7.6	8.8	25.3	22.5	12.8	9.2	11.1	2.6
	India	10.2	8.4	27.1	26.5	10.9	3.0	12.6	1.3
	South Africa	5.7	5.7	28.1	31.3	9.1	4.2	15.1	0.9
	Others	15.4	6.5	26.0	27.4	6.3	3.0	10.6	4.9
Flag of registry	Panama	4.9	7.2	29.6	19.2	12.1	4.4	17.9	4.7
	Liberia	3.7	6.9	32.0	17.9	11.8	4.3	18.2	5.2
	Hong Kong, China	2.0	8.6	30.8	18.1	10.7	5.1	18.8	5.9
	Bahamas	5.7	6.0	32.4	16.1	11.7	5.6	17.0	5.5
	Cyprus	4.9	7.0	32.0	21.5	10.2	5.3	14.6	4.5
	Singapore	3.9	7.9	30.5	21.5	10.6	5.6	16.0	4.0
	Russian Federation	10.1	11.6	22.0	27.5	11.9	2.4	13.2	1.3
	Malta	5.2	7.2	31.5	20.6	10.0	4.9	16.3	4.3
	Greece	3.7	4.0	30.2	17.4	10.3	4.8	22.7	6.9
	Others	6.8	7.5	28.1	21.5	11.7	5.5	15.5	3.3
Type of ship	Bulk Carrier	3.3	7.2	30.6	19.7	10.7	4.2	18.9	5.4
	General cargo/ multi-purpose ship	8.1	8.0	25.8	24.4	11.2	5.9	14.0	2.6
	Oil tanker	8.7	7.4	29.6	20.0	14.5	4.4	12.6	2.8
	Containership	4.6	7.4	30.4	20.0	12.0	7.1	14.5	4.1
	Chemical tanker	6.3	8.1	30.5	18.3	13.0	6.5	14.1	3.3
	Vehicle carrier	1.8	11.0	36.4	9.2	16.5	3.9	16.9	4.3
	Woodchip carrier	3.1	7.5	38.1	13.4	13.4	2.0	18.3	4.2
	Refrigerated cargo carrier	5.5	5.3	30.1	15.3	15.0	4.1	19.3	5.3
	Ro-ro cargo ship	13.3	7.7	25.8	17.3	12.0	7.5	13.9	2.5
	Gas carrier	4.3	5.5	36.1	13.9	10.4	6.9	20.2	2.6
	Others	10.0	6.6	27.7	18.4	12.7	5.0	16.8	2.8
Total		5.6	7.5	29.3	20.5	11.5	5.0	16.6	4.1

Source: Indian MoU (2007).

ships, while bulk carriers, refrigerated cargo carriers and gas carriers more often had deficiencies related to navigation and communication. Nevertheless, for all types of ship, deficiencies related to safety and fire appliances category are always the most common.

4. Determinants of the occurrence of deficiencies and detentions

To estimate how the characteristics of the vessels influence the probability for a ship to have deficiencies, a latent variable DEF^* was constructed such that $DEF^*>0$ when the ship has at least one deficiency and $DEF^*\leqslant 0$ when the ship is without deficiency. By definition, this latent variable remains unobserved, but DEF=1 when $DEF^*>0$ and DEF=0 when $DEF^*\leqslant 0$ are. DEF is a function of a vector of covariates X, which comprises age at inspection, inspecting authority, flag of registry, type of ship, recognised organisation and year of inspection. The corresponding model is hence:

$$DEF^*_{it} = X_{it}\beta + u_i + \varepsilon_{it} \tag{1}$$

where i and t as subscripts, respectively, refer to the ship and to the date of inspection. In (1), u_i is an unobserved vessel effect. These perturbations are supposed to be normally distributed, with mean 0 and variance σ_u^2 The error terms ε_{it} are also supposed to follow a normal distribution, with mean 0 and unitary variance. The corresponding model is then a random effects Probit model which is estimated using numerical approximations and Gaussian quadrature techniques [7].

To determine the factors influencing the number of deficiencies $DEFN$ detected during a PSC inspection, count data models were used (with Negative binomial instead of a Poisson regression model). Results of the random effects Probit models are in columns 1 and 2 of Table 4, while negative binomial estimates are in columns 3 and 4 of Table 4. As both sets of estimates give very similar results, only the results on the number of deficiencies are discussed.

As shown in column 3, the older the vessel, the higher is the number of deficiencies detected. Compared to the reference category (less than 5 years old), the number of deficiencies is 51.8% more for vessels between 5 and 10 years old and it reaches a maximum of 171.5% more for vessels more than 25 years old. With respect to other inspecting authorities (Kenya, Eritrea, Mauritius, Tanzania, Sri Lanka and Yemen), the number of deficiencies is 259.7% more if the inspection took place in Iran, 242.9% more if in Australia and 200% more if in India. It is however not possible at this stage to understand whether these differences are explained

Table 4
Econometric analysis of deficiencies (probability and number).

Variables	Random effects Probit				Negative binomial			
	(1)		(2)		(3)		(4)	
	coef	*t*-test	coef	*t*-test	coef	*t*-test	coef	*t*-test
Constant	−2.191***	(25.29)	−2.291***	(18.75)	−1.990***	(12.30)	−2.237***	(12.58)
Age at PSC inspection								
0–4	Ref.		Ref.		Ref.		Ref.	
5–9	0.420***	(13.18)	0.365***	(8.65)	0.518***	(11.69)	0.460***	(7.94)
10–14	0.655***	(18.51)	0.588***	(12.97)	0.878***	(19.12)	0.779***	(13.30)
15–19	0.930***	(25.56)	0.802***	(16.82)	1.175***	(25.88)	1.023***	(17.27)
20–24	1.099***	(30.82)	0.979***	(20.72)	1.425***	(32.17)	1.270***	(21.88)
25+	1.323***	(30.93)	1.195***	(20.82)	1.715***	(32.95)	1.551***	(23.32)
Inspecting authority								
Australia	1.965***	(29.32)	1.729***	(18.65)	2.429***	(18.33)	2.270***	(14.69)
Iran	2.198***	(31.67)	2.019***	(20.85)	2.597***	(19.85)	2.416***	(15.73)
India	1.389***	(20.82)	1.269***	(13.57)	2.000***	(15.14)	1.969***	(12.63)
South Africa	0.473***	(6.64)	0.356***	(3.55)	0.549***	(3.80)	0.482***	(2.70)
Others	Ref.		Ref.		Ref.		Ref.	
Flag of registry								
Panama	0.071**	(2.41)	0.060*	(1.73)	0.112***	(3.48)	0.147***	(4.06)
Liberia	−0.126***	(2.89)	−0.113**	(2.13)	−0.189***	(3.67)	−0.095	(1.54)
Hong Kong, China	−0.074	(1.62)	−0.028	(0.54)	−0.031	(0.60)	0.051	(0.95)
Bahamas	−0.121**	(2.47)	−0.071	(1.23)	−0.249***	(4.44)	−0.146**	(2.29)
Cyprus	−0.068	(1.35)	−0.032	(0.52)	−0.054	(0.86)	−0.031	(0.50)
Singapore	0.129**	(2.52)	0.071	(1.15)	0.196***	(3.50)	0.127**	(2.21)
Russian Federation	−0.217**	(2.31)	−0.282**	(2.38)	−0.656***	(7.00)	−0.504***	(4.93)
Malta	−0.017	(0.33)	−0.037	(0.59)	−0.071	(1.38)	−0.005	(0.07)
Greece	−0.180***	(3.07)	−0.166**	(2.42)	−0.354***	(5.51)	−0.257***	(3.29)
Others	Ref.		Ref.		Ref.		Ref.	
Type of ship								
Bulk carrier	0.272***	(5.63)	0.345***	(5.67)	0.249***	(4.30)	0.327***	(5.44)
General cargo/multi-purpose ship	0.327***	(6.43)	0.411***	(6.33)	0.356***	(5.84)	0.401***	(6.37)
Oil tanker	−0.190***	(3.46)	−0.054	(0.78)	−0.175**	(2.53)	−0.101	(1.34)
Containership	−0.087	(1.48)	0.036	(0.49)	−0.203***	(2.89)	−0.058	(0.77)
Chemical tanker	0.172**	(2.43)	0.329***	(3.68)	0.149*	(1.86)	0.264***	(2.94)
Vehicle carrier	−0.327***	(4.47)	−0.188**	(2.18)	−0.601***	(7.26)	−0.411***	(4.51)
Woodchip carrier	0.220**	(2.27)	0.334***	(3.15)	−0.136	(1.39)	0.030	(0.30)
Refrigerated cargo carrier	−0.073	(0.75)	−0.044	(0.32)	0.109	(0.97)	0.092	(0.58)
Ro-ro cargo ship	−0.167*	(1.67)	−0.084	(0.66)	−0.028	(0.19)	0.084	(0.48)
Gas carrier	−0.279***	(2.83)	−0.152	(1.19)	−0.611***	(4.70)	−0.528***	(3.01)
Others	Ref.		Ref.		Ref.		Ref.	
Recognised organization								
Nippon Kaiji Kyokai	−0.365***	(7.71)	−0.198***	(3.38)	−0.607***	(11.17)	−0.424***	(7.09)
Lloyd's Register	−0.370***	(7.71)	−0.203***	(3.42)	−0.596***	(10.93)	−0.395***	(6.41)
Det Norske Veritas	−0.482***	(9.24)	−0.257***	(3.97)	−0.725***	(11.99)	−0.463***	(6.79)
American Bureau of Shipping	−0.341***	(6.33)	−0.151**	(2.24)	−0.521***	(8.51)	−0.340***	(5.00)
Germanischer Lloyd	−0.218***	(3.81)	−0.044	(0.62)	−0.428***	(6.46)	−0.221***	(2.89)
Bureau Veritas	−0.202***	(3.78)	−0.052	(0.78)	−0.407***	(6.83)	−0.234***	(3.59)
Russian Maritime Register	0.288***	(3.24)	0.547***	(4.73)	−0.117	(1.36)	−0.026	(0.28)
China Classification Society	−0.607***	(9.22)	−0.395***	(5.01)	−0.885***	(11.70)	−0.650***	(7.74)
Korean Register of Shipping	−0.541***	(7.91)	−0.425***	(5.41)	−0.758***	(7.88)	−0.662***	(6.81)
Others	Ref.		Ref.		Ref.		Ref.	
Year of inspection								
2002	Ref.		Ref.		Ref.		Ref.	
2003	0.001	(0.05)	−0.016	(0.32)	−0.012	(0.37)	0.012	(0.22)
2004	−0.030	(1.08)	−0.036	(0.76)	−0.063**	(2.02)	−0.065	(1.17)
2005	0.032	(1.12)	0.033	(0.69)	0.050	(1.52)	0.070	(1.25)
2006	0.139***	(4.82)	0.126***	(2.63)	0.231***	(6.82)	0.209***	(3.66)
Nb of deficiencies during previous inspection			0.045***	(12.44)			0.055***	(16.81)
Number of observations	26 515		16 279		26 515		16 279	
Log likelihood	−15330.8		−9488.0		−51114.4		−32154.8	

Source: Indian MoU (2007).
Absolute values of t statistics are in parentheses. Significance levels are, respectively, 1% (***), 5% (**) and 10% (*). Standard errors are corrected for clustering at the vessel level in the negative binomial model.

by the characteristics of vessels calling or by tougher inspections carried out by the various authorities. This issue will be investigated in Section 5.

When it comes to flags of registry, flags that encountered relatively poor results compared with the other category of flags are Panama (+11.2%) and Singapore (+19.6%). The reduction effect is particularly strong for vessels under the Russian Federation's flag of registry (−65.6%), Greek (−35.4%) and Bahamian (−24.9%). General cargo/multi-purpose ships (+35.6% compared to the other ship category) and bulk carriers (+24.9%) have relatively more deficiencies detected while chemical carriers (−60.1%) and gas carriers (−61.1%) have relatively less compared to the "other ship type" category.[13] Furthermore, China Classification Society (−88.5%), Korean Register of Shipping (−75.8%), Det Norske Veritas (−72.5%) and Nippon Kaiji Kyokai (−60.7%) are performing relatively well. Finally, the year when inspection took place does not really affect the number of deficiencies detected.

The question on whether the number of deficiencies reported in the previous inspection has an effect on the number of deficiencies detected during the current inspection was also investigated. As shown in Table 4 column 4, it appears that the outcome during previous inspection has a significant and positive effect on the current number of deficiencies.

A decomposition analysis to estimate the contribution of the different covariates to the number of deficiencies was then implemented. For that purpose, the method described in Fields [8] and relying on OLS to explain the number of deficiencies was used. Assuming a linear specification of the form $DEFN=X\beta+\varepsilon$ (vessel specific heterogeneity is neglected here), the variance of $DEFN$ can be decomposed in the following way[14]:

$$V[DEFN] = \sum_k \mathrm{cov}[X^k \hat{\beta}^k, DEFN] + \mathrm{cov}[\hat{\varepsilon}, DEFN] \quad (2)$$

where $k=1,\ldots,K$ as subscript refers to the different covariates. Defining the weights $s[X^k]$ and $s[\hat{\varepsilon}]$, respectively, as $s[X^k] = \mathrm{cov}[X^k\hat{\beta}^k, DEFN]/V[DEFN]$ and $s[\hat{\varepsilon}] = \mathrm{cov}[\hat{\varepsilon}, DEFN]/V[DEFN]$, it follows that:

$$\sum_k s[X^k] + s[\hat{\varepsilon}] = 100\% \quad (3)$$

The weights that were determined use the variance as a measurement of dispersion of the dependent variable. The results reported in Table 5 indicate the most influential factors when explaining the number of deficiencies. As shown in the last column, age at inspection is the most important covariate since it contributes to 42.5% of the total number of deficiencies detected. The inspecting authority (30.8%) and the recognised organisation (14.5%) are the two following explanatory factors, the other covariates being less influential. That the condition of a vessel is strongly correlated with its age is a logical result.

Another interesting result is that whatever the type of deficiency, the first two factors to contribute to the number of deficiencies always remain either the age of the vessel (working and living conditions, safety and fire appliances, stability and structure) or the inspecting authority (certificates, ship and cargo operations, equipment and machinery, navigation and communication). It suggests that the place where the inspection takes place is important in order to understand the number of

Table 5
Decomposition analysis of the factors contributing to the number of deficiencies.

Variables	Certificates		Working and living conditions		Safety and fire appliances		Stabilityand structure		Ship and cargo operations		Equipment and machinery		Navigation and communication		Management		Total deficiencies	
	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank
Age at PSC inspection	27.20	2	49.60	1	48.50	1	50.90	1	27.20	2	27.50	2	19.30	2	7.50	4	42.50	1
Inspecting Authority	32.80	1	30.40	2	28.70	2	21.50	2	46.30	1	58.50	1	40.00	1	52.10	1	30.80	2
Flag of registry	1.40	5	2.00	6	5.30	5	1.80	5	4.20	5	3.30	5	5.30	6	2.90	6	3.70	5
Type of ship	12.00	4	3.90	5	5.30	4	9.00	4	4.80	4	3.50	4	16.20	3	14.40	3	7.30	4
Recognised organization	25.70	3	8.60	3	11.50	3	15.80	3	17.20	3	4.90	3	13.00	4	4.90	5	14.50	3
Year of inspection	0.80	6	5.50	4	0.70	6	1.10	6	0.30	6	2.40	6	6.30	5	18.20	2	1.20	6
Total	100		100		100		100		100		100		100		100		100	

Source: Indian MoU (2007).

[13] Other Ship Types are livestock carrier; offshore service vessel; combination carrier; passenger ship; tugboat; NLS tanker; heavy load carrier; special purpose ship; ro-ro passenger ship; MODU&FPSO; fishing vessel; high speed passenger craft; high speed cargo craft. This category also includes vessels listed under unspecified "other types of ship".

[14] For the presentation, the subscript for each inspection is dropped.

Table 6
Econometric analysis of the probability of detention.

Variables		(1) Marginal effects	(2) Marginal effects	(3) Marginal effects
Age of ship at PSC inspection	0–4	Ref.	Ref.	Ref.
	5–9	2.6%***	1.9%***	0.3
	10–4	7.4%***	5.8%***	1.0**
	15–19	11.7%***	9.3%***	1.9***
	20–4	14.4%***	11.2%***	2.3***
	25+	22.3%***	17.9%***	3.6***
Inspecting authority	Australia	7.8%***	8.2%***	−1.8***
	Iran	16.0%***	16.4%***	−1.4***
	India	14.9%***	20.9%***	0. 6
	South Africa	−1.3%	−0.8%	−1.6***
	Others	Ref.	Ref.	Ref.
Flag of registry	Panama	1.0%***	1.4%***	0.2
	Liberia	−0.5%	−0.2%	0.4
	Hong Kong, China	−1.7%***	−1.2%	−0.6*
	Bahamas	−1.2%*	−0.4%	0.1
	Cyprus	0.3%	0.3%	0.4
	Singapore	0.7%	0.1%	−0.0
	Russian Federation	−4.8%***	−4.7%***	−1.9***
	Malta	−1.6%***	−1.4%*	−0.7**
	Greece	−1.3%*	−0.2%	0.2
	Others	Ref.	Ref.	Ref.
Type of ship	Bulk carrier	2.1%***	3.0%***	0.1
	General cargo/multi-purpose ship	4.0%***	5.0%***	0.9**
	Oil tanker	1.0%	2.7%**	0.5
	Containership	0.7%	2.7%**	0.8
	Chemical tanker	4.8%***	6.1%***	1.6**
	Vehicle carrier	−2.1%**	−1.0%	−0.1
	Woodchip carrier	1.1%	2.3%	1.2
	Refrigerated cargo carrier	0.7%	−0.9%	−0.4
	Ro-ro cargo ship	0.2%	2.0%	−0.3
	Gas carrier	−2.3%	−0.7%	0.1
	Others	Ref.	Ref.	Ref.
Classification society	Nippon Kaiji Kyokai	−5.7%***	−5.0%***	−2.0***
	Lloyd's Register	−4.3%***	−3.8%***	−1.5***
	Det Norske Veritas	−4.5%***	−3.8%***	−1.6***
	American Bureau of Shipping	−3.6%***	−3.4%***	−1.3***
	Germanischer Lloyd	−3.2%***	−2.1%***	−1.1***
	Bureau Veritas	−3.1%***	−1.9%***	−1.1***
	Russian Maritime Register	−2.4%***	−1.9%**	−0.9**
	China Classification Society	−4.8%***	−4.3%***	−1.8***
	Korean Register of Shipping	−4.3%***	−4.1%***	−1.4***
	Others	Ref.	Ref.	Ref.
Nb of deficiencies during previous inspection			0.3%***	
Any deficiencies				
	Certificates			5.0***
	Working and living conditions			0.3*
	Safety and fire appliances			4.1***
	Stability and structure			2.4***
	Ship and cargo operations			3.7***
	Equipment and machinery			1.1***
	Navigation and communication			2.0***
	Management			6.6***
Number of observations		26 515	16 279	26 515

Source: Indian MoU (2007).
Marginal effects obtained from Probit models. Significance levels are, respectively, 1% (***), 5% (**) and 10% (*). Standard errors are corrected for clustering at the vessel level.

deficiencies detected and more specifically for those related to equipment and machinery (58.5%) or management (52.1%).

The determinants of the probability of detention were then estimated using simple Probit models. The standard errors are corrected using a clustering method at the vessel level, since a given ship may have recorded former detentions (Table 6). Interestingly, results for detentions are similar to former estimations on the number of deficiencies, suggesting that the factors explaining the occurrence of these two events are very similar.

Results on marginal effects[15] again evidence the strong positive effect of age at inspection (column 1, Table 6). The probability for a vessel to be detained increases by 14.4 points of percentage when the vessel is between 20 and 24 years at inspection and even 22.3 points of percentage for vessels older than 25 years, the predicted probability of detention being equal

[15] Detailed results with coefficients and *t*-values are available from the authors upon requests.

to 4.9 points (at the mean of the sample). Iran, India, and Australia record higher detentions than other inspecting authorities. Furthermore, vessels flying the Russian Federation flag have relatively good records when it comes to detentions, while bulk carriers and chemical carriers are subject to more detentions. Finally, all recognised organisations have good records compared

Table 7
Decomposition analysis of the factors contributing to detentions.

Variables	All		Inspecting authority			
			Australia		Other countries	
	%	Rank	%	Rank	%	Rank
Age at PSC inspection	40.4	1	64.2	1	42.5	1
Inspecting Authority	16.6	3	–	–	–	–
Flag of registry	4.2	5	3.5	4	6.2	4
Type of ship	5.9	4	6.3	3	8.1	3
Recognised organization	31.1	2	25.1	2	39.1	2
Year of inspection	1.8	6	1.0	5	4.1	5
Total	100		100		100	

Source: Indian MoU (2007).

Table 8
Econometric analysis of detention, by inspecting authority.

Variables		Inspecting authority		Decomposition	
		Australia marginal effects	Other countries marginal effects	Endowments (Total: 5.58%)	Coefficients (Total: −0.59%)
Constant					11.28%
Age at PSC inspection	0–4	Ref.	Ref.	Ref.	Ref.
	5–9	1.7**	5.5***	−0.19%	0.14%
	10–14	5.7***	14.0***	−0.34%	0.16%
	15–19	10.2***	16.8***	−0.17%	−0.18%
	20–24	12.0***	21.1***	0.84%	0.22%
	25+	14.8***	26.4***	3.19%	0.26%
Flag of registry	Panama	0.8*	0.7	−0.14%	0.17%
	Liberia	0. 7	−0.4***	0.03%	−0.30%
	Hong Kong, China	−1.3*	−2.7*	0.11%	−0.09%
	Bahamas	−0. 3	−3.0***	0.05%	−0.18%
	Cyprus	2.5***	−2.8***	−0.02%	−0.33%
	Singapore	1.2	0.1	0.00%	−0.05%
	Russian Federation	−1.4	−6.6***	−1.37%	−0.07%
	Malta	0.9	−3.7***	−0.17%	−0.24%
	Greece	−0.6	−4.5***	0.06%	−0.12%
	Others	Ref.	Ref.	Ref.	Ref.
Type of ship	Bulk carrier	3.3***	−0.4	0.06%	−2.38%
	General cargo/multi-purpose ship	5.0***	2.2**	0.99%	−0.06%
	Oil tanker	−0.0	1.7	0.17%	0.13%
	Containership	2.5***	−1.7	0.02%	−0.37%
	Chemical tanker	4.2***	+0.6***	0.06%	0.05%
	Refrigerated cargo carrier	7.0**	−3.4**	−0.08%	−0.05%
	Ro-ro cargo ship	0.3	−1.9	−0.03%	−0.01%
	Gas carrier	−0.9	−5.3*	0.07%	−0.10%
	Others	Ref.	Ref.	Ref.	Ref.
Recognised organization	Nippon Kaiji Kyokai	−2.9***	−6.3***	3.16%	−5.27%
	Lloyd's Register	−1.5**	−5.5***	0.16%	−2.29%
	Det Norske Veritas	−2.0***	−6.2***	0.42%	−1.71%
	American Bureau of Shipping	−1.1	−4.7***	0.19%	−1.29%
	Germanischer Lloyd	−0.0	−4.7***	−0.42%	−1.03%
	Bureau Veritas	−0.5	−4.0***	−0.14%	−1.00%
	Russian Maritime Register	2.9	−2.8***	−1.17%	−0.10%
	China Classification Society	−3.8***	−5.6***	0.09%	−0.51%
	Korean Register of Shipping	−3.3***	−4.1***	0.39%	−0.42%
	Others	Ref.	Ref.	Ref.	Ref.
Number of observations		15017	11498	Total difference	
Log likelihood		−2961.2	−3158.8	5.00%	

Source: Indian MoU (2007).
Marginal effects from Probit models. Significance levels are, respectively, 1% (***), 5% (**) and 10% (*). Standard errors are corrected for clustering at the vessel level.

to the other category, a conclusion particularly true for China Classification Society and Korean Register of Shipping.

In column 2 of Table 6, the number of deficiencies recorded during the previous inspection was taken into consideration and estimates stress a positive effect as expected. The type of deficiencies was then included (column 3, Table 6). Estimations suggest that deficiencies related to management, safety and fire appliances and certificates are important contributors to detentions (as shown by their marginal effects). This later result is consistent with results from Knapp and Franses [3] that underline these last two elements (safety and fire appliances and certificates) as the first two contributors to the probability of detention.

A final decomposition analysis was done to estimate the contribution of the explanatory variables to detentions.[16] As shown in Table 7, the first factor to explain the probability for a vessel to be detained is the age at inspection (40.4%) followed by the recognised organization (31.1%), the inspecting authority (16.6%) and the type of ship (5.5%).

Age at inspection is by far the first factor to explain detentions records in Australia (see Table 7). This single factor explains 64.2% of the detention outcome and is a result in line with the AMSA study (see Appendix B). Another major factor when explaining detentions is the recognised organisation (39.1% for other countries, but 25.1% for Australia). Furthermore, it seems that the split done by AMSA between bulk carriers (60% of vessels calling at Australian ports) and other types of ships would make sense as different target factors should apply to the various types of vessels. Finally, the recognised organisation and the flag of registry matter less to understand the probability of detention.

To summarize, it appears that the relative importance of the various covariates to explain the number of deficiencies (Table 5) and the probability to be detained (Table 7) are of similar magnitude. Another expected finding is that the age of the vessel plays a very important role, and that the inspecting authority might also be an influential element. The importance of this last covariate is investigated further in the next section.

5. Estimation results on the effect of inspecting authorities

That the inspecting authority plays a role in understanding both the number of deficiencies detected during an inspection and the probability for a vessel to be detained is striking from a policy viewpoint. Since PSC regimes aim at setting uniform or harmonized standards and procedures worldwide, this result is often used by shipowners to question the fairness of PSC inspections. This question was partially tackled by Knapp and Franses [3], who identified the background of inspectors (engineer, nautical, naval architect or radio) as an element explaining the type of deficiencies detected.

This section tries to understand differences that can be found at a country level on detentions. For that purpose, results for the Australian authority (56.6% of the inspections) are compared with records for other inspecting authorities (43.4%). Let C be a country specific dummy, such that C=1 when the inspection is made in Australia and C=0 in the other cases. A first Probit regression on the pooled sample (which includes all authorities) was estimated and introduce a specific-country variable C. According to estimates (not reported here), the coefficient for C is positive and significant at the 5% level, meaning that the probability for a ship to be detained is higher in Australia.

[16] Again, the procedure described in Fields [8] is applied and relies on an OLS model to explain the probability for a vessel to be detained. Estimates from OLS and Probit regressions are very similar.

This result may be explained either by differences in the observables characteristics of the inspected vessels (for instance ships inspected in Australia are in relatively poor conditions) or by differences in the returns to these characteristics (for instance Australian authorities attach more weight to the vessel's age and are more severe with older ships). To compare $\Pr(DET_{i,C=1})$ and $\Pr(DET_{i,C=0})$, the dependent variable being discrete, the method described in Yun [9] which allows to decompose difference in the first moment instead of the traditional Oaxaca–Blinder decomposition applicable for continuous variables was used [10].

Let $\Pr(DET_{i,C=1})=\Phi(Z_{i,C=1}\delta_1)$ and $\Pr(DET_{i,C=0})=\Phi(Z_{i,C=0}\delta_0)$, where $Z_{i,C=1}$ and $Z_{i,C=0}$ are exogenous covariates excluding the inspecting authority, and δ_1 and δ_0 are the vectors of coefficients to estimate. It follows that:

$$\bar{P}_{C=1} - \bar{P}_{C=0} = [\bar{\Phi}(Z_{i,C=1}\delta_1) - \bar{\Phi}(Z_{i,C=1}\delta_1)] + [\bar{\Phi}(Z_{i,C=1}\delta_0) - \bar{\Phi}(Z_{i,C=0}\delta_0)] \quad (4)$$

where $\bar{P}_{C=1}$ and $\bar{P}_{C=0}$ are the mean probabilities of being detained when the inspection occurs respectively in Australia and in other countries. The first term in brackets in (4) measures differences in the impact of the explanatory variables, while the second term in brackets sheds light on differences in vessels' characteristics. A fictitious group of vessels with the same characteristics of vessels inspected in Australia was built, i.e. $Z_{i,C=1}$, for which the effects of the covariates are those of vessels inspected in other countries, i.e. δ_0. The marginal effect estimates[17] of specific-authority Probit regressions are reported in Table 8.

It appears that age at inspection has a similar impact on the probability of detention in both groups of countries, although the marginal effects are slightly higher in Australia. Significant differences for flag of registry exist. Vessels from Cyprus are more likely to be detained in Australia, while the reverse pattern holds for the other inspecting authorities. In the latter group, vessels from Liberia, Bahamas, Russia, Malta or Greece have a lower probability of detention. Interestingly, estimates on the flag of registry in Australia confirm the findings in the study by AMSA that points out the flag of registry as not being particularly significant in explaining detentions (with a ranking of 3 on the 1–4 scale of importance—see Appendix B).

An inverse conclusion can be reached for the type of vessels. This factor is not significant when it comes to other countries (only chemical carriers are significant at 1%), while the results are more convincing for the Australian subsample. Finally, the recognised organisation appears to produce significant results for all vessels calling at other countries, while this factor might not be as representative for vessels calling at Australian ports. As a reminder, the recognised organisation was ranked in the 3 out of 4 categories for bulk carriers and 4 out of 4 for other types of vessels in the study from AMSA.

An analysis of the differences in the probability of detention between the two groups of inspecting authorities was then done. At the mean of the sample, the difference in probability amounts to five points of percentage. In fact, it appears that the gap essentially stems from the fact that vessels inspected in the two geographic areas have different characteristics. If vessels inspected by Australian and other authorities were similar, then the difference in probability would be reduced by 5.58% points. The role associated to differences in the impact of these characteristics is very limited in comparison (−0.59%).

A detailed decomposition was done to estimate the contribution of each individual variable to these differences in endowments and in coefficients. As shown in Table 8, one of the main

[17] Initial detailed results with coefficients and t-values are available from the authors upon requests.

differences is related to the older age at inspection (more than 25 years). If there were the same proportion of older vessels inspected by the two groups of authorities, then the total difference in probability of detention would be reduced by 3.19 points of percentage. While flag of registry and type of ship have little impact, another difference is coming from the recognised organisation. The proportion of vessels registered under Nippon Kaiji Kyokai is 37.5% in Australia and 20.1% in other countries but its negative marginal effect is much more important in the latter group than in the former. If the proportions of vessels under this registry calling in other countries were similar, our results suggest the difference in probability of detention would be reduced.

6. Conclusion

This paper aims at investigating two issues, i.e., the weight that should be given to factors within the target systems and the role the inspecting authority plays in explaining differences in detention rates.

On the first issue, it appears that most findings do not contradict the current targeting factors used by most of MoU or individual states. For instance, the age of vessel at inspection, records from previous inspections, the classification society, and type of vessel proved to be significant factors in predicting the number of deficiencies detected or the probability for a vessel to be detained. Furthermore, in line with the study of AMSA, the analysis on the contribution of the various factors to detentions also stresses the major role played by the age of the vessel at inspection. Finally, the results shows that the weight of the different factors changes according to the kind of deficiencies considered. On that last element, the findings could be quite relevant for "inspection campaigns" aiming at targeting specific types of deficiencies.

On the second element, an interesting finding was to point out the inspecting authority as an important factor to explain detentions. Keeping in mind that one of the objectives of PSC regimes is to apply uniform standards across various states, this conclusion stating that most of differences stem from the characteristics of vessels calling rather than from different degrees of severity from inspecting authorities is in that sense a positive result.

Finally, a main issue concerning more specifically the Indian MoU region is the adoption of a more elaborate and harmonised targeting system instead of the current list of criteria to consider.[18] It might do well to take the cue from recent developments within the Paris MoU that led its Secretariat to propose a New Inspection Regime system to increase the proportion of vessels controlled within the region. With multiple inspections at a regional level, the fact that each inspecting authority within the Indian MoU uses its own criteria might be counterproductive.

Appendix A

See Table A1.

[18] The objective sets by the Indian MoU secretariat is for each authority to achieve a target inspection rate of 10% of the estimated number of individual foreign vessels entering ports under their national jurisdiction during the previous calendar year.

Table A1

Paris MoU(1) Target factor Signed in 1982 Belgium, Bulgaria, Canada, Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Latvia, Lithuania, Malta Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovenia, Spain, Sweden, United Kingdom Number of inspections: 25% of vessel entering for each individual states Total target factor=generic factor (GF)+historical factor (HF) If TF > 50 points then the control is mandatory The overall target factor is calculated at the end of each day. GF—flag. If detention during last 3 years is • More than 10% then TF=+4 • More than 13% then TF=+8 • More than 16% then TF=+14 • More than 18% then TF=+20
GF—vessel type. TF=+5 • for bulk carrier > 12 years old • for gas carriers > 10 years old • for Chemical carriers > 10 years old • for oil tanker GT > 3000 & > 15 years old • Passenger ship/ro-ro ferry > 15 years old (2)
GF—non-EU RO. If non-EU recognised classification society then TF=+3 GF=age • 25 years old then TF=+3 • 21–24 years old then TF=+2 • 13–20 years old then TF=+1
GF=flag state. TF=+1 if Flag has not ratified main conventions GF=targeted class. Class with a 3-year average record of detentions above the average class detention value. A classification society with class related deficiencies in the last 3 years exceeds the average class detention rate by: • 0% then TF=0 • 0–2% then TF=+1 • 2–4% then TF=+2 • > 4% then TF=+3
HF—new. If entering a region port for the first time in the last 12 months then TF=+20 HF—inspected. If not inspected in the last 6 months then TF=+10 HF—detained. If detained in the previous 12 months then TF=+15 • HF—Deficiencies • If last control 0 then TF=−15 • If last control 1–5 then TF=0 • If last control 6–10 then TF=+5 • If last control 11–20 then TF=+10 • If last control 21+ then TF=+15
HF—outstanding deficiencies For latest inspection if action taken "rectify deficiency at next port" or "Master instructed to rectify deficiency before departure" and for every two listed action taken "rectify deficiency within 14 days" and/or other" then TF=+1 For latest inspection in case "all deficiencies rectified" then TF=−2

(1) Does not consider the new inspection regime that should replace the current system.
(2) Other than ro-ro ferries and HS passenger craft operating in regular service under the provision of Council Dir. 1999/35/EC.

Appendix B. Australian maritime safety authority target factors (based on data from 2001 to 2005)

See Table B1.

Table B1

	Bulk carriers (17 520 observations)	Other ships[a] (11 658 observations)
Age of ship	1	1
Number of deficiencies at the previous inspection	2	3
Time since previous inspection	2	3

Table B1. (*continued*)

Recognised organisation	3	4
Flag	3	3
Ship is undergoing first inspection	4	4
Type of ship	–	2
Gross tonnage	–	2

Source: AMSA (2007).

[a] Passengers ships were excluded due to their specific regime.

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