Marine Policy 60 (2015) 27–39

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Identifying substandard vessels through Port State Control inspections: A new methodology for Concentrated Inspection Campaigns

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ARTICLE INFO

Article history:
Received 21 January 2015
Received in revised form
22 May 2015
Accepted 22 May 2015
Available online 6 June 2015

Keywords:
Maritime safety
Port State Control
Target factor analysis
Quantiles for counts

ABSTRACT

Substandard vessels that fail to comply with international maritime regulations are the target of Port State Control inspections. Despite their significant costs, many inspections do not lead to any detentions and, in a significant number of cases, no deficiencies are detected. In this paper, quantile regressions for count data are used to estimate the likelihood of having a high number of deficiencies of a specific type. The purpose is to complement existing practices focusing on detention with the objective to improve the selection process. Similar factors influence the likelihood of having a vessel detained and that of having a vessel recording a high number of deficiencies. However, quantile regressions applied to the number of deficiencies help improving the identification of factors influencing the likelihood of finding some specific types of deficiencies, which is the focus of Concentrated Inspection Campaigns. The paper concludes that the selection process for such campaigns should be improved using this new methodology.

1. Introduction

Accidents involving maritime vessels can lead to considerable losses borne by both the shipping industry and society [1]. After a series of oil tanker accidents in the 1970s, coastal states decided to group themselves into 10 regional Port State Controls (PSCs hereafter) and signed various memorandums of understanding (MoUs) to conduct safety inspections on foreign-flagged vessels entering their ports [2]. The purpose underlying such agreements was to complement flag state controls that ensure conformity of vessels flying their flags.

PSC inspections have since then played a major role in the improvement of maritime safety. As regards the shipping industry, Knapp et al. [3] estimate cost savings linked to incident management achieved through PSCs from US$ 74,000 to 193,000 per inspection from 2002 to 2007. The authors also assess the average cost per inspection in 2009 at US$ 1240–1540 in Australia and the United States, where 3127 and 9909 inspections were carried out, respectively, in the same year [4]. Coupled with the low number of inspectors devoted to maritime safety, these costs demand careful choices of vessels to be inspected.

These choices are reflected within targeting systems, which vary from one country to another. Nonetheless, they all derive from a statistical analysis of the likelihood of having a vessel detained. In this paper, quantile regressions for count data are applied to the total number of deficiencies detected during a PSC inspection. Introduced by Koenker and Bassett [5], quantile regressions aim at estimating specific quantiles of a dependent variable, whereas the focus of least square regressions is on the conditional mean given values of explanatory variables. The quantile regression model is especially relevant to the estimation of the number of deficiencies since the purpose of PSCs is to target the highest-risk vessels which are those in the poorest condition. This approach is useful for Concentrated Inspection Campaigns (CICs hereafter) that target specific types of deficiencies.

The rationale is twofold. First, identifying substandard vessels for CICs using the same targeting factors than those applied for detention might be too restrictive as detained vessels only represent 5–10% of all vessels inspected whereas vessels with deficiencies cover up to 65% of all inspections [4]. Second, investigating the average number of deficiencies using Ordinary Least Squares regressions as done in the previous literature might be too restrictive as a hierarchy exists amongst vessels according to the number of deficiencies identified. The use of quantile regressions [6] will be helpful to study those vessels located in the upper part of the distribution of deficiencies, which is expected to improve the selection process of the highest-risk vessels.

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http://dx.doi.org/10.1016/j.marpol.2015.05.013
0308-597X/

Specifically, our paper investigates two issues: first, the question whether targeting factors could be similar when focusing on the likelihood of having a vessel detained and when concentrating on the probability of having a large number of deficiencies; second, the question whether criteria to be considered may be similar when focusing on different types of deficiencies and on different percentiles of the distribution of deficiencies using the quantile regression framework.

The remainder of the paper is organized as follows. In Section 2 provides a review of PSC target factors used to identify vessels to be inspected by relevant authorities. In Section 3, the two main models employed to identify such target factors, i.e. Probit and count data models are presented. In Section 4, three types of regressions are applied to a unique PSC data set. Section 5 relies on quantile regression models to analyze the various types of deficiencies, and stresses how this new method may improve the selection of vessels to be submitted to CICs. Finally, conclusion and policy recommendations are presented in Section 6.

2. Literature review

The inspecting authorities rely on many factors when selecting vessels eligible for a PSC inspection [7–17]. These factors are set to target substandard vessels, defined as vessels that represent hazards to safety, health, or the environment, and which may therefore be subject to detention.

For instance, since January 2011, the 27 maritime administrations that have signed the Paris PSC MoU have considered ten criteria to rank vessels as low, medium, or high risk vessels[2]: vessel type (6 types), age (more or less than 12 years old), flag performance (appearance on black/gray/white lists), absence/existence of previous auditions by the International Maritime Organization, recognized organization (RO) performance,[3] recognition or non-recognition of the RO by at least one of the member States of the Paris MoU, ISM (International Safety Management) company performance, inspection or non-inspection within the last 36 months, number of deficiencies detected (higher or lower than five), and number of past detentions. The specific weights assigned to each of these criteria are mainly based on professional expertize.

Since 2001, the Australian Maritime Safety Administration has proposed a more scientific approach. To identify appropriate target factors, Australia's CSIRO Mathematical and Information Sciences Unit [18] undertook a detailed analysis of inspection records over six years (approximately 18,000 inspections). The main conclusion was that the age of a ship was by far the most important factor in predicting ship quality. Ship type, ship inspection history and, in some cases, ship size also appeared to have a significant influence. A follow-up study conducted in 2006 led AMSA to set guidelines for inspectors to scrutinize at least 80% of foreign vessels calling in Australia that were older than 15 years (high risk ships), 60% of those between ten and fourteen years, 40% of those between five and nine years, and 25% of those under five years old.

Though it is not the unique factor, the importance of age has been confirmed by Cariou et al. [7,10] from a dataset of inspections carried out respectively by the Swedish Maritime Administration and by the maritime administrations which are part of the Indian Ocean MoU. For instance, using a sample of 26,515 PSC inspections carried out from 2002 to 2006 by the 19 members of the Indian Ocean MoU's members and relying on variance decomposition techniques, Cariou et al. [10] concluded that 42.5% of the variation in the number of deficiencies detected could be explained by age. The three main other significant contributors were, in decreasing order of importance: the place of the inspection (30.8%), the vessel's recognized organization (14.5%) and the ship type (7.5%). Cariou and Wolff [11] found high consistency over time in the number of deficiencies found in a vessel, and therefore called for increasing the weight granted to historical factors. They also identified opportunistic behaviors among ship owners: vessels detained or with many deficiencies seemed more likely to change their flag of registry or classification society in order to avoid future inspections.

In their study on signatories to the Paris MoU, Knapp and van de Velden [19] highlighted differences across the various PSC regimes, and notably a greater focus of Paris MoU members on deficiencies related to stability and structure or safety, whereas the Australian Maritime Safety Administration (AMSA) insists more on radio communication-related deficiencies. Finally, in an analysis of 42,071 PSC inspections conducted within the Indian Ocean MoU, Cariou and Wolff [12] reported higher detention rates in India or Iran compared to Australia after controlling for differences in vessel characteristics.

Usually, targeting factors are identified based on two outcomes: either the likelihood of having a vessel being detained, or that of having a vessel with a high number of deficiencies recorded. There is a limitation in focusing on detentions though, since this prism does not take into account the information on the many vessels with deficiencies which are not detained. Besides, studies focusing solely on the number of deficiencies recorded are also problematic since they investigate the role played by the characteristics of the vessels on the average number of deficiencies, but the distribution of these deficiencies is skewed to the right given that most of them are concentrated on a limited number of vessels. In order to overcome these shortcomings, next section proposes a methodology to combine both approaches.

3. Empirical methodology

The first standard approach to identify target factors is based on discrete choice models through a Probit regression explaining the probability of detention. It considers a dichotomous variable related to the detention outcome so that $D_i=1$ when a vessel is detained and $D_i=0$ otherwise. D_i^* is defined as an unobserved latent variable associated to detention and is expressed in the following linear way:

$$D_i^* = X_i\gamma + \omega_i \tag{1}$$

with X_i the vessel's characteristics, γ the associated parameters to be estimated, and ω_i a random perturbation supposed to be normally distributed. Although the latent outcome D_i^* cannot be observed, information is available on its counterpart D_i with $D_i=1$ when $D_i^*>0$ and $D_i=0$ otherwise. The probability $\Pr(D_i=1)$ is:

$$\Pr(D_i = 1) = \Phi(X_i\gamma) \tag{2}$$

with $\Phi(.)$ the cumulative distribution function of the univariate normal distribution, corresponding to a standard Probit model.

The second standard model is based on count data models applied to the number of deficiencies. The dependent variable of interest is a non-negative integer [20]. Let Y be the number of deficiencies and X represents a vector of explanatory variables.

[2] Please consult: http://www.parismou.org/.

[3] Such classification societies (non-governmental organizations) develop technical standards (e.g. for ship construction rules), approve designs, conduct surveys during the construction of a vessel, issue certificates, and endorse a vessel's classification certificate for periodic surveys. Their role might be extended when a country delegates responsibility for statutory surveys and related activities, on behalf of flag State administrations. When acting in such capacity, a classification society is a "recognized organization" or RO.