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Analysis of the Maritime Safety Regime:

"Risk Improvement Possibilities for the Port State Control Target Factor"

(Paris MoU)

by

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Note from the Author:

The author would like to point out to the reader that the thesis and the conclusions have been seen and read by members of the Secretariat of the Paris Memorandum of Understanding (MoU) but not yet, in its full extend, by the MoU Advisory Board (MAB) or the Port State Control Committee.

Endorsement of the text and agreement with the conclusions from the Paris Memorandum of Understanding point of view can only be done by the Advisory Board and the Port State Control Committee.

The conclusions are therefore the sole responsibility of the author.

Dedicated to:

Robert Zambreno

"In respectful memory to a great person and friend"

Rotterdam, 25th August 2004

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Abstract

The prime scope of this thesis, besides giving an overall analysis of the maritime safety regime, is to deliver the scientific proof that the target factor used by the Paris Memorandum of Understanding (Paris MoU) can be improved by incorporating weight factors for deficiency codes. The author uses quantitative methods based on 76,248 individual port state control inspections for the time period May 2000 to May 2004 in conjunction with data from Lloyd's Register Fairplay, interviews and port state control inspections.

Linear regression and correspondence analysis confirm the general expectations of the relationships between the variables. Ships owned or managed by traditional maritime nations and flagged with reputable flags perform better compared to vessels that are owned or managed by countries from new open registries or new emerging maritime nations. This reflects the level of "safety culture" and associated human factor which is believed to be essential for safety since most accidents are caused due to human error. In addition, the analysis proves that there are differences in performance amongst the classification societies.

Binary Logistic Regression is used to calculate associated probabilities of detention. The analysis provides scientific proof that the type of deficiency matters and by assigning the deficiency categories a certain weight factor, the target factor in selecting substandard ships for inspections can be improved by 2%. The analysis further shows that the probability of detention is based on the total combination of all variables (classification society, flag state, ship's age and ship's size) besides the number and types of deficiencies. In addition, the inclusion of a factor capturing the ownership and management of a vessel can further improve the target factor since it can reflect the quality of the safety culture onboard including the human factor. Using the associated probabilities of detention, risk profiles for ship types can be created and used to be the base of a revised target factor. The analysis further shows that there are differences in the probabilities of detention across the port states. This reflects the different emphasis of the port states on deficiency codes based on ship type and flag. Finally, the analysis visually demonstrates differences in the probabilities of detention of class related deficiencies based on a variation of the classification societies.

Port state control can only been seen as the last resource to catch substandard ships which create a bad image and provide unfair competitive advantages for prudent ship owners. The problem should not be left with port state control but tackled at the source of it – the enforcement of plentiful legislation amongst flag states. The system should not punish good ship owners in an effort to eliminate substandard ships but should allow the industry to come up with commercial solutions to increase the pressure on non-performing flag states and non-prudent ship owners.

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List of Abbreviations

ABS	*American Bureau of Shipping (USA)*
ANOVA	*Analysis of Variance*
BV	*Bureau Veritas (France)*
CBT	*Clean Ballast Tanks*
CCS	*China Classification Society (China)*
CL	*Classification Society*
COLREG	*Convention on the International Regulations for Preventing Collisions at Sea*
COW	*Crude Oil Washing*
CSR	*Continuous Synopsis Record*
DNV	*Det Norske Veritas (Norway)*
DWT	*Deadweight*
EC	*European Community*
EMSA	*European Maritime Safety Agency*
EPIRB	*Emergency position indicating radio beacons*
EU	*European Union*
FS	*Flag State*
FS	*Flag States*
GL	*Germanischer Lloyd (Germany)*
GMDSS	*Global Maritime Distress and Safety System*
GT	*Gross Tonnage*
HL	*Hellenic Register of Shipping (Greece)*
IACS	*International Association of Classification Societies*
IBC Code	*International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk*
ILO	*International Labor Organization*
IMO	*International Maritime Organization*
INTERCARGO	*International Association of Dry Cargo Shipowners*
INTERTANKO	*International Association of Tanker Owner*
ISM Code	*International Safety Management Code*
ISPS	*International Ship and Port Facility Security Code*
ITOPF	*International Tankers Owners Pollution Federation*
KR	*Korean Register of Shipping (South Korea)*
LI	*Legal Instrument*
LN	*Natural logarithm*
LR	*Lloyds Register (UK)*
MARPOL	*International Convention for the Prevention of Pollution from Ships*
ML	*Maximum likelihood*
MoU	*Memorandum of Understanding*
NK	*Nippon Kaiji Kyokai (Japan)*
OBO	*Combination Carrier*
OECD	*Organization for Economic Co-operation and Development*
OLS	*Ordinary Least Squares*
OWN	*Ship's Owner*
PS	*Port State*
RINA	*Registro Italiano Navale (Italy*

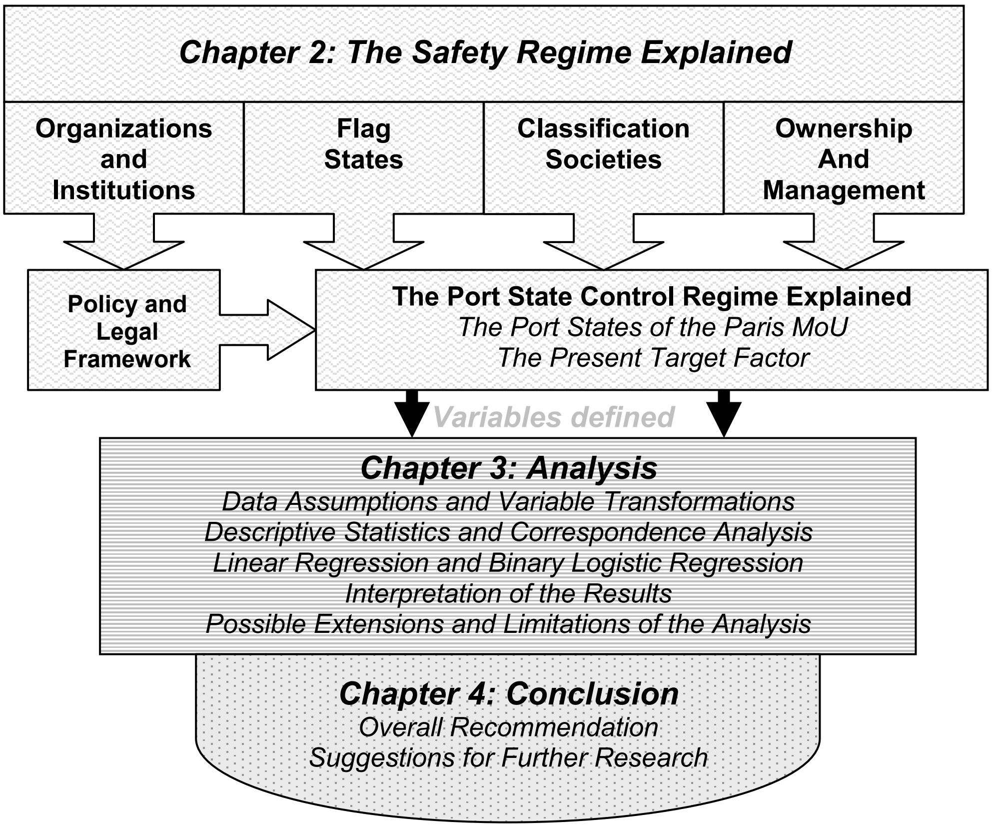
RINAVE	*Registro Internacional Naval (Portugal)*
RMSPE	*Root mean square prediction error*
RoRo	*Roll On – Roll Off*
RS	*Russian Maritime Register of Shipping (Russia)*
SART	*Search and rescue transponders*
SBT	*Segregated Ballast Tanks*
SIReNAC	*Central information system for port state inspection records*
SOLAS	*International Convention for the Safety of Life at Sea*
SPSS	*Statistical Software used by the author for the regression*
ST	*Ship Type*
STCW	*International Convention on Standards of Training, Certification and Watch keeping for Seafarers*
TONNAGE	*International Convention on Tonnage Measurement of Ships*
UN	*United Nations*
UNCLOS	*United Nations Convention on the Law of the Sea*
UNCTAD	*United Nations Conference on Trade and Development*
WLS	*Weighted least squares*

Chapter 1: Research Question and Methodology

Due to the international nature of the maritime industry and despite the fact that it operates under a heavy legal framework, maritime legislation is based on international law and enforcement is therefore sometimes restricted to the principle of reciprocity[1].

The scope of this thesis is based on safety aspects of the maritime industry, in particular, the port state control system of the Paris Memorandum of Understanding (Paris MoU) and the European Union. In essence, this thesis is trying to find an answer to the following research question: *Can the target factor of the Paris Memorandum of Understanding be improved?* In addition, the author tries to incorporate the European Union perspective on maritime safety. The structure of this thesis is visualized in Figure 1 below.

Figure 1: Structure of the Thesis



The author uses several quantitative methods, interviews, port state control inspections and some literature review as methods for this thesis.

The Paris MoU is an administrative agreement between various maritime authorities primarily located in Europe which was adopted in 1982 and its prime objective is to ensure enforcement of IMO (International Maritime Organization) and ILO (International Labor Organization) conventions. The Paris MoU uses an

[1] In international law, reciprocity means the right to equality and mutual respect between states.

internal target factor comprising of various variables including deficiencies in order to target a particular ship for a port state control inspection. A deficiency is a violation against a certain legal instrument. Data of port state control inspections including 25 main deficiency codes for the time period May 2000 to May 2004 constitute the basis for the quantitative part of the analysis. Besides the Paris MoU, a number of other port state control regimes around the world have been emerged due to the success of the latter and acting as a model regime. Appendix 1 provides a map of those regimes for further reference.

In a broader sense, the analysis is looking at a risk factor approach for the target factor in order to see if the decision of inspecting a ship can be further improved by enhancing the likelihood of selecting sub-standard ships versus non sub-standard ships for a port state control inspection. In addition, the present safety regime in the European Union from a legal and political aspect is analyzed and suggestions to improve the system are made. Incorporating the EU into this equation makes the system more complex since international law is transferred into EU law (either by directive[2] or regulation[3]) and due to the supremacy of EU law becomes binding for all EU member states under the jurisdiction of the European Court of Justice.

Chapter 2 gives an explanation of the safety regime in general and explains the reason for the existence of port state control as a safety net to eliminate substandard ships. The chapter will identify the variables that are relevant for the analysis. It is therefore important to understand the organizations and institutions that create the legal framework as well as the legal instruments themselves and how the various players interact. The port state control regime is by its nature an enforcement regime with a certain amount of political aspects. In addition, a short introduction to the concept of flag states and classification societies should make it easier for the reader to comprehend how flag states and classification societies relate to safety aspects of ships. The chapter ends with a detailed explanation of the port state control regime in the EU and explains the current target factor of the Paris MoU.

Chapter 3 contains the actual analysis based on port state control inspection data which has been merged with data from Lloyds Register Fairplay. The data assumptions and variable transformations are explained to facilitate understanding the overall methodology of the regression models. Descriptive statistics and correspondence analysis aims at providing a better insight into the relationships and facilitate the interpretation of the regression models. The findings of the models are interpreted and visualized for better understanding. The chapter concludes with an explanation of possible extensions and limitations to the analysis.

Chapter 4 provides the overall conclusion of the thesis and its major findings. In addition, some suggestions for future research in the area of safety are given and the author makes some suggestions on how the regime could be improved.

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[2] EU directives have to be transferred into national law within a certain time frame and/or can become *directly applicable* after the time frame has passed and if it matches certain criteria.
[3] EU regulations enter into force when they are enacted and do not need to be transferred into national law but are *directly applicable* and supreme to national legislation.

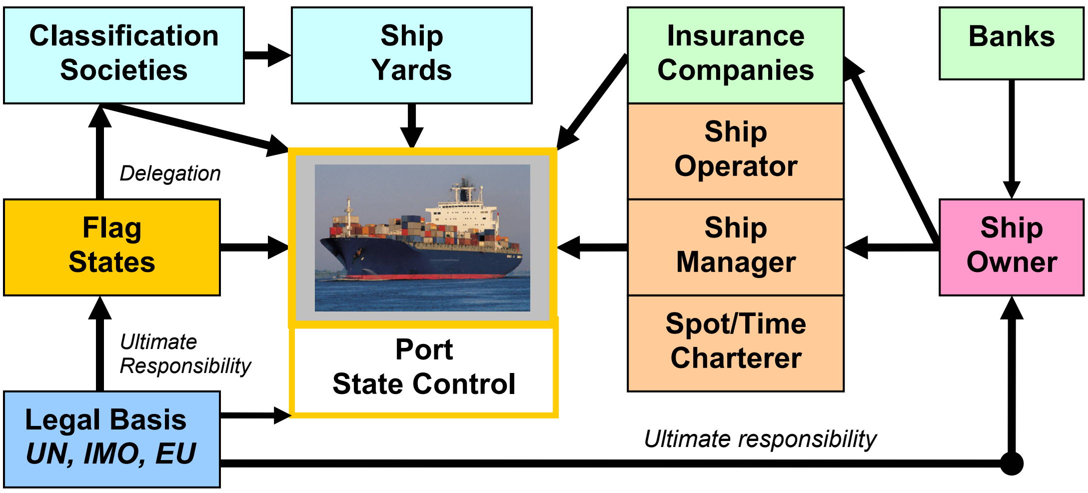
Chapter 2: The Safety Regime Explained

The following chapter will explain the present safety regime, its legal base and political perspectives and will show why port state control is a necessary part of the safety net. It will further highlight the interaction between the various players which are used as the variables in the analysis in chapter three. The chapter ends with a detailed explanation of the port state control system in the EU and the target factor of the Paris MoU.

2.1. The Need for Port State Control

Figure 2 provides a simplified version of the players of the safety regime. Those players are the organizations creating the legal framework (UN, ILO, IMO, EU)[4], the classification societies, the flag states, the port states (enforcing the port state control) and the ship owner/operator/manager. Other players that are also part of the system but are not included in this analysis in detail are the shipbuilders, the insurance companies and the financial institutions.

Figure 2: The Players of the Safety Regime



The ship owner has the ultimate responsibility in complying with the legal basis and the flag state has the ultimate responsibility in enforcing it. However, the line between the actual ship owner, operator or technical manager of the vessel is not completely clear in shipping and therefore complicates enforcement of the legal instruments. In an effort to gain some insight into the relationships, data from Fairplay's "World Shipping Encyclopedia" (March and April 2004) was merged with the data from the Paris MoU and included in the analysis.

Flag states can delegate parts of their responsibility to classification societies since some flag states do not have the technical and administrative capabilities to comply with their obligations. The reason of the existence of the port state control regime derives from the fact that a certain percentage of ship owners and flag states use the legal "loophole" created by the international legal framework

[4] UN: United Nations, IMO: Intern. Maritime Organization, ILO: Intern. Labor Organization, EU: European Union

and try to save costs by operating below the minimum safety standards. This can cause accidents and damage to the environment, the cargo and human lives. According to the OECD the percentage of sub-standard ships in the world commercial fleet lies between 10-15%[5]. Port State control can be seen as a last resource of safety to eliminate substandard ships from the seas.

According to the UN Conference on Environment and Development[6], maritime transport and dumping at sea contribute 20% of marine pollution and approximately 600 thousand tons of oil enters the oceans as a result of normal shipping operations, accidents and illegal discharges each year. Table 1 provides a summary of the major oil spills from 1979 to 2002. Statistics from the International Tankers Owners Pollution Federation however show that spills due to tanker accidents decreased since 1970[7] from an average of 25.2 spills to an average of 7.8 spills per year.

Table 1: List of Major Oil Spills, 1979-2002

Ship Name	Year	Location	Spill (tonnes)
Atlantic Empress	1979	Off Tobago, West Indies	287,000
ABT Summer	1991	700 nautical miles off Angola	260,000
Castillo de Bellver	1983	Off Saldanha Bay, South Africa	252,000
Amoco Cadiz	1978	Off Brittany, France	223,000
Haven	1991	Genoa, Italy	144,000
Odyssey	1988	700 nautical miles off Nova Scotia	132,000
Torrey Canyon	1967	Scilly Isles, UK	119,000
Sea Star	1972	Gulf of Oman	115,000
Irenes Serenade	1980	Navarino Bay, Greece	100,000
Urquiola	1976	La Coruna, Spain	100,000
Hawaiian Patriot	1977	300 nautical miles off Honolulu	95,000
Independenta	1979	Bosphorus, Turkey	95,000
Jakob Maersk	1975	Oporto, Portugal	88,000
Braer	1993	Shetland Islands, UK	85,000
Khark 5	1989	120 nm off Atlantic coast of Morocco	80,000
Prestige*	2002	Off the Spanish coast	77,000*)
Aegean Sea	1992	La Coruna, Spain	74,000
Sea Empress	1996	Milford Haven, UK	72,000
Katina P	1992	Off Maputo, Mozambique	72,000
Exxon Valdez	1989	Prince William Sound, Alaska, USA	37,000
Erika	1999	Off the coast of Brittany	20,000

*Source: International Tanker Owners Pollution Federation, *) amount of spill size estimated*

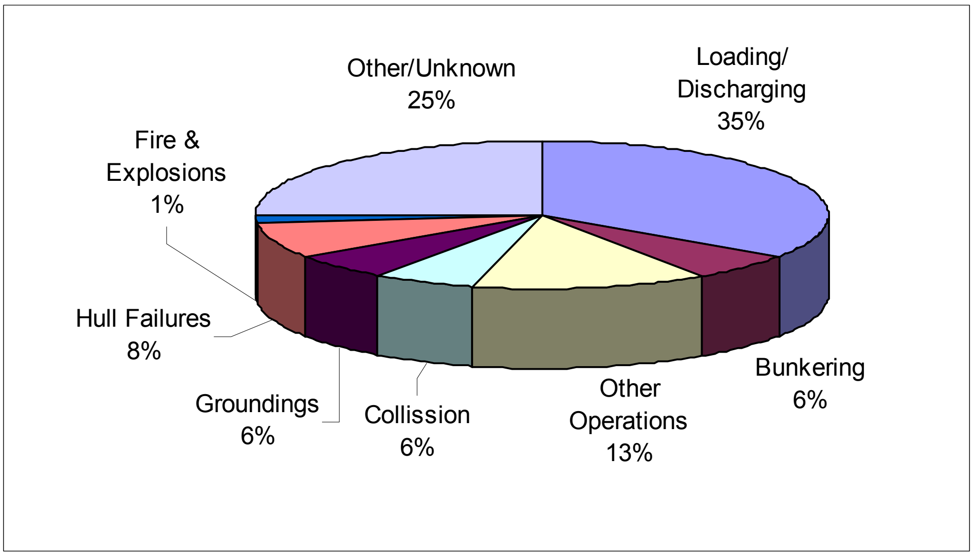
On the EU level, Appendix 2 provides two maps showing the major oil spills around Britain, Spain and France. This explains the interest of the EU in maritime safety due to political reasons since these areas show frequent oil spills which always enjoy great media coverage. New legislation can therefore be correlated to major accidents such as the Exxon Valdez (1989: oil pollution), the Estonia (1994: ferry accident, 852 lives lost), the Derbyshire (1980: bulk carrier

[5] Peijs, K. (2003). Ménage a trois. Speech at *Mare Forum* (November 2003: Amsterdam)
[6] Report of the United Nations Conference on Environment and Development, Rio de Janeiro, Brazil, 1992,www.un.org/esa/sustdev/documents/agenda21/english/agenda21chapter17.htm
[7] International Tanker Owners Pollution Federation (2004), Oil Tanker Spill Statistics, 2003

accident, 44 lives lost) and of course the Erika[8] (1999: oil tanker) and the Prestige (2002: oil tanker). The Erika accident provoked two major regulatory packages by the EU which will be explained later on in this thesis and the Prestige incident provoked an accelerated phasing out of single hull tankers in the EU. It is open to debate whether any additional legislation can actually improve the safety situation. The real problem within the maritime safety system is the enforcement of the existing legislation which is already burdensome and the system does not really provide any incentive for ship owners to comply.

Out of the total ship losses in the world, 94%[9] are more than 15 years old and more than half are general cargo ships, while bulk carriers account for about a quarter. The major causes of accidents at sea are related to human error – somehow 80%[10]. An exact figure is difficult to obtain due to the confidentiality of casualty data. Major causes of oil spills as reported by the International Tanker Owners Pollution Federation are shown in Figure 3 which confirms the theory of human error as most spills are caused by operational reasons such as loading and unloading or other operations and not from tanker accidents due to collision, groundings or hull failures.

Figure 3: Causes of Oil Spills, 1974-2003



Source: Data from the International Tanker Owners Pollution Federation

Some 25% of the causes of oil spills are unknown or due to other reasons. The dramatic spills caused by accidents are normally reported but there are other sources of pollution which should be taken into consideration. It remains however difficult to prosecute the offenders since in international waters, the offenders fall under the jurisdiction of the flag state and some flag states are reluctant of uncovering the actual ownership and are unwilling to start legal proceedings against a polluter.

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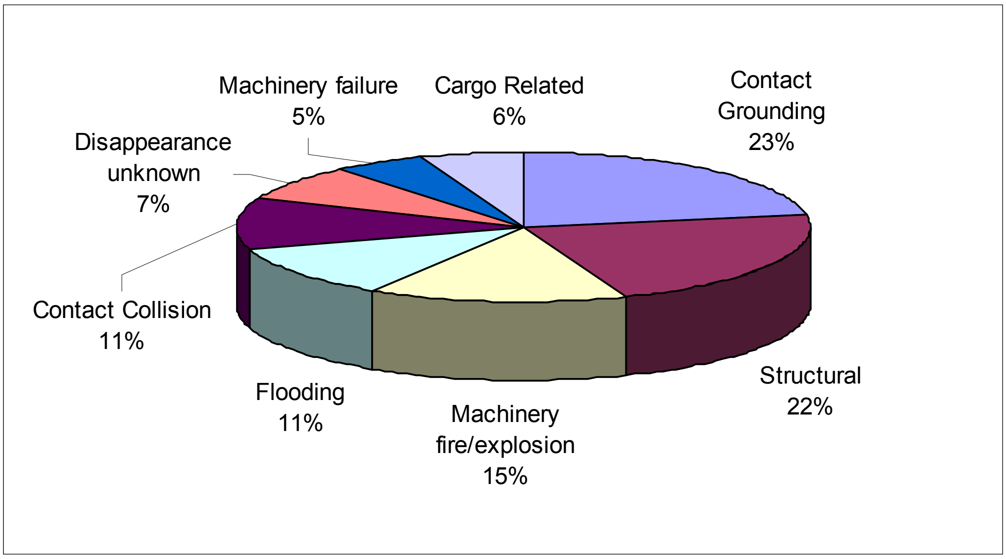
[8] oil tanker which broke apart of the coast of Brittany in 1999 and lost 20,000 t of heavy fuel oil
[9] European Maritime Safety Agency
[10] Niewpoort, G. (2002). The importance of strengthening flag state cooperation, Speech at *Mare Forum 2002*, (September 2002: Athens, Greece)

The American Bureau of Shipping reports that the overall tendency of total loss of tonnage is downwards over the last 10 years. The loss of tonnage in bulk carriers and general cargo ships is actually higher than with tankers but due to the nature of the cargo, bulk carriers do not get the same media coverage as the spectacular tanker accidents do. As for the causes for total losses as shown in Figure 4 and based on data from Intercargo[11], grounding and structural related reasons are dominant followed by machinery/fire explosion and flooding.

Figure 4: Major Cases of Total Losses, 1991-2000



Source: Data from Intercargo, 2001

It is not easy to obtain an accurate figure of the associated cost of maritime accidents. According to Hawkins (2001), an estimated of the total annual cost of vessel accidents lies in the area of USD 3.6 to USD 6 billion per year. According to the International Transport Federation, the estimated cost of the clean up of the Prestige incident alone was around USD 1 billion[12].

After this small overview of the magnitude of maritime casualties as introduction to maritime safety, the next chapter will explain how the safety regime on the international and EU level works and what variables are relevant for the actual analysis of the target factor for the port state control.

2.2. The Relevant Legal Instruments

There are two organizations responsible for the legal instruments in the area of maritime safety – the International Maritime Organization (IMO) and the International Labor Organization (ILO) which are both part of the United Nations (UN). The relevant IMO and ILO conventions for the evaluation of the target factor of the Paris MoU are explained in the subsequent paragraphs to come and are listed here below:[13]

[11] International Associations of Dry Cargo Ship Owners, www.intercargo.org
[12] International Transport Federation, www.itf.org.uk
[13] Paris Memorandum of Understanding on Port State Control, Section 2.1

1. International Convention on Load Lines, 1966 (plus the Protocol of 1988)
2. International Convention for the Safety of Life at Sea, 1974 (SOLAS 74) plus the Protocol of 1978 and the Protocol of 1988
3. International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78)
4. Protocol of 1992 to the International Convention on Civil Liability for Oil Pollution Damage (1969)
5. International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW 78)
6. Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREG 72)
7. International Convention on Tonnage Measurement of Ships, 1969 (TONNAGE 69)
8. Merchant Shipping (Minimum Standards) Convention, 1976 (ILO Convention No. 147) plus the Protocol of 1996

International Convention on Load Lines (1966) and Protocol (1988)
The load line convention deals with limitations on draught (freeboards) up to which a ship can be loaded as well as external weather tight and watertight integrity of the vessel. As such, the convention tries to eliminate excess stress on the hull of the ship and tries to ensure adequate stability of the ship. Both factors contribute highly to the overall safety of a ship. The 1988 Protocol provides harmonized certification and survey requirements between the load line convention and other conventions (SOLAS and MARPOL) so that the time a ship needs to spend out of service due to a mandatory survey is reduced.

International Convention for the Safety of Life at Sea (SOLAS 74) and Protocols (1978 and 1988)
The SOLAS convention is one of the most important conventions and contains twelve chapters concerning the safety of ships. The convention specifies minimum standards for the construction, equipment and operation of ships. It is up to the flag state to ensure that a ship which is registered under its flag complies with these requirements. In addition, the convention allows for the inspection of another contracting state if there are clear grounds for believing that such as inspection is needed – it is the base for port state control. The convention itself has been amended numerous times in order to keep the legislation updated and in line with technical developments. Chapter IX contains the International Safety Management Code (ISM Code) which is very important since it tries to ensure a safety management system between the ship and its owner/operator. One of the latest amendments to SOLAS is the ISPS[14] code which entered into force on 1st of July 2004 and although it is now part of the port state control inspection regime, it is not taken into consideration for the purpose of this analysis.

The Protocol of 1978 deals with several amendments for tankers and strengthens the surveys and the port state control requirements. The Protocol of 1988 links up with the Load Line Protocol of 1988 to facilitate harmonized surveys for all ships under SOLAS, MARPOL and the Load Line Convention.

[14] International Ship and Port Facility Security Code

International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) with Annexes I-V:

MARPOL and SOLAS are the two most important conventions for port state control. MARPOL's prime aim is to prevent pollution from ships either caused due to an accident (MARPOL has been influenced by the Torrey Canyon incident[15]) or due to normal operations. The convention is therefore split into six relevant Annexes as follows:

Annex I	Regulations for the Prevention of Pollution by Oil
Annex II	Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk
Annex III	Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form
Annex IV	Prevention of Pollution by Sewage from Ships
Annex V	Prevention of Pollution by Garbage from Ships
Annex VI	Prevention of Air Pollution from Ships (not yet in force)[16]

Annex I and II are the most important parts and they are obligatory while the rest is voluntary. Annex I is dealing with operational discharges of oil from tankers. The oil record book is one of the items inspected during a port state control inspection as well as the oily-water separating system. Annex I was amended by the Protocol of 1978 which introduced the SBT, COW and CBT[17] requirements. Annex II provides a list of dangerous substances and their discharge criteria and makes the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code) mandatory. Annex V provides a complete ban of all plastic to be dumped into the sea. Enforcement of the convention is like with all other conventions duty of the flag state. MARPOL has been amended many times but the most important amendments are the ones starting in 1992 up to 2003 dealing with the phasing out of single hull tankers. Depending on the size and age of the vessel, the last amendment of 2003 provides a time table for this process. By 2010 latest, all single hull oil tankers have to be phased out.

Protocol of 1992 to the International Convention on Civil Liability for Oil Pollution Damage (1969)

In addition and complimentary to MARPOL, this convention outlines the responsibility of the owner of a vessel in case of pollution by oil and ensures compensation of the victims. It further requires insurance coverage. Liability is calculated in special drawing rights which are based on the ship's gross tonnage. It also extends coverage to cover pollution damages caused within a certain economic zone and covers spills from ships carrying oil as bulk as well as spills from bunker oil.

International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW 78)

This convention is another very important convention for the port state control regime. It tries to ensure a minimum standard for training, certification and watchkeeping for seafarers on an international level. The implementation of the

[15] a tanker who run aground in 1967 entering the British Channel and spilling 120,000 tons of crude oil

[16] officially known as the Protocol of 1997 to Marpol 73/78

[17] SBT: segregated ballast tanks, COW: crude oil washing, CBT: clean ballast tanks

convention is the responsibility of the flag state while the port state control can also act to ensure compliance and the authority of the port state control has been increased with an amendment made in 1995. The convention is accompanied by the STCW Code which gives a minimum standard for competency for personnel onboard a ship and has a mandatory part and a non-mandatory part. The IMO maintains a list of countries ("White List") which have given full effect to the STCW Convention (STCW 95). Countries on the "White List" can refuse to accept seaman with a certificate of competency that is from a country not on the "White List".

Convention on the International Regulations for Preventing Collisions at Sea (COLREG 72)

COLREG provides a set of rules in order to prevent collision at sea. It consists of 38 rules which are divided into five sections (General, Steering and Sailing, Lights and Shapes, Sound and Light signals and Exemptions). It covers rules and regulations in any condition of visibility which states the rules the ships have to comply to prevent collision. The convention has four annexes dealing with technical details for lightening positioning, sound and signal appliances and distress signals.

International Convention on Tonnage Measurement of Ships (TONNAGE 69)

It took thirteen years for the TONNAGE convention to enter into force which shows the complexity of this convention since it provides for a system to calculate the gross and net tonnage of a ship. These items needed harmonization on an international level due to the fact that both tonnages are used to calculate harbor dues. The new system had to be adopted so that it did not interfere too much with the old system.

Merchant Shipping (Minimum Standards) Convention (ILO[18] Convention No. 147, 1976) and Protocol 1996

The Merchant Shipping (Minimum Standards) Convention from the ILO applies to seafarers on foreign flagged vessels. The convention itself relates to various other ILO conventions included in the appendix[19] of convention 147 and dealing with several crew related aspects. As for the assurance of the qualification, the STCW convention replaces this convention in practice although the ILO convention is still in force. The primary concern of this convention is to ensure safe working conditions and a minimum standard of onboard living conditions in order to ensure the safety of life onboard the vessel. Seaman can complain to a port state control officer about any conditions that might constitute a clear hazard to safety or health. The complaint is then forwarded to the flag state with a copy to the ILO. The ship can be detained in serious cases. The protocol of 1996 extends the coverage of the original convention including updated conventions on accommodation for crews, working hours, workers representation and health protection and medial care.

The next two sections will explain the role of the flag states and the classification societies as part of the maritime safety chain.

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[18] International Labor Organization, part of the UN

[19] C147 Merchant Shipping (Minimum Standards) Convention, 1976 and the Protocol of 1976

2.3. The Role of Flag States

The flag state besides the owner is a crucial player in the safety chain since it bears the ultimate responsibility in enforcing the legal instruments. The concept of flag state is governed by the *"United Nations Convention on the Law of the Sea (UNCLOS 1982)"*.

Article 91 defines the nationality of ships and grants the right to any flag state to register ships according to its own regulations. A flag state must *"effectively exercise its jurisdiction and control in administrative, technical and social matters over ships flying its flag"* and take *"such measures for ships flying its flag as are necessary to ensure safety at sea….."*.[20] It further calls for a "genuine link" between the state and the ship. However this link is not defined meaning that the flag state can register any ship if required.

Article 94 of the same convention defines the duties of the flag state further. With respect to safety, the flag state is required to undertake surveys (before and during registration time) and to ensure that the master and officers in charge of the vessel possess the right qualifications and knowledge to operate the vessel in accordance with generally accepted international regulations. In an effort to clarify the genuine link and to strengthen the enforcement of the duties of the flag states as described earlier, the *"United Nations Convention on Conditions for Registration of Ships (1986)"* [21] was created but never entered into force.

Since the convention is based on international law and the principle of reciprocity, enforcement is left by the flag states and kept to a minimum. One can identify two groups of registries – the national registries and the open registries (also sometimes called flags of convenience). According to Bergantino and O'Sullivan (1999), a flag of convenience can be identified as a flag which allows the following:

1. lower crew and manning cost since there are no restrictions on the number of crew, the minimum wage nor the nationality employed
2. less regulatory control and bureaucracy and therefore easy access to a registry
3. lower operating costs due to relaxed maintenance and less stringent enforcement of international conventions
4. avoidance of tax and the possibility to cover up true beneficial ownership thus limiting liability in case of accidents

Although ownership is still dominated by traditional maritime nations, about 36.6% of the world tonnage (dwt[22]) was flagged by national flags and 63.4% of the world tonnage (dwt) was registered by open registries as shown in Figure 5 in 2003. Out of the 63.4% of open register, the five leading open registry are Panama (22%), Liberia (8.9%), Bahamas (5.7%), Malta (4.8%) and Cyprus (4.2%).

According to Bergantino and Marlow (1998), the evolution of the open registries started actively in the 1970's and surpassed the national registries in 1988. The

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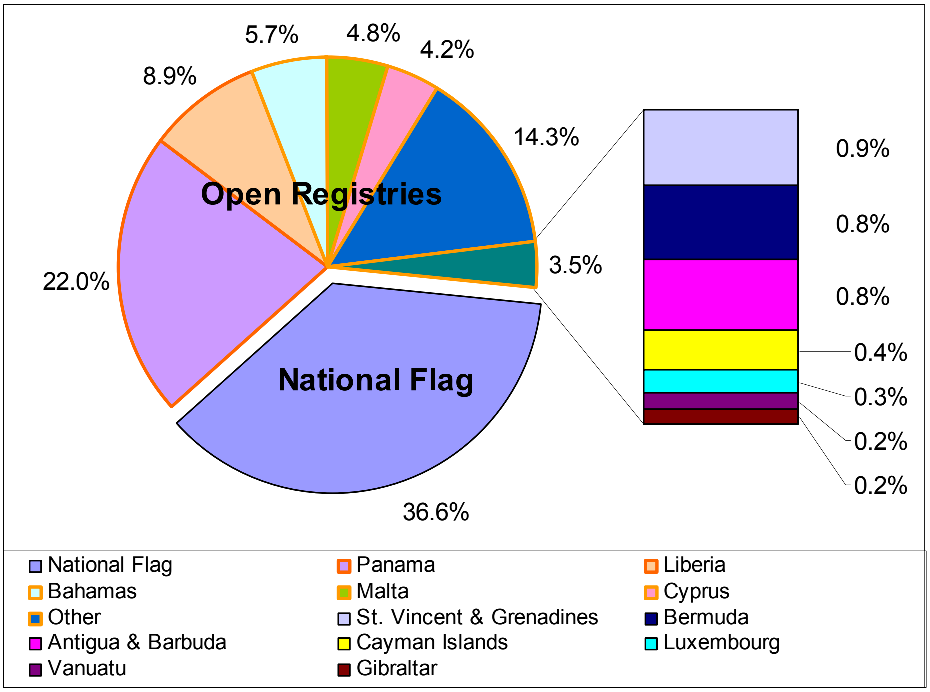
[20] United Nations Convention on the Law of the Seas, 1982, Part 7 (Art. 91)

[21] Admiralty and Maritime Law Guide, www.admiraltylawguide.com/conven/registration1986.html

[22] dwt: deadweight

major reason for this development was the need for cost reduction and the real cost of sea transport in 1970 dollars fell by 80%[23].

Figure 5: World Tonnage (dwt) Split Up per Flag, 2003



Source: Compiled with Data from UNCTAD, Review of Maritime Transport, 2003

The pressure on the ship owners to remain in business enhanced the development of the open registries and due to the different nature of the interest of the flag states, undermined the traditional system of flag states as the ultimate safety control. Since this period, several types of open registries emerged and some have adopted acceptable standards while others have not and are only interested in the profit. It is therefore dangerous to judge the quality of a flag only by its status of being an "open" registry or not.

Alderton and Winchester (2002)[24] show that an open registry cannot be set equal to bad quality and conclude in their study (based on data provided from Lloyd's Casualty Database for the years 1997-1999) that there are observable differences between the open registries and the national registries but that there are also substantial differences within the open registries. New entrants are much likely to have poorer safety standards than established open registries. As open registries grow, they are forced into the more stringent system of the established registries in complying with the international conventions.

Looking at the true ownership of the major open registries as can be seen in Figure 6, a different picture emerges with the traditional maritime nations still owning most of the fleet but under foreign flag. The graph represents 93% of the total tonnage (dwt) which is flagged by a foreign flag (open registry).

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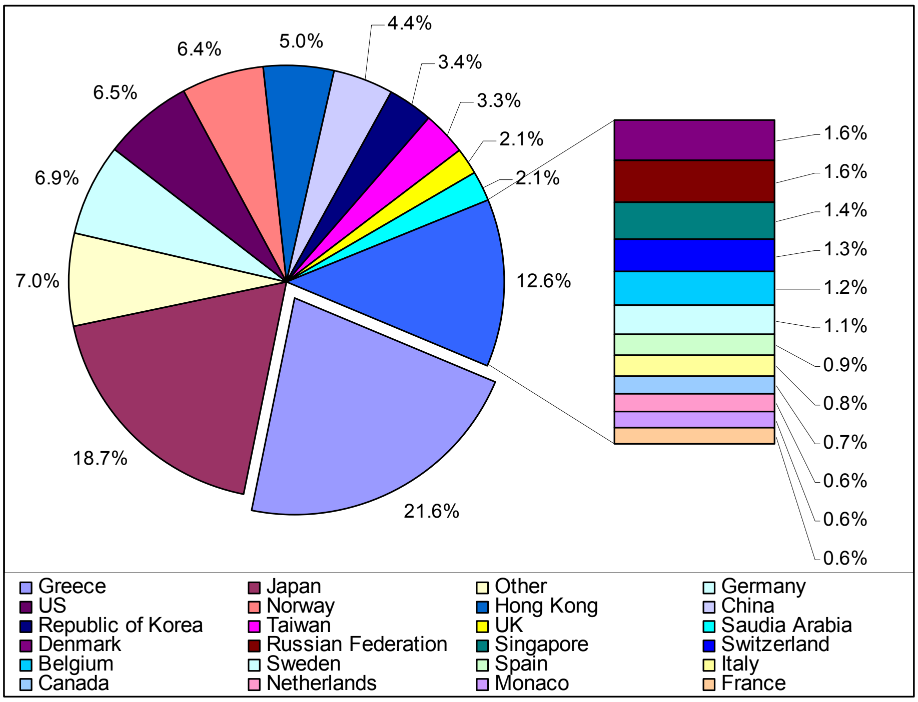
[23] Nieuwpoort, G. Speech at Mareforum, Athens, 2002
[24] see Alderton T. and Winchester N (2002). "Flag States and Safety: 1997-1999". Maritime Policy and Management, vol 29, No.2, pp 151-162

Figure 6: World Tonnage (dwt) Split Up per Ownership, 2003



Source: Compiled with Data from UNCTAD, Review of Maritime Transport, 2003

Ownership or management is important since it influences the management and the human factor. A good example is the good performance of selected open registries such as Bahamas, the Marshall Islands, Antigua, Bermuda and Liberia which are influenced by ship owners from traditional maritime nations such as the UK, the USA and Germany. Those registries can be classified as independent or affiliated registries. In addition, in an effort to counterbalance the development of the open registries, some governments of the traditional maritime nations created the so called international registries[25] . They are in-between the open registries and the traditional registries granting more freedom to the ship owner with respect to crewing but holding onto the stringent safety standards. Examples would be the Norwegian International Registry (NIS), the Danish International Registry (DIS), the German International Registry (GIS) or the Netherland Antilles.

Bergantino and Marlow (1998) also looked at the factors influencing the choice of flagging out. Three sets of cost factors can be identified: crew costs, operating costs and fiscal costs. As fiscal legislation does not constitute any major difference today within the shipping industry, it is a combination of crew and operating costs that are the major drivers behind the decision to flag a ship out. It is estimated that crew cost differences between EU flags and some open registries range from +22% to +333%[26]

However, there are other considerations and the choice of flagging out or not is basically done on a per ship basis and can also depend on the ship's age, size, type and trade routes. In addition, the degree of control is also important for

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[25] also called alternative or second registries
[26] Bergantino A. and Marlow P

owners so a flag state with lax control is of course more attractive for ship owners who do not care about safety. The fact is that flag states are responsible and as long as there are registries that operate at the bare minimum and ship owners who do not care and seek for such registries, there will always be a certain amount of substandard ships on the world's oceans.

On the long run and to improve this system, the flag state needs to meet certain requirements to be a quality flag state. Besides providing a commercially attractive environment for the ship owner, the flag state should invest enough resources to enforce international regulations, to work together with maritime nations who provide seafarers and to establish a quality culture for the shipping industry. Port state control can never substitute a flag state and should also not do so. It can only be seen as a last resource to catch the substandard ships which are the source of today's complex legislative framework to which at the end only the prudent ship owners will continue to comply and which add extra burden to these ship owners but do not eliminate the owner's who do not care.

2.4. The Role of Classification Societies

The classification societies play an important role in the safety net and were established as early as the second half of the 18th century[27] when marine insurers developed a system for independent inspections of the hull and equipment of a vessel requiring insurance coverage. Nowadays, classification societies are independent and self regulating organizations which establish and apply technical standards for the design and construction of ships – the so called class rules. Classification Societies represent a unique pool of technical expertise for the shipping industry and due to its importance to safety, was also recognized by the international conventions of the IMO. The SOLAS and Load Line conventions contain several references to the classification societies and the International Association of Classification Societies (IACS)[28] which was founded after the Load Line convention has also consultative status with the IMO. IACS members cover 94%[29] of all tonnage in the commercial shipping industry today which leaves a loophole of 6% of classification societies which do not have to comply with the class rules and which are therefore attractive for ship owners who do not care about safety.

The IACS members follow a code of ethics and a quality system certification scheme to keep it standard across the members. Classification societies conduct several types of surveys, depending on the age and construction of the vessel. It is the ship-owner's responsibility to conduct periodic surveys after the delivery of a ship and to ensure that the ship remains compliant to the rules. A ship can either be "in class" or if it does not meet the requirements of the class rules, "out of class" meaning that the class has been withdrawn or never granted upon construction. Class is a voluntary decision of the ship owner but highly

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[27] according to the International Association of Classification Societies

[28] members of the IACS are: American Bureau of Shipping (ABS), Bureau Veritas (BV), China Classification Society (CCS), Det Norske Veritas (DNV), Germanischer Lloyd (GL), Korean Shipping of Register (KR), Lloyds Register (LR), Nippon Kaiji Kyokai (NK), Registro Italiano Navale (RINA) and the Russian Maritime Register of Shipping (RS)

[29] according to the International Association of Classification Societies

recommended as a class certificate might be required as statutory requirement to register a ship depending on the flag state and if the flag state is a signatory to the international conventions.

Classification societies claim that they have no commercial interest related to the ship design, building, ownership and operation. However, flag states can delegate certain responsibilities to classification societies and can authorize classification societies for the inspection and statutory certification of their ships. The delegation to classification societies is common practice as many flag states do not have the manpower or the expertise to do so.

This raises the question of responsibility in case something happens and in addition, class rules do not cover every aspect of the ship. Classification societies are the center of attention with regard to safety as they have relationships with all other players in the safety net. In addition, they are paid by the ship owners or the flag states (if some of their responsibilities are passed onto the classification societies) and since at the end, classification societies are commercial entities, there can be a certain amount of interest conflict within the system. The IACS code of ethic tries to pre-empt this observation by making clear that the classification society should not be guided by this conflict. The code therefore states the following[30]: *"Classification Societies live on their reputation."* and *"Competition between Societies shall be on the basis of services (technical and field) rendered to the maritime industry but must not lead to compromises on safety of life and property at sea or to the lowering of technical standards."*

Out of the approximately 50[31] classification societies that exist worldwide, not all of them have a code of ethics, and only twelve classification societies are recognized by the European Union according to Commission Decision 221/2002/EC[32]. All but the last two are members of IACS and are as follows:

1. American Bureau of Shipping (USA)
2. Bureau Veritas (France)
3. China Classification Society (China)
4. Det Norske Veritas (Norway)
5. Germanischer Lloyd (Germany)
6. Korean Register of Shipping (South Korea)
7. Lloyds Register (UK)
8. Nippon Kaiji Kyokai (Japan)
9. Registro Italiano Navale (Italy)
10. Russian Maritime Register of Shipping (Russian Federation)
11. Registro Internacional Naval (recognition for Portugal only)
12. Hellenic Register of Shipping (recognition for Greece only)

Only EU member states can request EU recognition of a classification society and the recent enlargement of the EU might bring some changes within this area. It is also interesting to notice that the EU has created the legal basis to audit the

[30] International Associations of Classification Societies, Code of Ethics: www.iacs.org.uk

[31] European Maritime Safety Agency

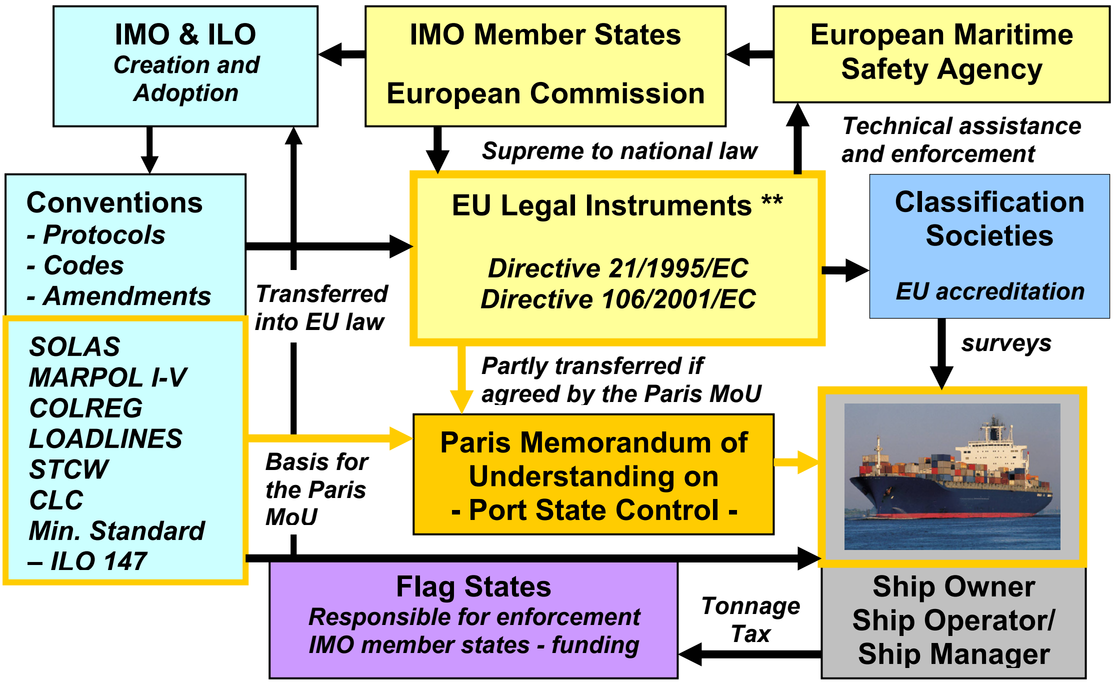
[32] Commission Decision 221/2002/EC of 14 March 2002 amending Decision 587/96/EC on the publication of the list of recognized organizations which have been notified by Member States in accordance with Council Directive 94/57/EC

classification societies every two years thus providing some kind of regulatory control over the otherwise self-regulating entities.

2.5. The EU Perspective on Port State Control

The European Commission is the only institution that has the right of initiative to make legislative proposals to the European Parliament and the European Council. The EU Commission implements community policies, enforces community law in conjunction with the European Court of Justice and negotiates international agreements. In the case of maritime safety, the role of the European Commission is slightly different. Figure 7 provides a simplified diagram of the interaction between the IMO, the EU, the Paris MoU, the flag states and the classification societies.

Figure 7: The EU Port State Control Regime Explained



** selected instruments

At first sight, it seems to be a rather complex system but before the regime will be explained further in depth in the following paragraphs, one should notice that despite the complicated system, port state control enforcement only happens at the ship level and does not include any other aspect such as port facilities, flag states or classification societies.

The individual IMO member states are the flag states. The ultimate responsibility for compliance to the IMO conventions lies with the ship owner and the ultimate responsibility for enforcement lies with the flag states as already highlighted earlier.

In addition, all EU member states[33] are also members of the IMO including the land locked EU countries. From a policy point of view, it is important to understand that the EU Commission is not a member of the IMO and does therefore not represent all 25 EU member states at the IMO with one voice like it does with the World Trade Organization. The EU Commission concluded an agreement of co-operation with the IMO. This further means that the European Commission does not have a voting right but is only participating in the committees and sub-committees of the IMO where draft legislation is created. Before an IMO conference, the presidency of the EU Council arranges European co-ordination meetings[34] of the EU member states and the EU Commission in order to ensure that the best possible consensus amongst the EU member states is found.

The most important actor in the regime is the Paris MoU representing the port state control enforcement for its member states. The executive body where policies are made is the Port State Control Committee in conjunction with the European Commission and the maritime authorities of the member states. The Committee is supported by the Advisory Board and the Technical Work Groups dealing with specific technical issues and the Secretariat who administers the Paris MoU. All changes to the Paris Memorandum of understanding have to be agreed upon by all member states.

The *European Maritime Safety Agency (EMSA)* provides technical assistance to the European Commission with respect to port state control. The agency was created after the "*Erika"* accident[35], an oil tanker which broke apart of the coast of Brittany in 1999 and lost 20,000 tonnes of heavy fuel oil. Parts of the French coast was polluted and caused damage to the environment. EMSA was established based on EC Regulation 1406/2002 amended in 2003 and 2004 to incorporate further tasks. With reference to port state control, EMSA has been given the technical responsibility for monitoring and strengthening of port state control at EU level including the auditing of recognized classification societies. In addition, EMSA deals with the investigation of maritime accidents and the establishment of a community vessel traffic monitoring and information system. Recently added tasks cover the development for an oil pollution response system, training and security. The agency is still in the process of being established but it will gain further importance on the EU level in the future with respect to safety related items.

The EU sometimes adds additional measures to an existing IMO convention in order to adapt it to the needs of the EU. By transferring the IMO legislation into EU legislation (either by directive or regulation), it is brought under the jurisdiction of the European Court of Justice since the *"acquis communautaire"*[36] is supreme to national law. By doing so, enforcement of port state control for EU member states is enhanced. If a member state does not comply, the EU Commission can start infringement procedures[37] against a member state. This transfer of international law to EU law is primarily based on EC Treaty Article

[33] including the ten new member states
[34] Gert-Jan Huisink, Royal Association of Netherlands' Shipowners, telephone interview by author
[35] Willem de Ruiter, "After Erika – Filling the Safety Gaps", AMRIE Conference, Lisbon, 2002
[36] Acquis communautaire: sources of community law consisting of primary, secondary and case law
[37] legal proceedings against a member state for violation against EU legislation

80 (2) as follows: *"The Council may, acting by a qualified majority, decide whether, to what extent and by what procedure appropriate provisions may be laid down for sea and air transport. - The procedural provisions of Article 71 shall apply."*

This further means that the legal base for the majority of the EU directives and regulations in the area of maritime safety are based on EC Treaty Article 80 (2) and that the procedural provisions used for the legislative procedure under EC Treaty Article 71 is the co-decision procedure (based on EC Treaty Article 251) in which the European Parliament has the power to stop a legislative procedure (on equal level with the European Council). Environmental legislation which can also cover safety aspects of the maritime industry in the EU are based on EC Treaty Article 174 (2) which defines that community policy on the environment should be precautionary and preventive and that the polluter should pay. However, most legislation was created after an accident and not due to preventive measurements.

One can identify a long list of EU regulations and directives dealing with safety which are not the scope of this thesis. The following section will only highlight the relevant instruments for port state control in the EU and other important measures in the area of safety.

The port state control directive with its amendment (Directive 106/2001/EC of 19th December 2001) and the Paris Memorandum of Understanding (Paris MoU) form the basis of port state control in the EU. As per requirement of this directive, all EU member states with the exception of the land-locked countries (Austria and Luxemburg) have to be members of the Paris MoU including the new EU member states. According to the directive, each member state is under an obligation to inspect at least 25% of the ships flying other countries' flags (including other EU flagged countries) which enter its ports. This 25% target is currently under revision at the EU commission and might be changed in the future[38].

The directive along with the Paris MoU establishes and explains the target factor to be used in order to identify if a ship should be inspected, the criteria for detention and the criteria for banning. Any ship with a target factor greater than 50 should be inspected if at least one month since the last inspection within the Paris MoU system has passed. There are several types of inspections as follows:[39].

1. *Priority inspections:* priority inspections are conducted regardless of the target factor. This can be if the ship was involved in a collision, grounding or has been withdrawn from class or has demonstrated a clear hazard to safety such as unsafe navigational practices or by notification from the pilot.
2. *Initial inspections:* the surveyor will check the ship's certificates and see if the overall condition of the ship, including the engine room and accommodations are satisfactory and in accordance with the regulations.
3. *Detailed inspections:* If the surveyor has "clear grounds" for believing that the ship needs further inspection, a detailed inspection is conducted. The condition for "clear grounds" are stipulated in the Paris MoU and the EU

[38] Paris MoU News – www.parismou.org
[39] Information compiled from the Paris MoU

directive and could be for instance: missing or falsified documents, crew members who are unable to communicate with each other, crew members who are unfamiliar with safety instructions or structural deterioration and unsafe cargo operations. Detailed inspections follow written procedures and cover all safety aspects onboard.

4. *Expanded inspections:* expanded inspections are mandatory and have to be done once in 12 months for oil tankers (over 3000 gt[40] and older than 15 years), bulk carriers (older than 12 years), passenger ships (older than 15 years, except ro-ro ferries and high speed crafts[41]) and gas and chemical tankers (older than 10 years). The procedures are very detailed and ship specific and include drills, testing of emergency equipment including blackouts, testing of watertight doors and lifeboats.
5. *Follow up inspection:* this inspection is done if there is a follow up to be done to see if a certain deficiency has been rectified.

In addition, the criteria for refusal to access to a community port (banning of a ship) is given. Ship types that can be banned are gas and chemical tankers, bulk carriers, oil tankers and passenger ships if the ship carries a flag which is "black listed"[42] and which has already been detained twice within three years in the "very high risk" or "high risk" category of the black list or if it has already been detained three times within two years in the "medium to high" or "medium risk" category of the black list. Interesting to notice is the fact that general cargo ships are not on the list for banning.

The Paris MoU ranks the flag states as Black, Grey or White depending on previous performances of those flag states during inspections. A full list of the Paris MoU black – grey and white list is provided in Appendix 3: Paris MoU Black, Grey and White List for further reference. The Paris MoU specifies the criteria for detaining a ship in Annex I, section 9.3 of the memorandum. The main criterion concerns the safety of the ship and if the ship is safe to proceed at sea or not. The second criterion concerns the seriousness of the deficiencies. The port state control officer is expected to use his professional judgment in all processes.

Other relevant EU legislation in the area of safety is related to the Erika I and II packages and a new maritime safety measures package (known as Erika III in the industry). The Erika I package was adopted in the aftermath of the Erika tanker disaster in 1999 and followed up by the Erika II package which created the European Maritime Safety Agency (EMSA) and increased liability for pollution.

Erika I Package

1. *Directive 106/2001/EC* of 19 December 2001 amending Directive 21/1995 and strengthening the existing directive on port state control
2. *Regulation 417/2002/EC* of 18th February 2002 on the accelerated phasing-in of double hull for single hull tankers and amended by *Regulation*

[40] gross tonnage

[41] according to Directive 35/1999/EC of 29 April 1999,these categories are not covered by the port state control directive

[42] rating system of flag states depending on previous performances and detentions

1726/2003/EC: Timetable for the worldwide phasing out of single hull oil tankers
3. *Directive 105/2001/EC* of 19th December 2001 on common rules and standards for ship inspection and survey organizations and for the relevant activities of maritime administrations which strengthens the existing Directive 57/1994/EC. These directives govern and monitor the activities of classification societies (by EMSA) and should raise quality requirements for classification societies. The amendment requires that each of the twelve EU recognized classification societies should be assessed once every two years.

Erika II Package
1. *Regulation 1406/2002/EC* of 27th June 2002 establishing the European Maritime Safety Agency (EMSA) plus two amendments (Regulation 1644/2003 and 724/2004)
2. *Directive 59/2002/EC* of 27th June 2002 establishing a Community vessel traffic monitoring and information system: this directive is to implement a notification system for improved monitoring of traffic including an automatic identification system and voyage data recorders (black box)
3. Efforts to increase the maximum liability of pollution caused by oil

Maritime Safety Measures Package (Erika III) - in process at the moment:
This new package is in formation at the moment. The EU Commission's proposal consists of several different legislative measures including an update of the Port State Control Directive.

The objective of this proposal will be to simplify port state control procedures and to change the 25% inspection target for each member state to an EU wide 100% coverage of inspections based on a yearly inspection of all ships spread across all EU member states. In addition, the measures might change the target factor system to a risk based system and the incorporation of a reward system for good ships in order to decrease the amount of inspections. Other measures are as follows[43]:
1. A communication on the implementation of ILO provisions on the living and working conditions of seafarers: this proposal will aim at promoting EU labor standards and might transfer ILO conventions into EU law.
2. A Regulation on the compliance with IMO flag State rules: the aim of this proposal will be to ensure that minimum flag state rules are applied by all flag states in the enlarged EU
3. A Directive on Maritime Transport Management and Information System (Update of Directive 2002/59/CE): this proposal will introduce a harmonized European system on maritime traffic management;
4. A Directive on Maritime Accident Investigation: this proposal will establish a legal framework for inquiries following accidents and establish common European standards for casualty investigations.
5. Clarification of plans for ports of refuge;

In general, the EU perspective to maritime safety works on two levels. First the level of the flag state where the accession of the new members states with flags

[43] Naftika Chronika, www.naftikachronika.gr and Lloyd's List, www.lloydslist.com and interview conducted by the author with the European Commission

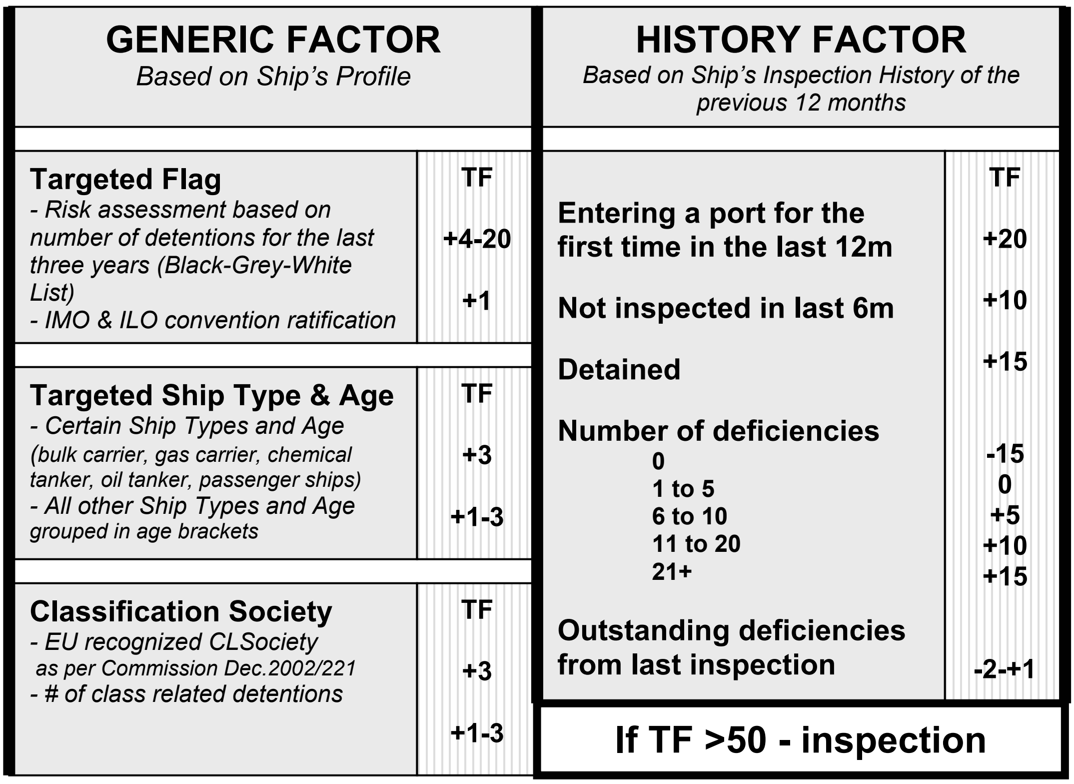
like Cyprus and Malta (both black listed at the moment) will lead to an improvement of safety on the flag state level since the new member states will have to comply to EU standards in the future. Second, from the EU perspective and on the level of the EU member states as port states, the EU is working on creating an approach for the whole union in order to improve the targeting of sub-standard ships while creating incentives for good ships and their owners in order to eliminate any distortion to competition which is a prime objective of the single market[44].

2.6. The Target Factor of the Paris MoU

Ship inspections are conducted by the member states who also communicate to the ship owners, flag states and classification societies. The database of the Paris MoU is the SIReNAC information system located in St. Malo (France) and contains all data of the port state control inspections. Data provided by this system is also the basis for the Paris MoU target factor.

The calculation of the target factor is divided into two parts – the generic factor and the history factor. A simplified diagram is shown in Figure 8 to visualize the process of the calculation. A detailed explanation is provided in Appendix 4: Paris MoU Target Factor Calculation in Detail for further reference.

Figure 8: Paris MoU Target Factor



44 single market: defined in EC Treaty Article 95, the single market is the heart of the EU and should guarantee the realization of the four freedoms based on EC Treaty Article 3 (free movement of persons, capital, goods and services and the freedom of establishment)

The diagram shows the variables in the target factor and their associated importance. These variables have all been incorporated into the analysis which will follow in chapter three. As can be seen under the history factor, only the number of deficiencies is incorporated but no information about the type of deficiency is used. This is the ultimate purpose of the analysis to follow – to find out if the target factor can be improved by incorporating qualitative information about the type of deficiencies and not only quantitative information.

This section concludes chapter two in giving an overview of the safety regime and in particular the port state control regime in the EU. It explained the reason for the existence of port state control and identified the role of each player in the safety net. In addition, the role of the EU and its policy perspective has been shortly highlighted.

The next chapter will deal with a series of analysis which is the most important part of this thesis. At first, a section of descriptive statistics and a correspondence analysis of the data set will be presented in order to provide the reader with an enhanced insight into the many variables that are involved and to facilitate the interpretation of the regression analyses.

Chapter 3: The Analysis

The analysis is based on port state control data for the time period of May 2000 to May 2004 supplied by the Secretariat of the Paris MoU. In total, 77,555 cases of raw data were extracted from the SIReNaC Database. Of the total dataset provided, 1307 cases were deleted (due to missing or insufficient entries) and the remaining 76,248 cases were used for the analysis. In addition, data from Lloyd's Register - Fairplay's "World Shipping Encyclopedia (March and April 2004)" was extracted and merged with the basic dataset. The analysis is split into descriptive statistics, correspondence analysis and regression analysis.

3.1. Descriptive Statistics and Correspondence Analysis

The descriptive statistics section and the correspondence analysis should help to explain and understand the different types of regression analyses as well as to provide a better feeling about the data and the major trends within the relationships. Table 2 provides a description of the main and sub deficiency codes used in the sections to come. A full list with the explanation of the nature of deficiencies can be seen in Appendix 5.

Table 2: Description of Main and Sub Deficiency Codes

Code	Deficiency Code Description	Code	Deficiency Code Description
100	Ship's certificates and documents	1300	Mooring arrangements (ILO 147)
200	Crew certificates	1400	Propulsion & auxiliary engine
300	Accommodation	1500	Safety of navigation
400	Food and catering	1600	Radio communications
500	Working spaces and accident prev.	1700	MARPOL annex I
600	Life saving appliances	1800	Gas and chemical carriers
630	Launching arrangements for surv. craft	1900	MARPOL annex II
700	Fire Safety measures	2000	Operational deficiencies
739	Emergency Fire Pump	2100	MARPOL related oper. deficiencies
800	Accident prevention (ILO147)	2200	MARPOL annex III
900	Structural Safety	2300	MARPOL annex V
1000	Alarm signals	2500	ISM related deficiencies
1100	Cargoes	2600	Bulk carriers
1200	Load lines		

Note: 630 and 739 are sub-codes, the rest are main codes

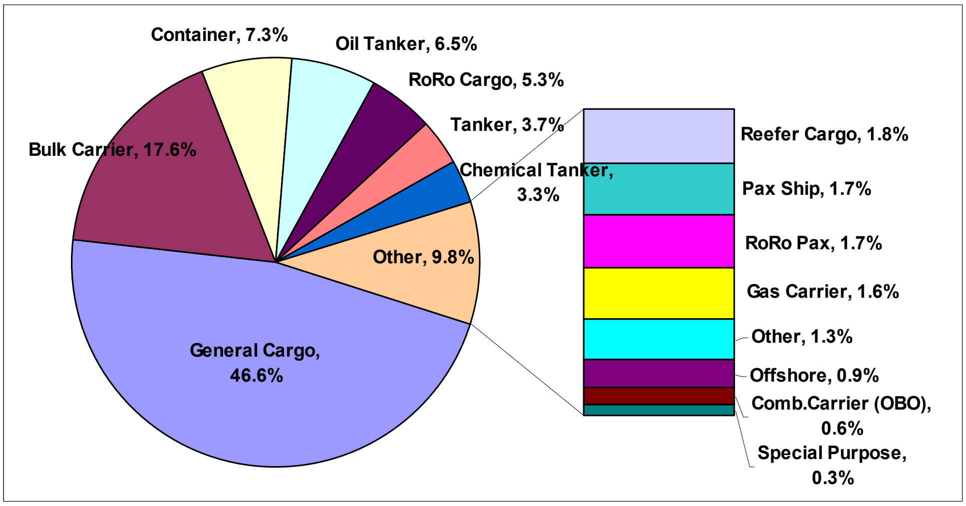
Out of the 76,248 cases, 6273 ships were detained or 8.2% of the total inspections and 1,168 ships were detained with class related deficiencies which is 18.6% of all detentions or 1.53% of all inspections. Around half (43.25%) of all inspections have zero deficiencies.

The mean of the total number of deficiencies is 3.55 per inspection with a variation from 0 to 105 deficiencies. The mean vessel age for the data set is 18.98 years and varies from age 0 to 125. The mean vessel age is rather high compared to an average world fleet vessel age of 12.6 years reported by UNCTAD (World Maritime Review, 2003) but this is due to the fact that the inspections are targeted towards older vessels and the data set is to a certain extent biased.

3.1.1. Ship Types

Dividing the data set per ship type, one can easily see in Figure 9 that most ships which were inspected are general cargo ships followed by bulk carriers, container ships, oil tankers and Roll On-Roll Off Cargo ships. This reflects the target factor since the targeted categories, either per ship type or by age, are these categories.

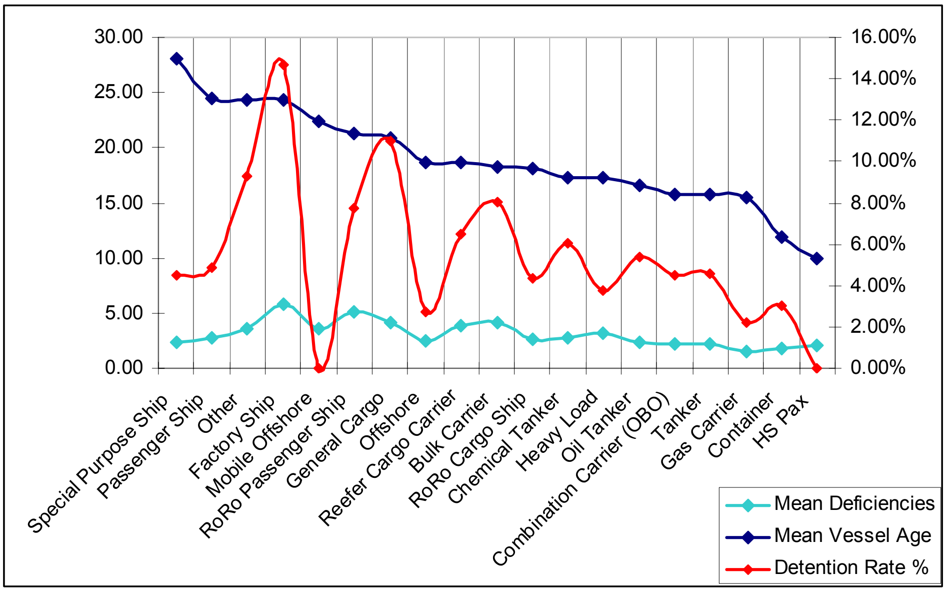
Figure 9: Ship Type Split Up of Total Inspections



Source: Based on whole dataset (May 2000 – May 2004)

The relation of detention, deficiencies and ship age per ship type gives an indication of the quality of maintenance. Figure 10 shows this relationship per ship type. Most detentions in relation to total inspections can be found with factory ships and general cargo ships followed by bulk carriers, chemical tankers and oil tankers.

Figure 10: Deficiencies; Age, Detention Rate per Ship Type



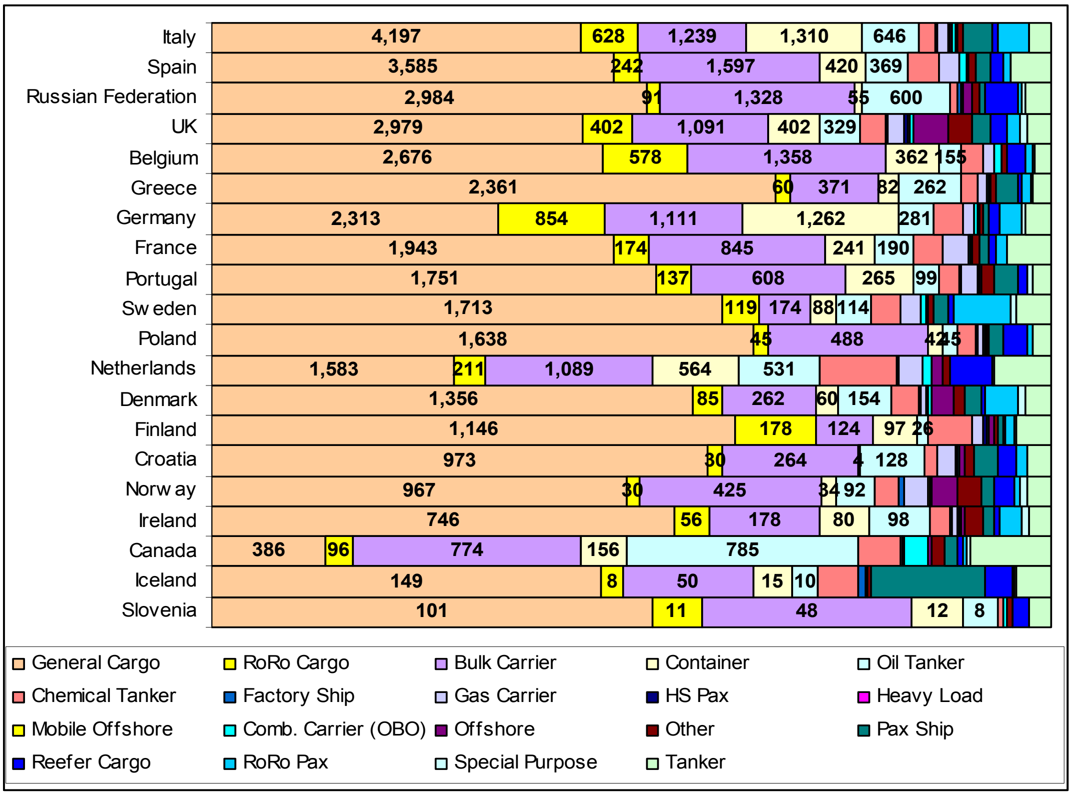
Source: Based on whole dataset (May 2000 – May 2004)

The dataset contains a couple of outliers with very high age in the categories passenger ships, general cargo and special purpose ships. The relation to age reflects the quality of maintenance done on ships meaning that an older ship with good maintenance depending on the category of the ship can show a lower detention and deficiency rate. Special Purpose Ships, Passenger Ships, Factory Ships and Mobile Offshore ships might show a better maintenance than for instance general cargo ships or bulk carriers. This also reflects the kind of commodity they are trading in and shows the diversity of the shipping industry in general. It also shows that targeting by ship type as done in the present target factor does prove to be effective.

3.1.2. Port States

As can be seen from Figure 11, most general cargo and bulk carriers went to the South of Europe or to the Baltic Region of Europe. Belgium also accounts to a high amount of general cargo and bulk carriers. This split up again reflects the selection of the target factor as those two categories are targeted. However, it gives a certain indication of the trade flow and how it is split up across Europe.

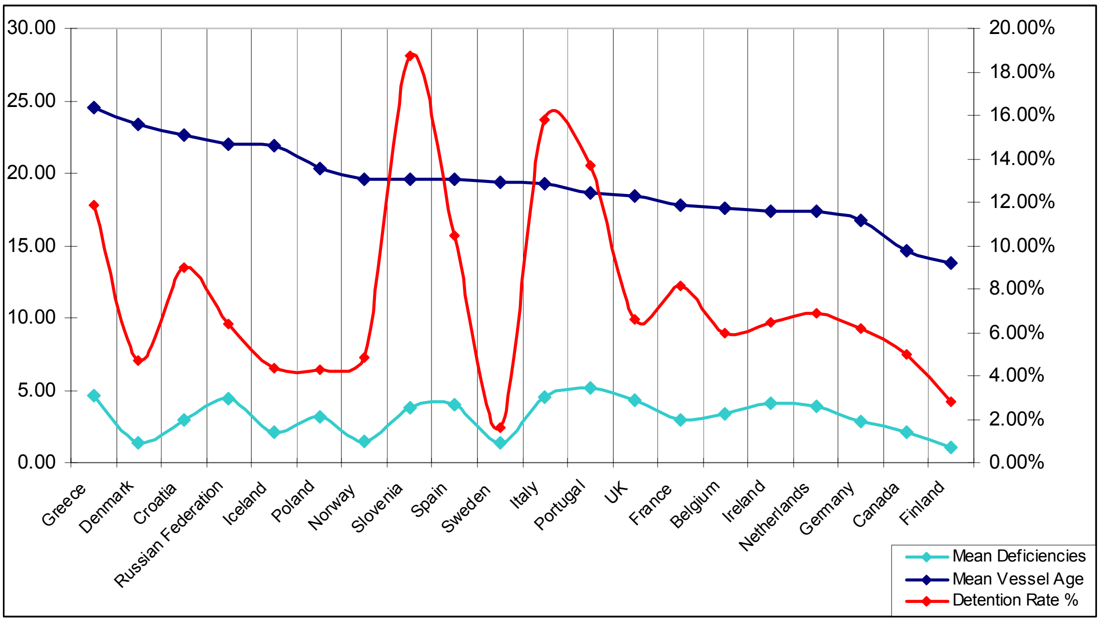
Figure 11: Ship Types and Port State



Source: Based on whole dataset (May 2000 – May 2004)

Figure 12 shows the relationship between the mean ship age, the detention rate and the mean number of deficiencies. The mean deficiency rate follows more or less the detention rate but the average age of the vessel does not confirm this relationship compared to the detention rate indicating that older ships calling these port states do not necessarily have higher detention rates (e.g. Greece, Denmark, the Russian Federation, Poland and Norway).

Figure 12: Deficiencies, Age, Detention Rate per Port State



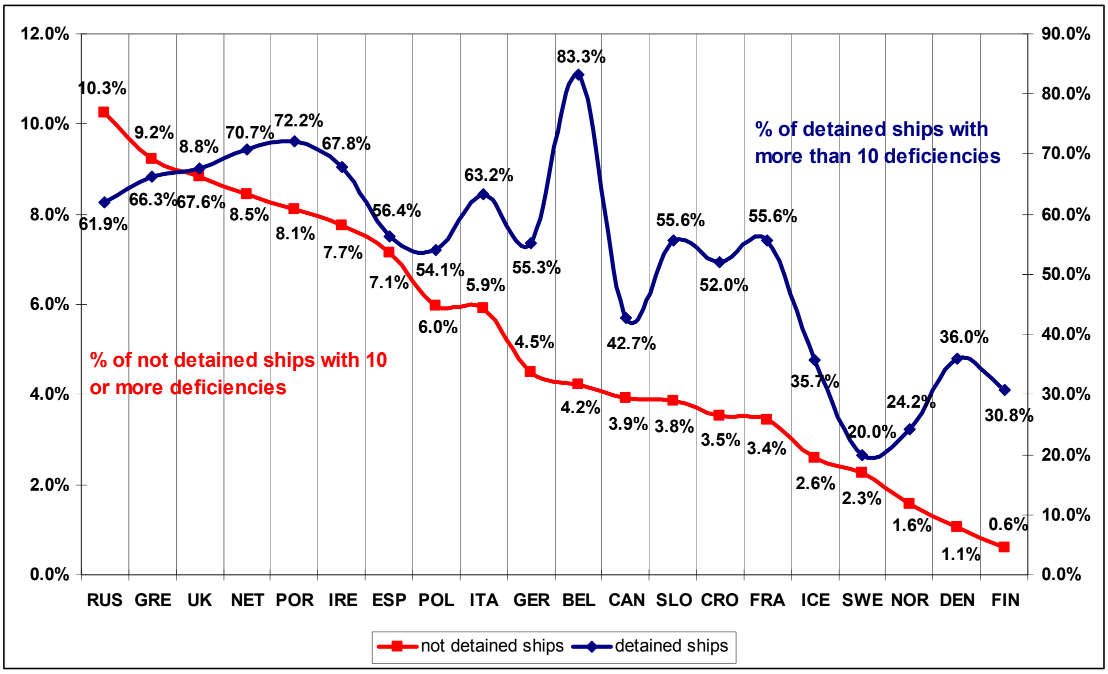
Source: Based on whole dataset (May 2000 – May 2004)

Most detentions compared to the total inspections in the time period were made by Italy, Portugal, Greece and Spain. The figures for Slovenia are biased because Slovenia only joined the Paris MoU in July 2003 and had only 192 inspections in the whole dataset. It also appears that there are more detentions in the South of the EU than in the North which also reflects the trade flows. Interesting to notice is the Russian Federation, Iceland, Denmark, Poland and Norway where the average age is relatively high but detention and deficiency rate is low. In addition, these countries do have a high amount of general cargo ships and bulk carriers compared to their total amount of ships visiting their ports.

In order to see the difference in port state performance, the percentage of inspections with 10 or more deficiencies was graphed in Figure 13 . The graph is split in "detained" ships and "not detained" ships. The graph shows that for instance for the Russian Federation, 10.3% of inspections that did not end in a detention had 10 or more deficiencies. On the other hand, 20 % of all detention in Sweden had more than 10 deficiencies. In total, 6% of all ships that were not detained had 10 or more deficiencies.

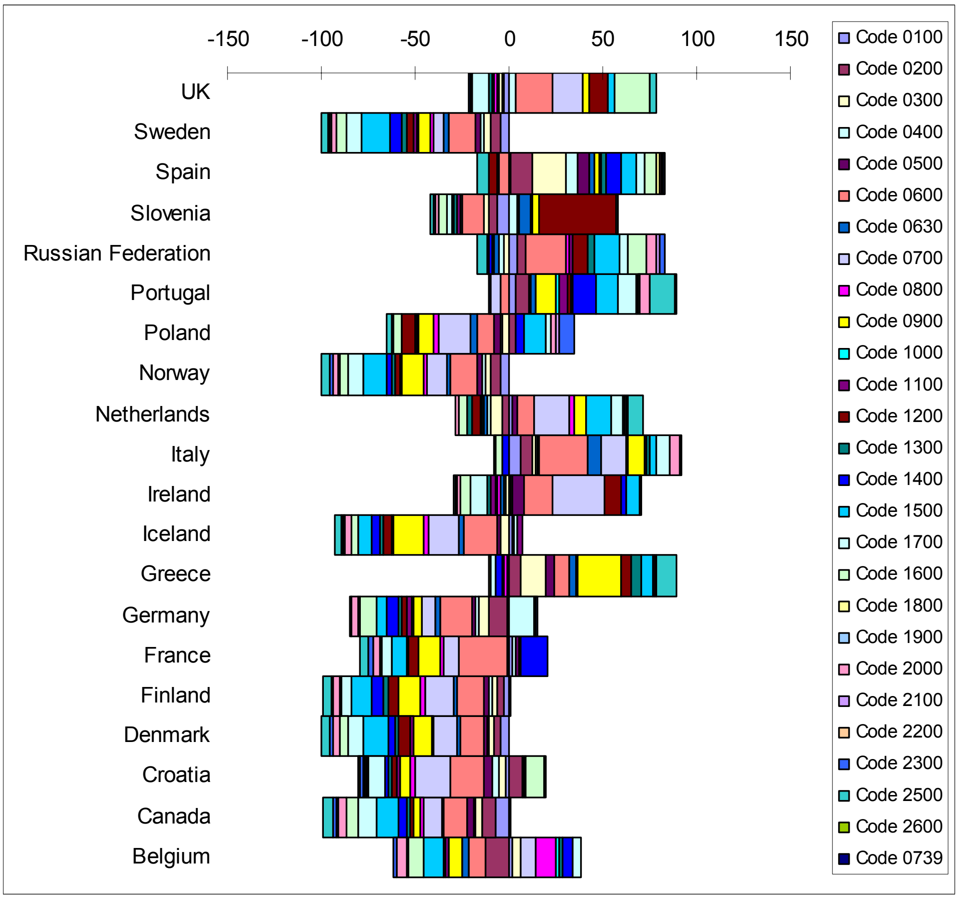
To visualize the differences of the deficiencies, the mean of each deficiency was compared to the total mean of each code and a graph produced which can be seen in Figure 14. This graph shows that port states in the North show a lower amount of deficiencies compared to the average while countries in the South show the opposite except the UK. Another approach to show the difference in the quality of the inspections of the port states will be shown based on the binary logistic model where probabilities of detention given a certain ship profile is graphed with a variation of port states in section 3.4.2.

Figure 13: Detention and Deficiencies per Port State



Source: Based on whole dataset (May 2000 – May 2004)

Figure 14: Mean Deficiencies to Total Mean Deficiencies by Port State



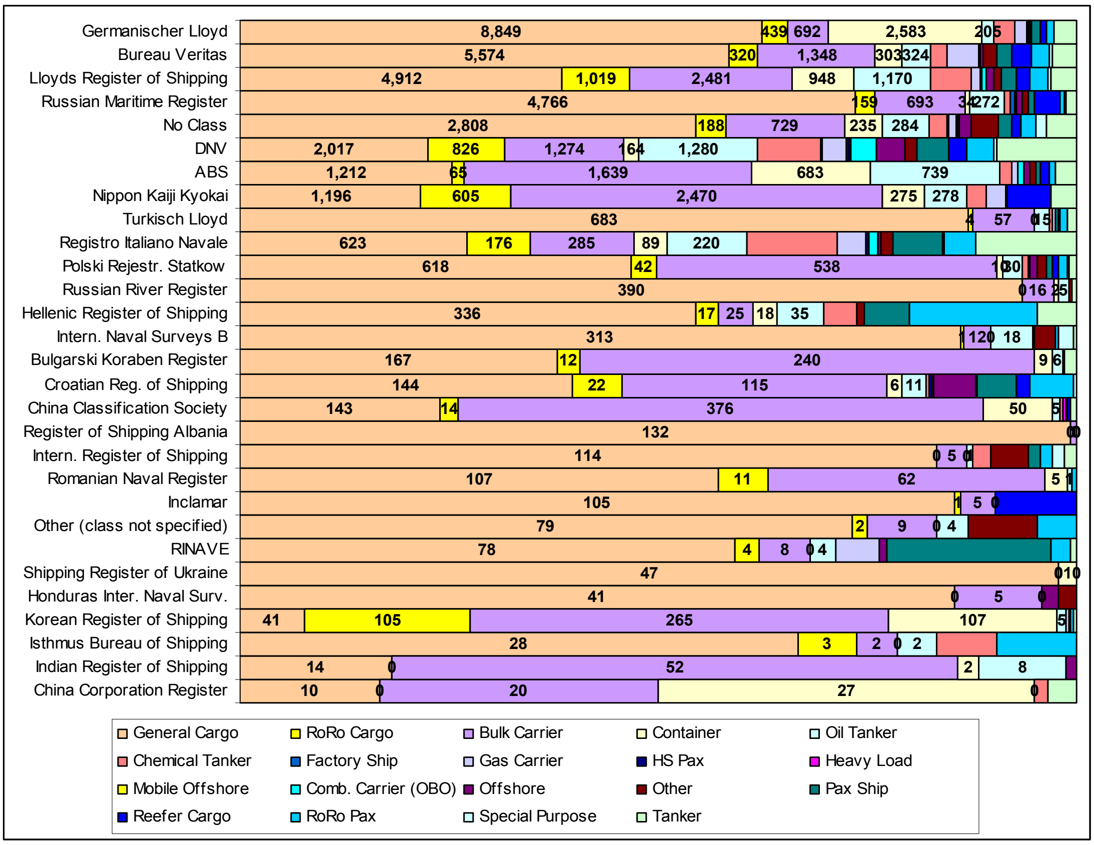
Source: Based on whole dataset (May 2000 – May 2004)

3.1.3. Classification Societies

Analyzing the classification societies per ship type, one can see in Figure 15 that most general cargo ships are classified by Germanischer Lloyd, Bureau Veritas, Lloyds Register of Shipping and the Russian Maritime Register who are all EU recognized classification societies. Interesting to notice is also the high amount of "No Class" ships in the dataset. For easier identification for the following sections, the EU recognized classification Societies are repeated here and are as follows:

- American Bureau of Shipping (USA) - ABS
- Bureau Veritas (France) - BV
- China Classification Society (China) - CCS
- Det Norske Veritas (Norway) - DNV
- Germanischer Lloyd (Germany) - GL
- Korean Register of Shipping (South Korea) - KR
- Lloyds Register (UK) - LR
- Nippon Kaiji Kyokai (Japan) - NK
- Registro Italiano Navale (Italy) - RINA
- Russian Maritime Register of Shipping (Russian Federation) - RS
- Registro Internacional Naval (recognition for Portugal only) - RINAVE
- Hellenic Register of Shipping (recognition for Greece only) - HR

Figure 15: Ship Types and Classification Society



Source: Based on whole dataset (May 2000 – May 2004)

In total, around 87% of all ships inspected were classified by EU recognized classification societies. Ships with classification societies that are not recognized by the EU accounted for almost three times of the detentions in % to the total detentions compared to EU recognized classification societies in the given time period and as shown in Table 3. The number of mean deficiencies is about half. This indicates that there is a noticeable level of quality between the two groups.

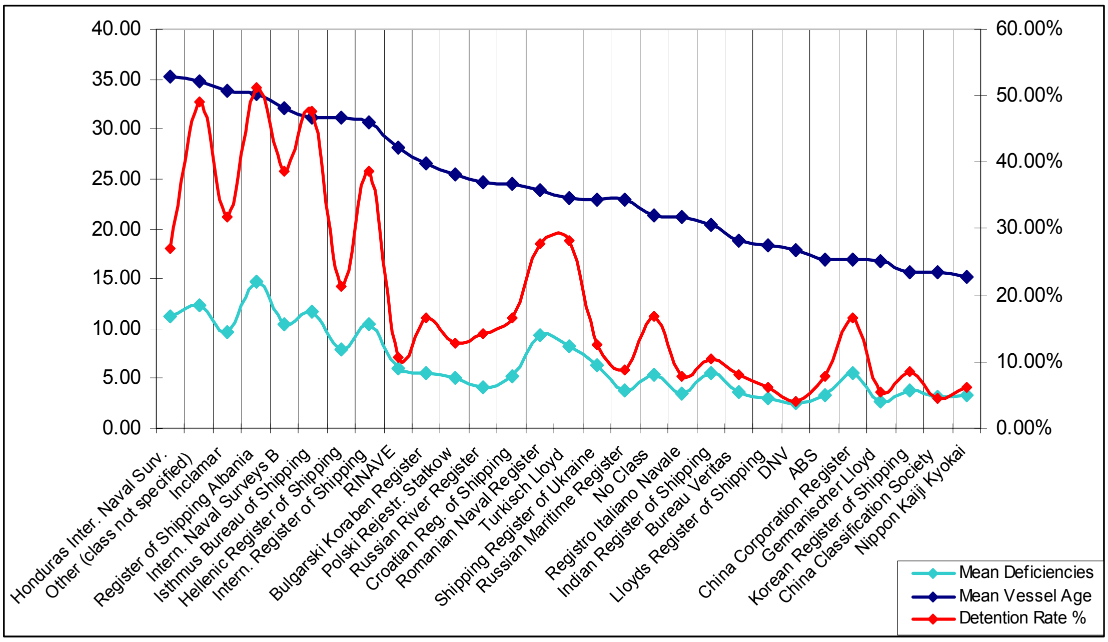
Table 3: EU Recognized versus EU Non-Recognized CS

	Total Inspections	Detained	% of Detentions	Mean Deficiencies	Total Deficiencies
EU not recognized CL	9,940	1,923	19.35%	6.17	61,323
EU recognized CL	66,308	4,350	6.56%	3.16	209,459
Total or Mean %	**76,248**	**6,273**	**8.23%**	**3.55**	**270,782**

Source: Based on whole dataset (May 2000 – May 2004)

Comparing the detention rate to the average vessel age and the average number of deficiencies as shown in Figure 16, one can see that there is somehow a pattern although the movement is not equally strong. It could mean that an older ship automatically does not have a higher rate of deficiencies or a higher rate of detention.

Figure 16: Deficiencies, Age, Detention Rate per Classification Society



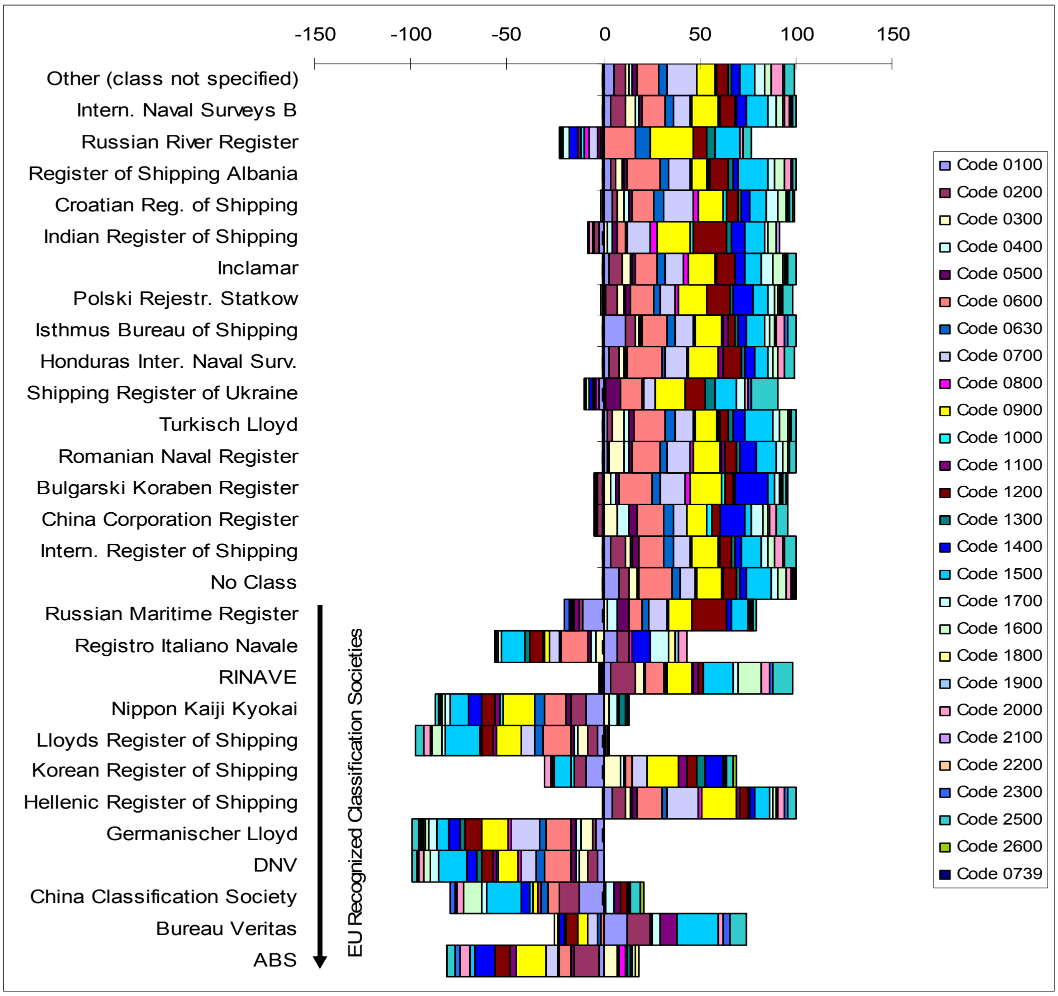
Source: Based on whole dataset (May 2000 – May 2004)

For instance, Turkish Lloyd, Romanian Register and Indian Register have younger ships but the detention rate and the number of deficiencies is relatively high. The same pattern can be seen for China Corporation Register and for the category "No Class". In general, the EU recognized classification societies with the exception of the Hellenic Register of Shipping can be found on the right hand side of the graph with younger ships, a lower mean deficiency rate and a lower detention rate.

Combining this information with the previous graph, it is also interesting to notice that for instance Germanischer Lloyd, Bureau Veritas and the Lloyds Register of Shipping have lower detention and deficiency rates despite the high amount of general cargo ships and bulk carriers which gives a certain indication of quality. Some other classification societies show a relatively high amount of detention and deficiencies, such as Turkish Lloyd, the International Naval Survey B., the Register of Albania, the International Register of Shipping, Inclamar, Honduras International Naval Survey or Isthmus Bureau of Shipping. These class societies also have a high relation of general cargo and bulk carriers to the total ships inspected within their class.

To compare the actual performance of the classification societies with each other, the difference of the mean deficiencies per main code (plus two sub-codes) to the total mean deficiencies for all classification societies was computed and graphed and the result is visualized in Figure 17.

Figure 17: Mean Deficiencies to Total Mean Deficiencies by Class



Source: Based on whole dataset (May 2000 – May 2004)

It has been sorted into two groups – classification societies recognized by the EU and the rest. The graph confirms that classification societies which are recognized by the EU perform better compared to the rest. However, one can see that there are variations within this group and that there are some such as RINAVE, the Korean Register of Shipping, the Hellenic Register of Shipping and Bureau Veritas which have more violations against certain codes than the average.

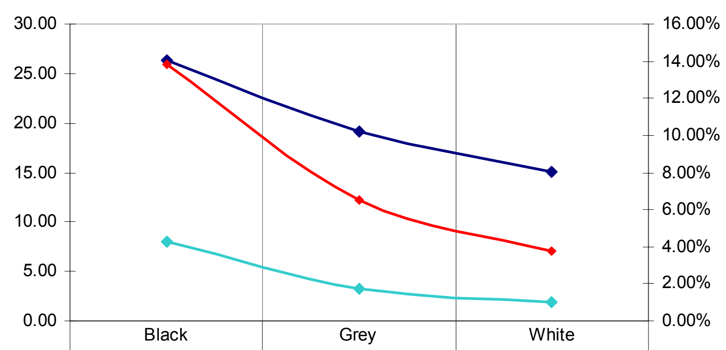
One way to evaluate the differences in performance amongst EU recognized classification societies is to link detention or number of total deficiencies with the flag states (white, grey or black) and the classification society in order to see how a certain class performs for a ship owner with a vessel that is flying a black listed flag versus a grey listed or white listed flag. These differences have been visualized and can be seen in Appendix 6 for the detention rate and Appendix 7 for the mean number of deficiencies. The graphs show that there is a difference of performance within the same class depending on the flag of the vessel. Another perspective for the evaluation of the classification societies will be given based on one of the binary logistic models which provide the probability of detention with class related deficiencies and can be seen under section 3.4.1.

3.1.4. Flag States

The analysis for the flag states is the most interesting and most important one since it gives an indication on what to expect in the regression analysis. First the ship types where grouped according to the flag states and the result can be seen in Appendix 8: Ship Type and Flag States. This split up is very interesting and will be correlated with detentions and deficiencies in the next section.

Analyzing deficiencies and detentions per flag state, the highest detention rate lies within the flag states which are classified as "black" followed by the category "grey" and finally "white". However the three items do not move completely in line with the detention rate as visualized in Figure 18.

Figure 18: Black, Grey and White Flag States Compared



	Black	Grey	White
Mean Deficiencies	7.95	3.26	1.93
Mean Vessel Age	26.36	19.18	15.11
Detention Rate %	13.86%	6.49%	3.75%

Source: Based on whole dataset (May 2000 – May 2004)

"Black" flag states show a higher detention rate in relation to the number of deficiencies than "grey" and "white" flag states indicating that the type of deficiency is important for detention and not only the number of deficiencies. The same analysis was done for each flag state individually and can be seen in Appendix 9: Deficiencies, Age, Detention Rate per Flag State. The graph has been sorted into black, grey and white listed flag states.

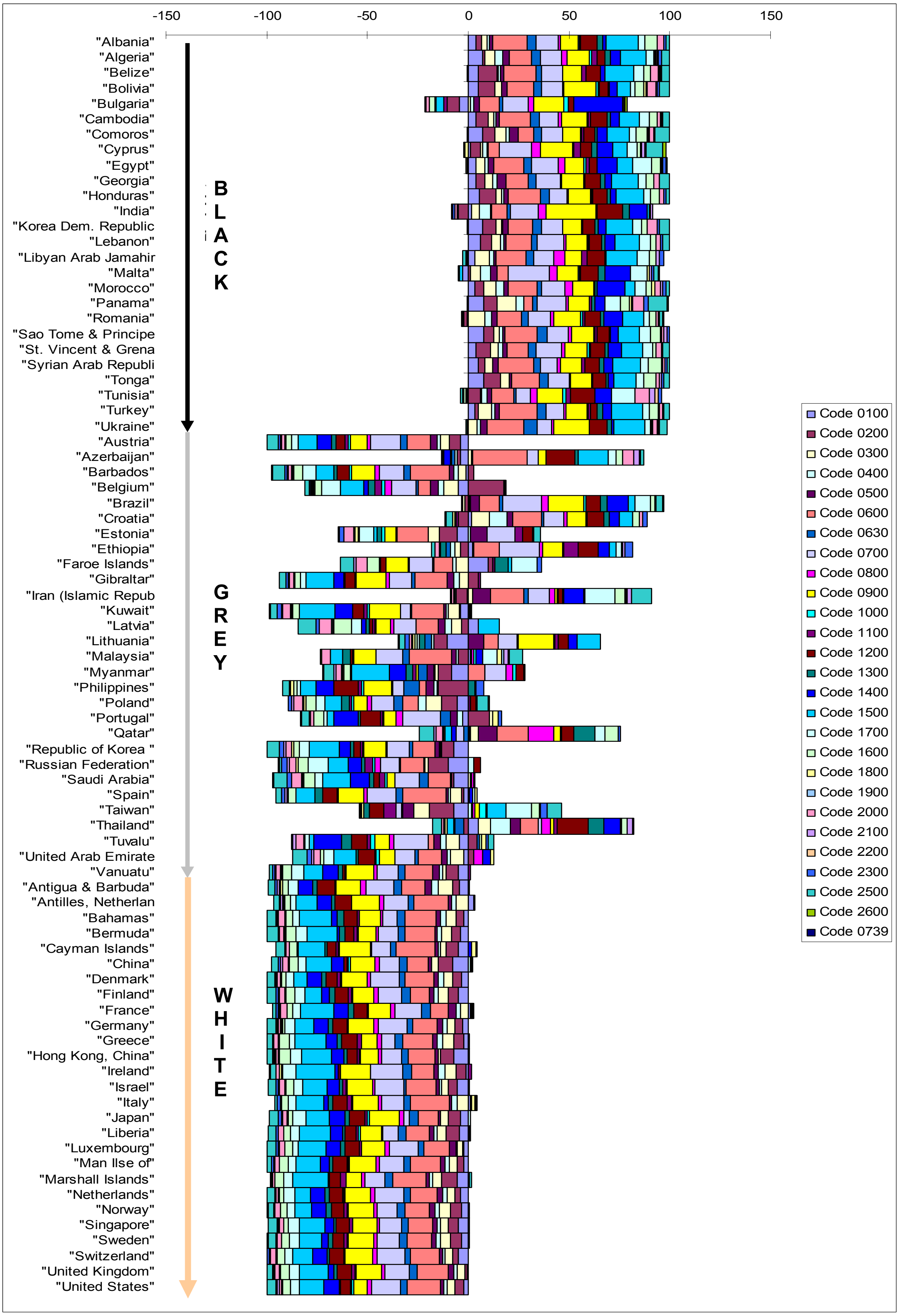
Most interesting to notice is that each group has some older ships and some younger ships meaning that the ship age is not the only indication for performance. In general, the graph shows that black flag states show a high detention rate and a higher average number of deficiencies compared to the grey and white flag states. Black flagged ships are older than the average vessel age of 19 years. However, one can also see that there are variations amongst the black flag states and that not all flag states with old ships have a very high detention rate.

Correlating this information with ship types, some flag states with high general cargo and bulk carriers such as Antigua, Cyprus or Malta do not have a high detention rate while other such as St. Vincent and the Grenadines or Turkey do have a high amount of general cargo ships and bulk carriers and a high detention rate.

The next section looks at the deficiency codes in detail. First a split per code in relation to the total number of deficiencies for each flag state and was made and can be seen in Appendix 10: % of Deficiencies to Total Deficiencies per Flag State. Certain codes show a higher frequency across all flag states such as code 600 (life saving appliances), 700 (fire safety), 900 (structural safety), code 1500 (safety of navigation) and to a certain extend code 1700 (Marpol Annex I) and code 1400 (propulsion & aux. engines). Those are all safety related codes and although there are some variations of the violations across the flag states, it confirms that the frequency of a certain violation of a code compared to the total deficiency of a particular flag state does not vary that much.

Second, to see the actual difference in performance between the flag states, the difference of the mean deficiency per main code to the total mean deficiency per code was calculated and a graph produced which can be seen in Figure 19: Mean Deficiencies to Total Mean Deficiencies by Flag State. All flag states on the right hand side of the graph have more violations than the average and vice versa. It is easy to see that in general, the flag states which are on the black list have more violations on average than the grey and white flag states.

Figure 19: Mean Deficiencies to Total Mean Deficiencies by Flag State



Source: Based on whole dataset (May 2000 – May 2004)

3.1.5. Vessel Ownership Structure

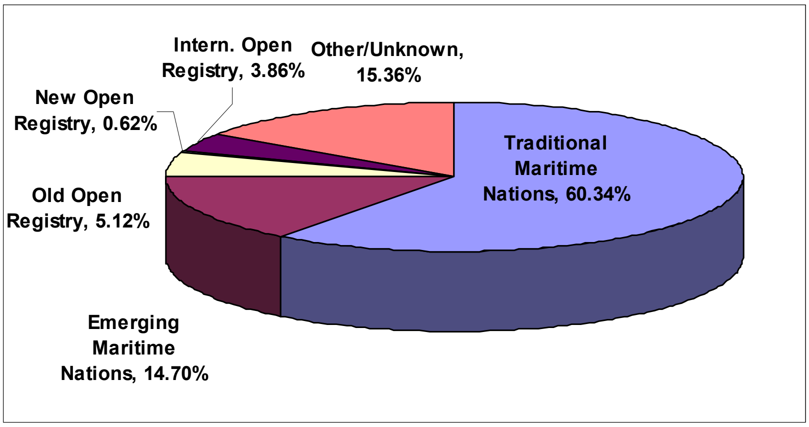
To add another dimension to the analysis, data from Lloyd's Register-Fairplay "World Shipping Encyclopedia (March and April 2004)" was used and information about the owner's country of location was merged with the data provided by the Paris MoU. Out of the 76,248 records, 10,327 records are missing .The results might therefore only bee seen as a general indication but it nevertheless gives some explanatory insight. The countries were grouped into six main groups as follows:

1. *Old Open Registries:* Antigua and Barbuda, Bahamas, Bermuda, Cyprus, Honduras, Liberia, Malta, Marshall Islands, Panama, St. Vincent & the Grenadines
2. *New Open Registries:* Barbados, Belize, Bolivia, Cambodia, Canary Islands, Cayman Islands, Cook Islands, Equatorial Guinea, Gibraltar, Lebanon, Luxembourg, Mauritius, Myanmar, Sri Lanka, Tuvalu and Vanuatu
3. *International Registries:* Anguila, British Virgin Islands, Channel Islands, DIS, Falklands, Faeroes, Hong Kong, Isle of Man, Kerguelen Islands, Macao, Madeira, NIS, Philippines, Sao Tome and Principe, Singapore, Turks and Caicos, Ukraine, Wallis and Fortuna, Netherlands Antilles
4. *Traditional Maritime Nations:* Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Mexico, Netherlands, New Zealand, Norway, Portugal, Russia, South Africa, Spain, Sweden, Switzerland, UK, Uruguay, USA, Venezuela.
5. *Emerging Maritime Nations:* Albania, Algeria, Angola, Azerbaijan, Bahrain, Bangladesh, Benin, Brunei, Bulgaria, Cameroon, Cape Verde, China, Colombia, Comoro, Congo, Costa Rica, Croatia, Cuba, Djibouti, Dominica, Dominican Republic, Egypt, El Salvador, Ecuador, Eritrea, Estonia, Ethiopia, Fiji, Gabon, Gambia, Georgia, Ghana, Grenada, Guatemala, Guinea, Guyana, Haiti, Hungary, India, Indonesia, Iran, Iraq, Israel, Jamaica, Jordan, Kazakhstan, Kenya, Kiribati, North Korea, South Korea, Kuwait, Laos, Latvia, Libya, Lithuania, Madagascar, Malaysia, Maldives, Mauritania, Micronesia, Morocco, Mozambique, Namibia, Nicaragua, Nigeria, Oman, Pakistan, Papua New Guinea, Paraguay, Peru, Poland, Qatar, Romania, St. Helena, St. Kitts & Nevis, Samoa, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Slovakia, Slovenia, Solomon Islands, Somalia Republic, Sudan, Surinam, Syria, Taiwan, Tanzania, Thailand, Togo, Trinidad, Tunisia, Turkey, Turkmenistan, UAE, Vietnam, Yemen, Yugoslavia
6. *Other/Unknown:* Undefined by dataset, Unknown (Fairplay), Azores, Cameroon, Greenland, Monaco, Puerto Rico, Serbia & Montenegro, St. Pierre & Miquel

This classification was taken over from Alderton and Winchester (1999) for analyzing the performance of flag states. This reason for division can be described as follows: First, the so called "traditional maritime nations" are expected to have a more complex regulatory framework and are usually but not exclusively the Western European Countries while the emerging maritime nations are mostly developing countries which do not have such a complex framework. Although this might not reflect the regulatory framework of the flag state, it does reflect the attitude of the owner and the level of safety culture the vessel is operating in. The division of the open registries makes also sense since the old open registries also have more rigid guidelines than the newer ones.

The "owner" in Lloyd's Register-Fairplay's database is defined as the true owner (not the registered owner) who has the financial benefits. Management of the vessels technical aspects can also be sub-contracted to a manager who runs the vessel of behalf of the owner. However, for this analysis and to keep it simple, only owner was used since the ultimate responsibility lies with the owner and not enough information was known about charter contracts or technical management contracts. Figure 20 shows the split up of the ownership as defined in the dataset. More than half of the vessels inspected were owned by developed countries (most of which are the traditional maritime nations).

Figure 20: Vessel Ownership Split Up



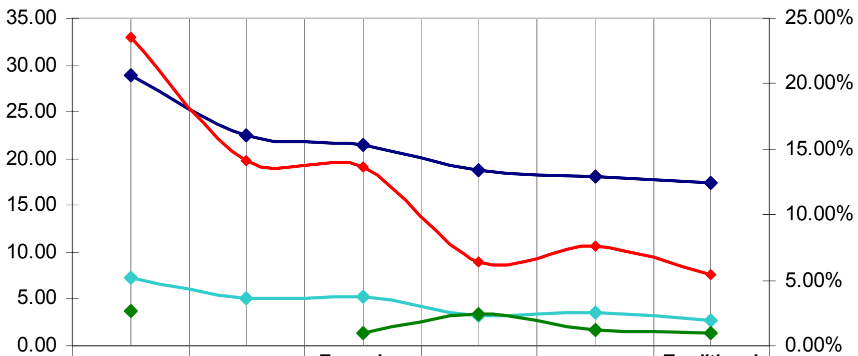
Source: Based on whole dataset (May 2000 – May 2004)

Only a small amount was owned by the open registries and around 15% by emerging maritime nations which include mainly developing countries. Actual ownership of vessels registered under open registries is relatively low and is only around 10%. There are around 15% of the dataset where the owner is not known and therefore the figures can only be seen as a general indication. The split up of these 15% missing data entries is probably between the traditional and the emerging maritime nations.

The next relationship will look at the mean number of deficiencies, the mean vessel age and the detention rate by owner but with the categories defined by Alderton and Winchester (1999). This can be seen in Figure 21. As expected, the traditional maritime nations show a lower deficiency and detention rate. In the dataset, emerging maritime nations show a relatively high amount of detentions and a higher vessel age than open registries or traditional maritime nations. One can further see that there are substantial differences within the open registries and that the new open registries perform the worst. In addition, casualty rates[45] were added to the analysis as an additional indication. The new open registries perform the worse and have the highest detention rate compared to the other categories. Old open registries perform similar to the traditional maritime nations and actually slightly outperformed the international open registries.

[45] Alderton and Winchester (1999) based on Lloyd's Casualty Database for the years 1997-1999

Figure 21: Deficiencies, Age, Detention Rate per Owner



	New Open Registry	Other/Unknown	Emerging Maritime Nations	Old Open Registry	Intern. Open Registry	Traditional Maritime Nations
Mean Vessel Age	28.97	22.49	21.56	18.78	18.13	17.43
Mean Deficiencies	7.21	5.09	5.18	3.16	3.55	2.76
Casualty Rate	3.64		1.37	3.41	1.62	1.32
Detention Rate %	23.58%	14.13%	13.65%	6.43%	7.65%	5.43%

Source: Based on whole dataset (May 2000 – May 2004)

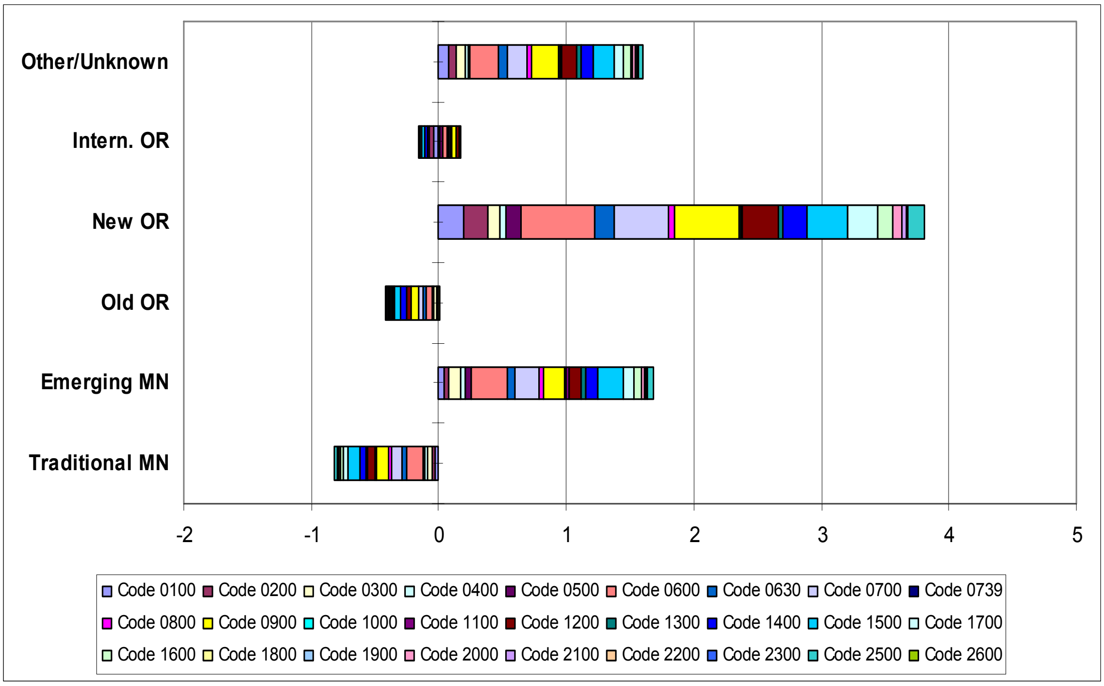
The next section of this analysis will look at the main codes and performance and can be seen in Figure 22. This graph visualizes the difference of the mean of each of the deficiency main codes (plus two sub-codes) to the total mean deficiency rate for each code. In this way, one can see the difference in performance of the vessels per country of ownership.

It shows that vessels that are owned by new open registries have more violations than the average. This is within a whole array of codes starting from 100 (ship's certificates) to 200 (crew certificates) to the more important codes such as code 600 (life saving appliances) and 630 (launching equipment for survival craft), code 700 (fire safety measures), code 900 (structural safety), code 1200 (load lines), code 1400 (propulsion), code 1500 (safety of navigation), code 1700 (Marpol Annex I which deals with oil pollution), code 1600 (radio communications) and finally code 2500 (ISM code) which reflects crew and management responsibilities and attitudes. Interesting to see is that International registries perform slightly worse than old open registries.

The emerging maritime nations are second in line after the new open registries with violations against similar codes. This graph summarizes the assumption that the owner is crucial to safety and that a certain level of safety culture is more established within the traditional maritime nations and to some extend the old open registries. Flying the flag of an open registry does not automatically mean that the ship will be worse. It also depends on who owns or manages the vessel.

The final section of this analysis will give a different inside into the question of vessel management as it will correlate the owner with the classification societies and with the flag states as can be seen in Table 4 and is only based on detained vessels.

Figure 22: Mean Deficiencies to Total Mean Deficiencies by Owner



Source: Based on whole dataset (May 2000 – May 2004)

This relationships show that 15.58% of all detained vessels of owners from new open registries had classification societies that are not recognized by the EU and out of this detentions, 21.26% were flying flags listed on the black list of the Paris MoU.

Table 4: Owner with Classification and Flag States for Detained Ships

based on Vessels Detained	Total Detentions	EU Recog. Classification	EU Non Recog. Classification
Traditional MN	2500	4.68%	0.76%
Emerging MN	1530	8.41%	5.24%
Old OR	251	4.87%	1.56%
New OR	112	8.00%	15.58%
Intern. OR	225	5.78%	1.87%
Other/Unknown	1655	7.33%	6.80%
Total	**6273**	**5.71%**	**2.52%**
based on Vessels Detained	**Paris MoU FS_BlackList**	**Paris MoU FS_GreyList**	**Paris MoU FS_WhiteList**
Traditional MN	2.64%	0.62%	2.17%
Emerging MN	11.91%	0.83%	0.91%
Old OR	4.69%	0.28%	1.46%
New OR	21.26%	1.89%	0.42%
Intern. OR	6.36%	0.20%	1.09%
Other/Unknown	11.36%	1.39%	1.37%
Total	**5.71%**	**0.74%**	**1.77%**

Source: Based on whole dataset (May 2000 – May 2004)

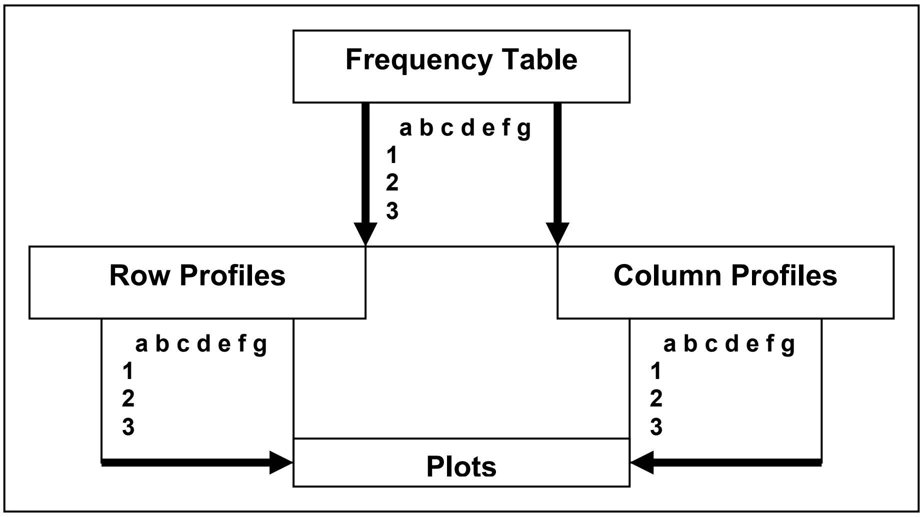
Out of all detentions in the dataset, one can see that the correlation between owner and the performance of the flag state can be seen easily as flag state enforcement is minimal.

The following section of this analysis will try to summarize the relationships shown under the descriptive analysis and will try to give a visualization of the latter. For this technique, correspondence analysis will be used.

3.1.6. Correspondence Analysis

Correspondence analysis is a powerful tool in order to make relationships between variables visible and easier to interpret. These relationships can best be described as correlation between the variables. In essence, it can deal with large contingency (frequency) tables and plot distances in a two-dimensional space where the distance between the variables in question represents the association between them. The process of calculation contains various stages for each set of variable as illustrated in Figure 23.

Figure 23: Analytical Process of Correspondence Analysis



Source: Clausen, S. (1998), Applied Correspondence Analysis, page 4

The data source is the frequency or contingency table. In the present analysis and due to the numerous amount of variables, the variables were grouped together in order to reduce the size of the contingency table. The grouping was done as follows:

- *Flag states:* grouped into the three categories used by the Paris MoU – white, grey and black flag states
- *Classification societies:* split into EU recognized and EU non-recognized classification societies
- *Owners:* grouped the same way as in the previous section namely in traditional maritime nations, emerging maritime nations, old open registries, new open registries, international open registries and the category “unknown” for missing entries.
- *Deficiency Codes:* all main codes plus 2 sub-codes

Based on the contingency table, the *relative frequencies* (or conditional proportions) and the *marginal proportions* (critical masses) are calculated for the rows and columns and in this way, the row and column profiles are created. Each profile can be represented as a point in space. The average profile is the weighted average and is also the point of origin. The further a point is away from this point of origin (also called *centroid*), the more different it is from the average profile.

In order to plot the distances, the best possible fit of the axis to the point has to be found. To measure this closeness, the *weighted sum of the squared distances*[46] from the points to the axis is used. For the purpose of this analysis, two dimensional plots were used. The variance in correspondence analysis is called *inertia* and measures to what extent the points are spread around the average profile.

For the purpose of this analysis, two plots were used to interpret the relationships. Figure 24 and Figure 25 analyze the relationship between the deficiency codes, the flag states, the owner and the classification societies.

In total, there are 26 columns (the 25 main deficiency codes plus one sub-code) and 11 row variables. Sub-code 739 was identified as an outlier and left out of the analysis since it did not have enough counts of frequencies. The analysis shows that 76.8% of the variance is explained by the first dimension and 10.36% of the variance by the second dimension which adds up to a total of 87.23%. The third dimension only adds 4.3% to the variance explained. Therefore, a two dimensional representation is appropriate. The full computer output of the analysis with row and column contributions for each dimension is given in Appendix 11 for further reference.

Looking at Figure 24, the relationships basically summarize and confirm to a certain extend the findings of the descriptive analysis. It shows that ships which are flagged with flags on the "white" list lie in the same direction than traditional maritime nations, old open registries and EU recognized classification societies. This shows that there is a high correlation between these variables. On the other side of the plot, ships that are flagged by "black" listed flag states tend to be closer to "unknown owners" or new open registries and EU non recognized classification societies.

All data points are well represented with the exception of grey flag states, old and new open registries which should therefore be interpreted with caution. Ships owned or managed by unknown owners or emerging maritime nations are more likely be classified by EU non-recognized classification societies and flagged by black listed flag states.

Combining this information with the deficiency codes, Figure 25 gives the overall picture of all relationships. It helps to comprehend the many variables that are involved in the analysis. The plot was divided into two sections by a red line for easier interpretation. The right hand side would reflect "better" performing ships and the left hand side "worse" performing ships.

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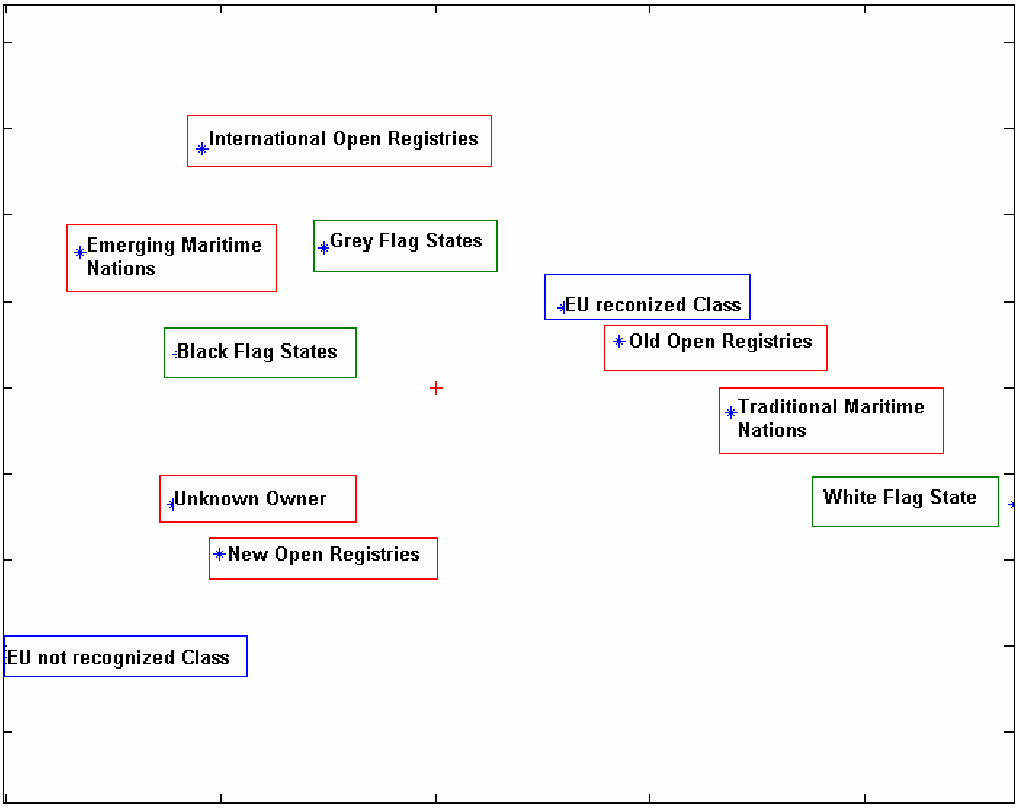
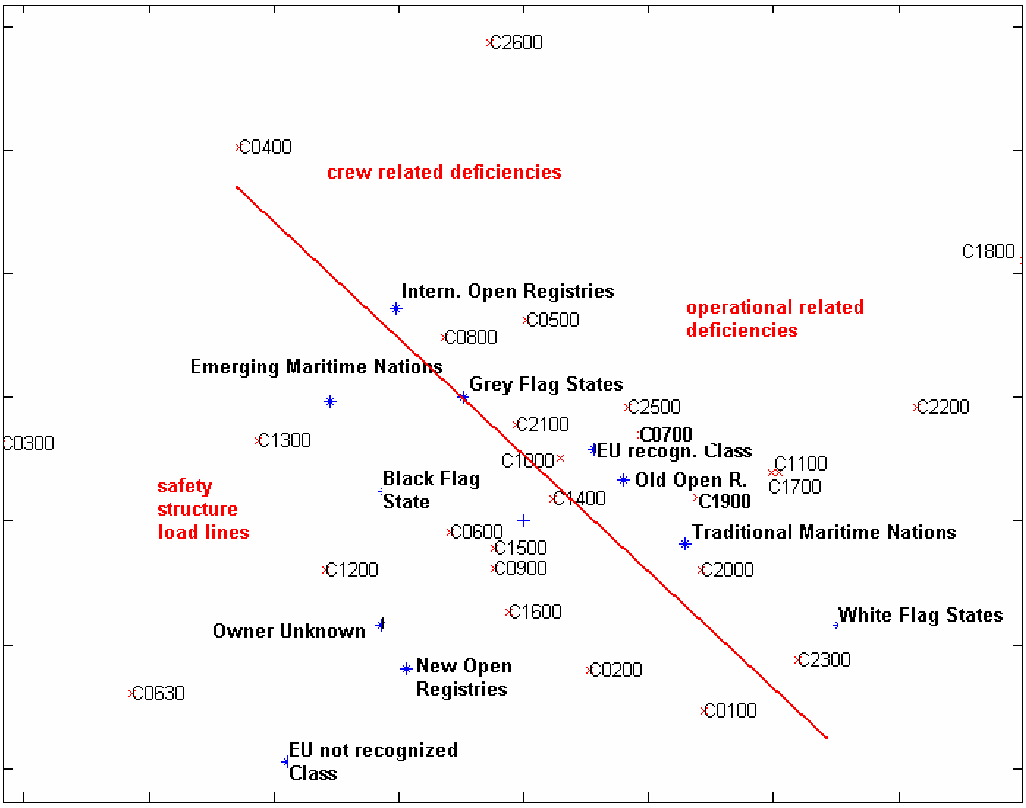
[46] For further explanation, see Clausen, S. (1998), Applied Correspondence Analysis, page 13

Figure 24: Correspondence Analysis: Flag States, Class and Owner



Source: Based on whole dataset (May 2000 – May 2004)

Figure 25: Correspondence Analysis: Deficiency Codes, FS, CL and Owner



Source: Based on whole dataset (May 2000 – May 2004)

Black listed flag states owned by nations from new open registries, emerging maritime nations or unknown owners are more likely to be classified by non EU recognized classification societies and have more violations against the following codes: code 600 (life saving appliances), code 630 (launching equipment for survival craft), code 1200 (load lines), code 1500 (safety of navigation), code 900 (structural safety), code 1600 (radio communications), code 200 (crew certificates and code 100 (ship certificated) although the two latter lie between the two groups.

On the right hand side of the graph, the remaining codes are gathered around ships that are classified by non EU recognized societies, managed by traditional maritime nations or old open registries and are more likely white flagged. There is also an array of deficiency violations but those codes are more related to operational issues. The reason for this could be explained by the fact that a port state control inspector will most likely look for operational deficiencies on a good ship than a bad ship which shows signs of structural deficiencies. This also reflects the kind of ships and the trade flows as it divides general cargo ships and bulk carriers mostly expected to be found on the left hand side from oil tankers or container ships expected to be found on the right hand side.

3.1.7. Major Findings of Descriptive and Correspondence Analysis

The following is a short summary of the major findings of the descriptive analysis and the correspondence analysis in a condensed format:

Overall Relationship – Deficiency Codes

- Descriptive analysis and correspondence analysis show that there is a certain influence on the quality of safety based on a relationship between ship's age, the type of ship, its classification society, the ship's registry and its owner or manager.
- Some ships although older than average age but with good maintenance can perform better than younger ships with worse maintenance.
- The analysis by main and sub-codes shows that certain codes show a higher frequency such as code 600 (life saving appliances), code 700 (fire safety measures), 900 (structural safety), 1200 (load lines), 1400 (propulsion), 1500 (safety of navigation) and 2500 (ISM code). Their relative importance towards detention will be analyzed and visualized using regression.

Ship Types – Port States

- Most ships inspected during the time period in question were general cargo ships (47%), bulk carriers (18%) and container ships (7%) and detention rate was highest with general cargo ships (20%) and bulk carriers (15%) where both categories also show older ships than the average vessel age of around 19 years.
- Detention rate is higher in the south of Europe than in the North where more general cargo ships can be found (e.g. Italy or Spain).
- There is a considerable difference in the variation of detention among port states where the detention rate with 10 or more deficiencies varies from 10.3% to 0.6%. In total, 6% of the ships with 10 or more deficiencies were not detained.

- The mean deficiency rate compared to the overall mean deficiency rate is higher in the South than in the North of Europe meaning that more violations against certain deficiencies can be found in the South than the North which further shows the different emphasis given by port states to deficiencies and detentions.
- The emphasize of a port state control varies per ship and flag since ships which are flagged by black listed flag states show a higher correlation with structural and safety related deficiencies than ships flagged with white or grey flags who are more dominant with operational deficiencies.

Flag States – Classification Societies - Owners

- 60% of all ships that were inspected were owned or managed by a traditional maritime nation compared to 14% of an emerging maritime nation.
- The human factor which is reflected by the safety culture onboard is the key to safety and the human factor is primarily influenced by the crew onboard as well as the overall management and how this management is enforced onboard.
- The expectation that "black" listed flag states perform worse is confirmed.
- The flag state by itself however does not give the only indication since considerable differences in the performances of ships owned by countries from open registries where the new open registries perform the worst.
- 87% of the ships that were inspected were classified by EU recognized classification societies while the remaining 13% accounted for almost 3 times of the % of detentions compared to EU recognized classification societies.
- A considerable difference amongst the EU recognized classification societies with respect to flag (categorized into black, grey and white) can be found. Overall, that performance is worse with black flag states than with white or grey flag states.

3.2. Variable Transformations for Regression Analysis

The following part of the analysis will deal with the regression analysis. This series of analysis is the most important part of the thesis since it provides the answer to the prime research question. Two types of relationships are analyzed. First, linear regression is used to analyze the relationship between the number of deficiencies and the variables which influence the safety quality of a ship and second, binary logistic regression is used to obtain the estimated probabilities of detention of a certain vessel given the variables in question. The same model is then used to suggest weight factors for the main deficiency codes. The model methodologies are explained in detail under each respective model but first, the data assumptions and variable transformations are explained.

The dataset received from the Secretariat of the Paris MoU contained all necessary variables to perform the regression analyses with the exception of the ratification of the IMO and ILO conventions and information about the ownership of a vessel. The legal instruments were added to the dataset based on the ratification status of the flag states and the ship owner's country of location was taken from Lloyd's Register-Fairplay (World Shipping Encyclopedia). Table 5 provides a list of the raw data received and how it was transformed to be used for the regression analyses.

Table 5: Transformation of Raw Data Variables from SIReNaC and Fairplay

Variable	Raw Data Type	Transformed into
IMO#	Number	n/a
Ship Name	Text	n/a
Ship Type	Coded	Dummy variables
Year built	Number	Ln (Vessel age)
Gross Tonnage	Number	Ln (Vessel tonnage)
Flag State	Coded	Dummy variables
Classification Society	Coded	Dummy variables
Port State	Coded	Dummy variables
Total number of deficiencies	Total # of all deficiencies	Ln (deficiencies)
Deficiencies main codes	Frequency of deficiency	Split into 25 variables
Detained	Yes or No	Recoded 1 or 0
Detained with class related deficiencies	Yes or No	Recoded 1 or 0
Ship Owner's Country (from Fairplay)	Text	Dummy variables

The flag states, classification societies, port states and the legal instruments had to be recoded into dummy variables for each respective item. The variable "detained" is split up into two categories. The first variable – "detained", contains all cases and the total dataset for this variable is 76,248 cases. The second variable – "detained with class related deficiencies" contains only the ships that were detained with class related deficiencies and the total dataset for this variable is 6,273 cases.

The deficiency main codes had to be split up using computer programming since the dataset did not provide the frequency of violation of each code separately. After the split up of the data, the resulting table containing each deficiency code separately was merged back into the matrix. The nature of each of these deficiencies can be found in Appendix 5. In addition and since the amount of original variables was quiet extensive for the analysis, the variables were re-grouped and the amounts of variables were reduced from 529 to 201 as shown in Table 6.

Table 6: Variable Grouping

	Original	After Grouping
Dependent Variables	**3**	**3**
Vessel Age	**1**	**1**
Vessel Gross Tonnage	**1**	**1**
Classification Society Type	**62**	**29**
Port State	**20**	**20**
Ship Type	**35**	**19**
Flag State	**203**	**82**
Deficiency main codes	**25**	**25**
IMO/ILO convention ratification	**53**	**15**
Ship Owner's Country	**126**	**6**
Total	**529**	**201**

The selection of the classification societies and the flag states was based on a minimum amount of 30 inspections for the whole time period. The ship types were grouped together as per instructions of the Secretariat of the Paris MoU into similar ship types.

For the IMO and the ILO convention ratification, only the relevant instruments explained in Chapter 2 were used. For the variables age, gross tonnage and total number of deficiencies, the natural logarithm was used since these variables show a wide range which can be seen below.

Table 7: Descriptive Statistics of Selected Variables

	N	Min	Max	Mean	Std. Dev.
VesselAge	76248	0	125	18.98	10.090
GrossTonnage	76248	69	234006	15077.94	20525.768
total_deficiencies	76248	0	105	3.55	6.075
Detained_regardless of type of deficiency	76248	0	1	n/a	n/a
Detained_with class related deficiencies	6273	0	1	n/a	n/a
Valid N (listwise)	76248				

In addition, the detention rate for the total dataset is 8.2% which will be important for the binary logistic regression as the determination for the cut off value. Out of the 6273 detentions, 1168 were with class related deficiencies or 18.6%. A full list of all variables and the respective dummy variables can be found in Table 8 for further detailed reference.

Table 8: Description of Variables used for the Regression Models

Transformed Variables used in Regression	total cases	total count	Description of Variable
ln_totaldeficiencies	76248	n/a	Ln of total # of deficiencies
detained_new	76248	n/a	detained - yes/no
detained_withclass_new	6273	n/a	detained with class related deficiencies
ln_vessel_age	76248	n/a	Ln of vessel age
ln_vessel_tonnage	76248	n/a	Ln of vessel gross tonnage
Classification Societies with > 30 inspections			**Description of Variable**
CL_NoClass	76248	**5153**	No Class Recorded
CL_IRS	76248	137	International Register of Shipping (IS)
CL_ABS	76248	4772	American Bureau of Shipping
CL_ChinaCorp	76248	60	China Corporation Register of Shipping
CL_ChinaClass	76248	600	China Classification Society (Ccs)
CL_BulgarskiKoraben	76248	441	Bulgarski Koraben Registar
CL_BureauVeritas	76248	9532	Bureau Veritas (France)
CL_Hellenic	76248	617	Hellenic Register of Shipping (Greece)
CL_DNV	76248	8993	Det Norske Veritas (Norway)
CL_RomanianNaval	76248	187	Romanian Naval Register
CL_RINAVE	76248	132	RINAVE Portuguesa (Portugal)
CL_GermanischerLloyd	76248	14182	Germanischer Lloyd (Germany)
CL_TurkischLloyd	76248	784	Turkisch Lloyd (Turkey)
CL_KoreanSouth	76248	530	Korean Register of Shipping (South Korea)
CL_SRUkraine	76248	48	Shipping Register of Ukraine
CL_LloydsUK	76248	12742	Lloyd's Register of Shipping (U.K.)
CL_NKKJapan	76248	5557	Nippon Kaiji Kyokai (Japan)
CL_HondurasInterNav	76248	48	Honduras Inter. Naval Surve. and Insp. Bur.
CL_IsthumsBS	76248	42	Isthmus Bureau of Shipping
CL_PolskiReSt	76248	1324	Polski Rejestr Statkow (Poland)

CL_RINA	76248	2299	Registro Italiano Navale (Italy)
CL_Inclamar	76248	123	Inclamar
CL_RussianMS	76248	6484	Russian Maritime Register of Shipping
CL_IndianRegistrar	76248	77	Indian Register of Shipping (India)
CL_CroatianRS	76248	363	Croatian Register of Shipping (Croatia)
CL_RegisterAlbania	76248	133	Register of Shipping (Albania)
CL_RussianRiver	76248	417	Russian River Register
CL_InternNavSurB	76248	363	International Naval Surveys Bureau
CL_OtherClass	76248	108	Other (Class Not Specified)
Port States - total of all cases			**Description of Variable**
PS_Belgium	76248	5738	Belgium
PS_Canada	76248	2852	Canada
PS_Croatia	76248	1646	Croatia
PS_Denmark	76248	2366	Denmark
PS_Finland	76248	1839	Finland
PS_France	76248	4057	France
PS_Germany	76248	6770	Germany
PS_Greece	76248	3512	Greece
PS_Iceland	76248	321	Iceland
PS_Ireland	76248	1352	Ireland
PS_Italy	76248	9523	Italy
PS_Netherlands	76248	5488	The Netherlands
PS_Norway	76248	1959	Norway
PS_Poland	76248	2541	Poland
PS_Portugal	76248	3302	Portugal
PS_RussianFed	76248	5750	Russian Federation
PS_Slovenia	76248	192	Slovenia
PS_Spain	76248	7493	Spain
PS_Sweden	76248	2813	Sweden
PS_UK	76248	6734	United Kingdom
Ship Type - regrouped as per the Paris MoU			**Description of Variable**
ST_BulkCarrier	76248	13424	Bulk Carrier, Cmentcar
ST_ChemicalTanker	76248	2504	Chemical Tanker
ST_Container	76248	5551	Containership
ST_Factory	76248	68	Factory Ship
ST_GasCarrier	76248	1251	Gas Carrier, Gcar.lpg, Gcar.lng
ST_GeneralCargo	76248	35547	Unit.Ves, Barge Car, Pall.Car, General Cargo - Multipurpose ship, Livestock Carrier
ST_HSPax	76248	58	H.S. Passenger Craft
ST_HeavyLoad	76248	53	Heavy load carrier
ST_MobileOffsh	76248	16	Mobile Offshore Drilling Unit
ST_OBO	76248	447	Combination Carrier (OBO)
ST_Offshore	76248	661	Offshore Service Ship, Stbyship
ST_OilTanker	76248	4922	Oil Tanker
ST_Other	76248	788	Icebreaker, Research Ship, Cutdredg, Dyncraft, Other
ST_Passenger	76248	1275	Passenger Ship
ST_ReeferCargo	76248	1346	Refrigerated Cargo Carrier
ST_RoRoCargo	76248	4035	Vehi. Car, Ro-ro Cargo Ship
ST_RoRoPax	76248	1264	Roro Passenger Ship
ST_SpecialPur	76248	245	Special Purpose ship
ST_Tanker	76248	2793	Tankship +cc, Tanker, Vegetank

Flag States with > 30 inspections			Description of Variable
FS_Albania	76248	260	Albania
FS_Algeria	76248	263	Algeria
FS_NetherlandsAntilles	76248	629	Antilles, Netherlands
FS_Antigua	76248	5038	Antigua and Barbuda
FS_Austria	76248	95	Austria
FS_Azerbaijan	76248	169	Azerbaijan
FS_Bahamas	76248	4211	Bahamas
FS_Barbados	76248	343	Barbados
FS_Belgium	76248	41	Belgium
FS_Belize	76248	477	Belize
FS_Bermuda	76248	266	Bermuda
FS_Bolivia	76248	105	Bolivia
FS_Brazil	76248	50	Brazil
FS_Bulgaria	76248	372	Bulgaria
FS_Myanmar	76248	44	Myanmar
FS_CaymanIslands	76248	464	Cayman Islands
FS_China	76248	355	China
FS_Comoros	76248	91	Comoros
FS_Croatia	76248	225	Croatia
FS_Cyprus	76248	5017	Cyprus
FS_Cambodia	76248	1211	Cambodia
FS_Denmark	76248	1713	Denmark
FS_Egypt	76248	249	Egypt
FS_Estonia	76248	374	Estonia
FS_Ethiopia	76248	44	Ethiopia
FS_FaroeIslands	76248	60	Faroe Islands
FS_Finland	76248	657	Finland
FS_France	76248	336	France
FS_Georgia	76248	459	Georgia
FS_Germany	76248	1683	Germany
FS_Gibraltar	76248	512	Gibraltar
FS_Greece	76248	1960	Greece
FS_Honduras	76248	275	Honduras
FS_HongKong	76248	796	Hong Kong,china
FS_India	76248	221	India
FS_Iran	76248	287	Iran Islamic Republic of
FS_Ireland	76248	234	Ireland
FS_Israel	76248	75	Israel
FS_Italy	76248	1093	Italy
FS_Japan	76248	94	Japan
FS_KoreanDR	76248	126	Korea Democratic People's Rep.
FS_SouthKorea	76248	138	Korea Republic of
FS_Kuwait	76248	48	Kuwait
FS_Latvia	76248	65	Latvia
FS_Lebanon	76248	289	Lebanon
FS_Liberia	76248	3534	Liberia
FS_Libya	76248	50	Libyan Arab Jamahiriya
FS_Lithuania	76248	483	Lithuania
FS_Luxembourg	76248	249	Luxembourg
FS_Malaysia	76248	205	Malaysia
FS_Malta	76248	6175	Malta
FS_IsleofMan	76248	810	Man Isle of

FS_MarshallIslands	76248	842	Marshall Islands
FS_Morocco	76248	246	Morocco
FS_Netherlands	76248	3916	Netherlands
FS_Norway	76248	3475	Norway
FS_Panama	76248	7186	Panama
FS_Philippines	76248	271	Philippines
FS_Poland	76248	236	Poland
FS_Portugal	76248	848	Portugal
FS_Qatar	76248	37	Qatar
FS_Romania	76248	236	Romania
FS_RussianFeder	76248	3312	Russian Federation
FS_StVincentGren	76248	3184	St Vincent and the Grenadines
FS_SaoTomePrin	76248	99	Sao Tome and Principe
FS_SaudiArabia	76248	77	Saudi Arabia
FS_Singapore	76248	847	Singapore
FS_Spain	76248	316	Spain
FS_Sweden	76248	1171	Sweden
FS_Switzerland	76248	80	Switzerland
FS_SyrianAraRep	76248	451	Syrian Arab Republic
FS_Taiwan	76248	63	Taiwan
FS_Thailand	76248	139	Thailand
FS_Tonga	76248	136	Tonga
FS_Tunisia	76248	61	Tunisia
FS_Turkey	76248	3236	Turkey
FS_Tuvalu	76248	60	Tuvalu
FS_Ukraine	76248	926	Ukraine
FS_UK	76248	1378	United Arab Emirates
FS_UnitedArabEmi	76248	50	United Arab Emirates
FS_USA	76248	187	United States of America.
FS_Vanuatu	76248	162	Vanuatu
Deficiencies Main and Sub- Codes			**Description of Variable**
Code 0100	76248	n/a	Ship's certificates and documents
Code 0200	76248	n/a	Crew certificates
Code 0300	76248	n/a	Accommodation
Code 0400	76248	n/a	Food and catering
Code 0500	76248	n/a	Working spaces and accident prevention
Code 0600	76248	n/a	Life saving appliances
Code 0700	76248	n/a	Fire Safety measures
Code 0800	76248	n/a	Accident prevention (ILO147)
Code 0900	76248	n/a	Structural Safety
Code 1000	76248	n/a	Alarm signals
Code 1100	76248	n/a	Cargoes
Code 1200	76248	n/a	Load lines
Code 1300	76248	n/a	Mooring arrangements (ILO 147)
Code 1400	76248	n/a	Propulsion & aux.
Code 1500	76248	n/a	Safety of navigation
Code 1600	76248	n/a	Radio communications
Code 1700	76248	n/a	MARPOL annex I
Code 1800	76248	n/a	Gas and chemical carriers
Code 1900	76248	n/a	MARPOL annex II
Code 2000	76248	n/a	Operational deficiencies
Code 2100	76248	n/a	MARPOL related operational deficiencies
Code 2200	76248	n/a	MARPOL annex III

Code 2300	76248	n/a	MARPOL annex V
Code 2500	76248	n/a	ISM related deficiencies
Code 2600	76248	n/a	Bulks carriers
Legal Instruments - IMO and ILO			**Description of Variable**
LI_SOLASConv74	76248	55812	Intern. Conv. for the Safety of Life at Sea, 1974
LI_SOLASProt78	76248	69015	Protocol relating to SOLAS (74), 1978
LI_SOLASProt88	76248	57623	Protocol relating to SOLAS (74), 1988
LI_LOADLINESConv66	76248	73947	Intern. Conv. on Load Lines, 1966
LI_LOADLINESProt88	76248	56934	Protocol relating to LOAD LINES (66), 1988
LI_TONNAGEConv69	76248	73648	Intern. Conv. on Tonnage Measurements, 1969
LI_COLREGConv72	76248	73337	Intern. Conv. on the Intern. Regulations for Preventing Collisions at Sea, 1972
LI_STCWCon72	76248	73947	Intern. Conv. on Standards of Training, Certification and Watchkeeping for Seafarers, 1978
LI_MARPOL73_78AnI-II	76248	73073	Annex I: Oil, Annex II: Noxious Liquid Substances
LI_MARPOL73_78AnIII	76248	63322	Annex III: Harmful Substances in Packaged Form
LI_MARPOL73_78AnIV	76248	42992	Annex IV: Sewage
LI_MARPOL73_78AnV	76248	72503	Annex V: Garbage (Plastic)
LI_CLCProt92	76248	69437	Intern. Conv. On Civil Liability for Oil Pollution Damage, 1992
LI_ILO147MinStandConv1976	76248	45588	Merchant Shipping (Minimum Standards) Convention, 1976 - ILO
LI_ILO147Prot1996	76248	18446	Protocol to ILO(147), 1996
Owner Groupings (See Section 3.1.5. for details)			**Description of Variable**
OWN_TraditionalMN	76248	48325	Traditional Maritime Nations
OWN_EmergingMN	76248	11104	Emerging Maritime Nations
OWN_OldOR	76248	1773	Old Open Registries
OWN_NewOR	76248	506	New Open Registries
OWN_InternOR	76248	2530	International Open Registries
OWN_OtherUnkn	76248	12010	Other or Unknown cases

3.3. Linear Regression Model

The linear regression model is used to analyze the relationship between the total number of deficiencies and a series of independent variables in order to predict the total number of deficiencies. This should give an insight into what variables have an influence on the total number of deficiencies. Linear regression is appropriate to use in this case since the dependent variable is continuous in nature. The variable of interest to the regression in this model is the conditional mean given a certain matrix and the model can be expressed in the following form where the independent variables are listed in Table 9 for easier identification:

$$ln(Y_i) = \beta_0 + \beta_1 ln(AGE) + \beta_2 ln(SIZE) + \sum_{i=1}^{29} \beta_i CL_i + \sum_{i=1}^{82} \beta_i FS_i + \sum_{i=1}^{19} \beta_i ST_i + \\ + \sum_{i=1}^{15} \beta_i LI_i + \sum_{i=1}^{20} \beta_i PS_i + \sum_{i=1}^{6} \beta_i OWN_i + \varepsilon_i$$

Table 9: Linear Regression Model: List of Variables

Variables		# of var.	value	remarks
Dependent	# of total deficiencies	1	continuous	ln is used
AGE	Vessel Age	1	continuous	ln is used
SIZE	Vessel Size	1	continuous	ln is used
CL	Classification Society Type	29	1 or 0	dummy variable
FS	Flag State	82	1 or 0	dummy variable
ST	Ship Type	19	1 or 0	dummy variable
LI	IMO & ILO Conventions	15	1 or 0	dummy variable
PS	Port State Country	20	1 or 0	dummy variable
OWN	Ship's Owner Country	6	1 or 0	dummy variable
	Total	**173**		

In total, the model has 173 independent variables plus the constant β_0. Most of these variables are recoded into dummy variables with the exception of age and size where the natural logarithm is used as well as for the dependent variable. Around half (43.25%) of all inspections have zero deficiencies which turned out to be one of the focus points for finding the best sample for this model since it had an influence on the distribution of the error term (residuals). The error term turned out not to be normally distributed if the sample used too many inspections with zero deficiencies.

A 10% significance level is used for the testing of the significance of the parameters since a 10% chance of a type I error was assumed to be adequate in this model. The type I error is committed when a true null hypothesis is rejected. This means that the coefficient is believed to be significant when it actually is not significant or in other words, the variable is believed to influence the total number of deficiencies when it actually does not have an influence.

Autocorrelation is not assumed to be a problem with the matrix in question since one port state control inspection with associated number of deficiencies does not influence another port state control inspection and associated number of deficiencies of a different ship. The legal instruments were excluded from the analysis after detecting that they were the source of multicollinearity with the flag states. Five models are evaluated based on various sample sizes including a variation on the number of deficiencies and the results can be seen in Table 10.

In order to find the best possible model, the samples for the models are based on several variations of the number of deficiencies. Model A is a random selection from the whole dataset which represents the normal amount of zero deficiencies (43%). Model B and C are based on either detained ships or not detained ships since this influences the number of zero deficiencies. Model D is based on all cases that have more than zero deficiencies and model E is a combination with reduced amount of zero deficiencies (25%).

In order to choose the best final model, the following criteria are taken into consideration:

1. Overall fit of the model based on R^2
2. Normal distribution of the residuals (ε)

3. Interpretation and significance of the coefficients based on some of the results of the descriptive statistics and correspondence analysis
4. Root mean square prediction error[47]

Table 10: Linear Model Testing: General

Model Name	Model A	Model B	Model C	Model D	Model E
Total cases used	15,459	6,273	14,623	43,270	57,693
Zero deficiencies	6,646	0	6,888	0	14,423
Zero def in %	43.00%	0.00%	47.10%	0.00%	24.90%
Detained	n/a	6,273	0	n/a	n/a
Not Detained	n/a	0	14,623	n/a	n/a
Method Used	Backward	Backward	Backward	Manual	Manual
Selection Criteria	Random	Detained	Not Detained	All cases > 0 def.	reduced 0 def.
Model Summary & Residuals					
R square	0.237	0.219	0.184	0.1777	0.219
ANOVA - F statistic	26.71	25.26	43.60	105.52	153.35
(Significance)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Residuals Normally Distr.	no	yes	no	yes	yes
Model Prediction: Root Mean Squared Prediction Error					
Black	0.525	0.772	1.043	0.612	0.873
Grey	0.583	0.629	0.757	0.562	1.069
White	0.793	0.621	0.771	0.621	0.943
Total	**1.900**	**2.023**	**2.570**	**1.794**	**2.885**

Model A and C do not pass the criteria that the residuals are normally distributed although their model summary statistics indicate that the model does have some explanatory power. This leaves model B, D and E for final selection. From these three models, the R^2 and ANOVA statistics are acceptable given the amount of cases and variables the models contain. It further indicates that all of these models do have some explanatory power. These statistics cannot be compared across the models since the models do have different sample sizes. Out of the five models, model D shows the best results due to the lowest root mean squared prediction error.

One can identify a certain amount of *heteroskedasticity* in all models from plotting the residuals against the total number of deficiencies. If heteroskedasticity is present, the variance of the residuals is not constant but varies. It can normally occur due to the difference in the size of the observations of the dependent variables. This is why the natural logarithm was used for age and size. The consequence of heteroskedasticity is that the OLS[48] estimators are no longer the most efficient linear estimators and this can lead to an over or underestimation of the results of the models since the standard errors are not constant and this influences the t-statistics which means that some parameters might not be significant in the model although they actually are or vice versa.

[47] The root mean square prediction error is based on 50 randomly chosen ships with white, grey and black flags. It is calculated by calculating the mean of the squared residual terms of the 50 chosen ships and by taking the square root of this figure. The lowest result has the best predictive power.

[48] OLS: ordinary least squares

A remedy for heteroskedasticity is to use weighted least squares (WLS) for the estimation of the parameters. This was tested for the two continuous variables – age and gross tonnage in the model. The models were compared against model D and the result is shown in Table 11. Neither of the models using weighted least squares for estimation show a better result which means that model D is selected for the final model and coefficient testing. It further means that heteroskedasticity, although present to a certain degree does not influence the parameters of the coefficients significantly and that model D cannot be further improved.

Table 11: Linear Model Testing: Weighted Least Squares

Model Name	Model D	WLS1	WLS2
Weight variable	*n/a*	*age*	*gross tonnage*
Total cases used	43,270	43,270	43,270
Zero deficiencies	0	0	0
Zero def in %	0.00%	0.00%	0.00%
Detained	n/a	n/a	n/a
Not Detained	n/a	n/a	n/a
Method Used	Enter	Enter	Enter
Selection Criteria	All cases > 0 def.	All cases > 0 def.	All cases > 0 def.
Model Summary & Residuals			
R square	0.1777	0.146	0.178
ANOVA - F statistic	105.52	48.34	61.41
Significance	0.00	0.00	0.00
Residuals Normally Distributed	yes	yes	yes
Root Mean Squared Prediction Error			
Black	0.612	0.837	0.834
Grey	0.562	0.585	0.605
White	0.621	0.638	0.659
Total	**1.794**	**2.059**	**2.097**

The coefficients of model D seems to give a good indication of the relationships and are therefore used for the final testing of the model. In addition, model D has the best predictive value since it has the lowest root mean squared prediction error. A full summary of the computer software output (SPSS[49]) including the relevant plots for this model can be found in Appendix 12. The coefficients for this model are shown below in Table 12.

Table 12: Coefficients for Model D - Linear

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.987	.027		35.967	.000
ln_vessel_age	.269	.006	.207	42.546	.000
CL_NoClass	-.078	.018	-.028	-4.260	.000
CL_ABS	-.190	.020	-.062	-9.673	.000

[49] SPSS: software used for the regression models, version 12

CL_ChinaClass	-.181	.041	-.021	-4.389	.000
CL_BureauVeritas	-.164	.017	-.077	-9.522	.000
CL_DNV	-.220	.019	-.090	-11.658	.000
CL_RomanianNaval	.242	.057	.019	4.288	.000
CL_GermanischerLloyd	-.235	.018	-.124	-13.179	.000
CL_KoreanSouth	-.138	.042	-.016	-3.303	.001
CL_LloydsUK	-.178	.017	-.088	-10.349	.000
CL_NKKJapan	-.214	.020	-.076	-10.815	.000
CL_IsthumsBS	.229	.114	.009	2.016	.044
CL_PolskiReSt	-.146	.027	-.028	-5.405	.000
CL_RINA	-.222	.026	-.054	-8.544	.000
CL_RussianMS	-.209	.020	-.085	-10.375	.000
CL_CroatianRS	-.114	.044	-.012	-2.601	.009
CL_RussianRiver	-.165	.044	-.018	-3.758	.000
PS_Belgium	-.081	.015	-.027	-5.323	.000
PS_Canada	-.133	.022	-.028	-5.977	.000
PS_Croatia	-.449	.023	-.090	-19.220	.000
PS_Denmark	-.447	.024	-.085	-18.464	.000
PS_Finland	-.406	.027	-.070	-15.237	.000
PS_France	-.250	.016	-.077	-15.777	.000
PS_Germany	-.175	.013	-.067	-12.997	.000
PS_Greece	-.183	.017	-.053	-10.603	.000
PS_Iceland	-.340	.052	-.029	-6.506	.000
PS_Ireland	.063	.024	.012	2.639	.008
PS_Italy	-.087	.012	-.041	-7.191	.000
PS_Netherlands	.121	.015	.041	8.218	.000
PS_Norway	-.445	.025	-.083	-17.987	.000
PS_Poland	-.132	.019	-.033	-7.027	.000
PS_RussianFed	-.207	.014	-.084	-15.225	.000
PS_Spain	-.174	.012	-.076	-14.020	.000
PS_Sweden	-.472	.021	-.105	-22.404	.000
ST_BulkCarrier	.131	.010	.070	12.547	.000
ST_Factory	.369	.095	.017	3.888	.000
ST_GasCarrier	-.083	.031	-.012	-2.676	.007
ST_GeneralCargo	.094	.009	.065	10.854	.000
ST_ReeferCargo	.156	.025	.029	6.344	.000
ST_RoRoPax	.301	.025	.056	12.187	.000
ST_SpecialPur	-.175	.059	-.013	-2.953	.003
FS_Albania	.639	.046	.064	13.799	.000
FS_Algeria	.583	.045	.059	12.964	.000
FS_NetherlandsAntilles	.067	.037	.008	1.825	.068 *)
FS_Antigua	.072	.016	.025	4.512	.000
FS_Azerbaijan	.284	.061	.021	4.651	.000
FS_Bahamas	.062	.016	.019	3.814	.000
FS_Belize	.204	.036	.026	5.696	.000
FS_Bolivia	.630	.070	.040	8.994	.000
FS_Brazil	.537	.106	.022	5.057	.000

FS_CaymanIslands	.084	.046	.008	1.823	.068 *)
FS_Comoros	.652	.075	.038	8.685	.000
FS_Cyprus	.180	.015	.063	12.363	.000
FS_Cambodia	.296	.024	.062	12.240	.000
FS_Egypt	.349	.050	.032	7.047	.000
FS_Ethiopia	.211	.108	.009	1.962	.050
FS_Georgia	.399	.036	.051	11.124	.000
FS_Germany	.053	.028	.009	1.902	.057 *)
FS_Gibraltar	.160	.043	.017	3.739	.000
FS_Greece	.075	.024	.015	3.167	.002
FS_Honduras	.342	.047	.033	7.294	.000
FS_India	.246	.054	.020	4.544	.000
FS_Iran	.233	.051	.021	4.594	.000
FS_Italy	.174	.035	.027	4.923	.000
FS_KoreanDR	.537	.064	.038	8.428	.000
FS_Lebanon	.529	.043	.055	12.203	.000
FS_Liberia	.116	.019	.030	6.225	.000
FS_Libya	.638	.105	.027	6.085	.000
FS_Malaysia	.135	.061	.010	2.212	.027
FS_Malta	.171	.014	.067	12.552	.000
FS_MarshallIslands	.139	.036	.017	3.808	.000
FS_Morocco	.313	.047	.030	6.642	.000
FS_Norway	.065	.019	.017	3.431	.001
FS_Panama	.200	.014	.081	14.777	.000
FS_RussianFeder	.054	.022	.015	2.415	.016
FS_StVincentGren	.252	.016	.078	15.488	.000
FS_SaoTomePrin	.673	.069	.043	9.701	.000
FS_Singapore	.083	.037	.010	2.282	.023
FS_SyrianAraRep	.450	.036	.058	12.586	.000
FS_Thailand	.157	.070	.010	2.240	.025
FS_Tonga	.568	.062	.041	9.148	.000
FS_Tunisia	.258	.100	.011	2.574	.010
FS_Turkey	.378	.017	.123	21.630	.000
FS_Ukraine	.212	.029	.037	7.359	.000
OW_TraditionalMN	-.039	.010	-.027	-3.805	.000
OW_OldOR	-.060	.017	-.018	-3.512	.000
OW_NewOR	.068	.036	.009	1.862	.063 *)
OW_OtherUnk	.040	.012	.021	3.490	.000

a Dependent Variable: ln_totaldeficiencies
*) significant at the 10% significance level, otherwise significant at the 5% significance level

3.3.1. Model Interpretation

The interpretation of this model should only be seen as an indication of the relationships between the variables since the next model, the binary logistic model will give the proof that the type of deficiency matters and not only the amount of deficiency. Therefore more emphasis is placed on the binary logistic model and the limitations of the linear model are explained in section 3.6. Possible Extensions and Limitations of the Analysis.

The model confirms that the age of the vessel is significant but it does not confirm that the size of a vessel is significant for the number of deficiencies. It further confirms that ship type has an influence on the total number of deficiencies such as ship type bulk carrier, factory ships, general cargo ships, reefer cargo ships and Ro-Ro passenger ships which are all significant at the 5% significance level.

For the flag states, most of the “black” listed flag states appear to be significant at the 5% or 10% significance level such as Albania, Algeria, Belize, Bolivia, Brazil, Comoros, Cyprus, Cambodia, Egypt, Georgia, Gibraltar, Honduras, India, Korean Democratic Republic, Lebanon, Libya, Morocco, Panama, St. Vincent and the Grenadines, Sao Tome & Principe and the Syrian Arabian Republic. Very few grey listed flag states are significant but a few white listed are significant such as Antigua, Bahamas, the Netherlands Antilles, Germany, Greece, Liberia, Singapore and even Norway.

In addition, the type of ownership of a vessel matters since ships owned or operated by traditional maritime nations or old open registries have a negative influence on the number of total deficiencies while ships owned by new open registries or from unknown owners have a positive influence on the total number of deficiencies. Difficult to interpret are the classification societies since the model suggests that only two classification societies namely Romanian Naval and Isthmus BS have a positive influence on the number of deficiencies.

Interesting to see is also the difference of the contributions towards the number of deficiencies amongst the port states. Only Ireland and the Netherlands show a positive contribution towards the total number of deficiencies while all other port states show a negative contribution. There are also some significant differences between the coefficients which show that some port states are more likely to issue deficiencies than other port states. It also reflects to a certain extent the trade flows and the different ship types since some northern port states (Denmark, Finland, Iceland, Norway and Sweden) have a significant lower contribution towards the number of deficiencies than for instance Belgium, France, Greece, Italy or Spain – the southern port states. This basically confirms the finding of the descriptive analysis in the previous section.

In order to test the model and to visualize the results, ship profiles are created and the expected number of deficiencies is calculated and graphed against the average number of deficiencies for certain flag states. The result can be seen in Appendix 13: Coefficient Testing, Model D - Linear. The graph shows that the model predicts well for some ships and less well for other ships. It confirms that the model has some predictive qualities and that a certain combination of the variables influence the number of deficiency one can expect to encounter. The next model is the most important model of the analysis. It will provide the estimated probabilities of detention and proof that the type of deficiency matters and not only the number of deficiency.

3.4. Binary Logistic Regression Model

This model will provide probabilities of detention. The dependent variable in this case is "detained" or "not detained". Since the dependent variable is binary in nature and not continuous, the linear model cannot be used and instead, the binary logistic model is used. Firstly, a model with dependent variable "detained (yes/no)" which depicts a detention of a vessel independent of the type of deficiency and secondly, a model with dependent variable "detained with class related deficiencies" in order to evaluate the classification societies separately. The reason for the usage of the binary logistic model is due to the fact that it is flexible and easy to use and can provide a meaningful interpretation.

The binary logistic model allows modeling independent variables onto a binary variable which in this case is 1 for "detained" and 0 for "not detained". The binary logistic model in its end result provides the necessary coefficients in order to computer the *"estimated probabilities of detention"* given a certain combination of ship type, classification society, flag state, port state, deficiency code and ship owner. The model can be written in the following form and for easier identification, the independent variables are listed Table 13:

$$ln\left[\pi(x)/1-\pi(x)\right]_i = \beta_0 + \beta_1 ln(AGE) + \beta_2 ln(SIZE) + \sum_{i=1}^{29}\beta_i CL_i + \sum_{i=1}^{82}\beta_i FS_i + \sum_{i=1}^{19}\beta_i ST_i + $$
$$+ \sum_{i=1}^{15}\beta_i LI_i + \sum_{i=1}^{25}\beta_i CODE_i + \sum_{i=1}^{20}\beta_i PS_i + \sum_{i=1}^{6}\beta_i OWN_i + \varepsilon_i$$

Table 13: Binary Logistic Model: List of Variables

Variables		# of var.	value	remarks
Dependent	Type 1: detained with class related deficiencies	1	1 or 0	binominal
Dependent	Type 2: detained regardless of type of deficiency.	1	1 or 0	binominal
AGE	Vessel Age	1	continuous	Ln is used
SIZE	Vessel Size	1	continuous	Ln is used
CL	Classification Society Type	29	1 or 0	dummy variable
FS	Flag State	82	1 or 0	dummy variable
ST	Ship Type	19	1 or 0	dummy variable
LI	IMO Convention Ratification	15	1 or 0	dummy variable
CODE*)	Deficiency main codes total	25	continuous	frequency
PS	Port State Country	20	1 or 0	dummy variable
OWN	Ships Owner Country	6	1 or 0	dummy variable
	Total for each regression	**198**		

*) in addition, a separate model was used with variable" total number of deficiencies"

The term *ln[π(x)/1-π(x)]* is the logit and *π(x)* denotes the logistic function with probability *π(x)*. The logit is used in the binary logistic model because it is linear in its parameters and can take continuous values in the range from - ∞ to + ∞ and therefore serves as the link function. In order to calculate out the estimated probability, the following formula is used where *ln[π(x)/1-π(x)]* is denoted by $X\beta$ X denotes the vector of the dependent variables and β the vector of the unknown parameters of the model.

$$Probability\ of\ Detention = \frac{e^{(X\beta)}}{1+e^{(X\beta)}}$$

To estimate the coefficients, maximum likelihood (ML) is used as method of estimation in the binary logistic regression. The likelihood function expresses the probability of a given matrix as a function of the unknown parameters. It yields to the most likely correlation between the dependent variable and the independent variables.

For both models, a significance level of 10% is used for testing of the significance of the parameters. Like with the linear model explained in the previous section, a 10% chance of a type 1 error is assumed to be acceptable given the fact that it is worse having a ship not detained when it should be versus having a ship detained when it should not be detained. In this sense, a parameter which is not significant but due to a type 1 error turns out to be significant constitutes a safer approach towards a possible detention than the other way round where a parameter is not assumed to be significant but actually is significant towards the probability of detention.

3.4.1. Type 1 Regression: Detained with class related deficiencies

The first model is based on a total of 6273 cases which represent all detained ships. Out of the 6273 detained ships, 1168 have class related deficiencies or 18.6% and the rest is detained without class related deficiencies. This model gives an insight of the performance of classification societies. A full print out of the software output can be seen in Appendix 14.

The omnibus test (likelihood ratio test) along with the iteration history shows that the variables used in the model contribute to the model since the -2 log likelihood (= -2 x max. log likelihood value) which represents the unexplained variance in the model, decreased from 4,250.03 to 3,643.19 by adding the variables to the model. This is confirmed by the significance of 0.000 of the chi-square statistic of 606.841 with 27 degrees of freedom.

The Hosmer and Lemeshow Test shows a significance of 0.819 which is well above 0.5 and therefore indicates that the model fits the data well. The Mc Fadden R^2 of 0.143 is not very high but shows that there is a relationship. The Mc Fadden R^2 is not provided by the software but was computed separately[50].

The total hit rate shown in the classification table lies by 70% for the selected cases and at 68.4% for out of sample forecasting which is better than a random selection of 50%. The cut off point for the classification table is set at 0.19 since 18.6% of all ships were detained with class related deficiencies. The model was produced using manual elimination of variables with high standard error and variables that were insignificant in a series of steps of elimination. In doing so,

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[50] see Franses, P.H. and Paap, R. (2000). *Quantitative Models in Marketing Research*. Erasmus University Rotterdam, Rotterdam, page 76 for further explanation of the Mc Fadden R^2

only the most insignificant variables in each group were eliminated at each step. The coefficients of the resulting model are shown in Table 14.

Table 14: Coefficients for Binary Logistic Model Type 1

		B	S.E.	Wald	df	Sig.	Exp(B)
1(a)	ln_vessel_age	.481	.133	13.110	1	.000	1.617
	ln_grosstonnage	.144	.039	13.667	1	.000	1.155
	CL_ABS	-.684	.212	10.423	1	.001	.505
	CL_BureauVeritas	-.574	.143	16.023	1	.000	.564
	CL_DNV	-.402	.187	4.628	1	.031	.669
	CL_GermanischerLloyd	-.870	.161	29.313	1	.000	.419
	CL_SRUkraine	1.946	.991	3.856	1	.050	7.003
	CL_IsthmusBS	1.191	.566	4.437	1	.035	3.291
	CL_PolskiReSt	-1.216	.336	13.080	1	.000	.296
	CL_RINA	-.621	.270	5.277	1	.022	.537
	CL_Inclamar	.767	.425	3.252	1	.071*)	2.153
	CL_CroatianRS	.760	.345	4.846	1	.028	2.139
	CL_RegisterAlbania	1.580	.354	19.911	1	.000	4.854
	CL_InternNavSurB	.859	.241	12.689	1	.000	2.360
	PS_Greece	-1.481	.235	39.755	1	.000	.227
	PS_Italy	-.269	.107	6.256	1	.012	.764
	PS_Netherlands	-.579	.190	9.277	1	.002	.561
	PS_RussianFed	-2.789	.423	43.430	1	.000	.061
	Code_0500	-.101	.048	4.329	1	.037	.904
	Code_0600	.060	.018	10.684	1	.001	1.062
	Code_0800	.131	.050	7.018	1	.008	1.140
	Code_0900	.133	.017	62.713	1	.000	1.142
	Code_1200	.102	.023	19.870	1	.000	1.107
	Code_1600	.111	.037	9.255	1	.002	1.118
	Code_2000	-.132	.056	5.497	1	.019	.876
	Code_2100	.361	.149	5.892	1	.015	1.435
	Code_2500	.051	.024	4.683	1	.030	1.052
	Constant	-4.443	.612	52.752	1	.000	.012

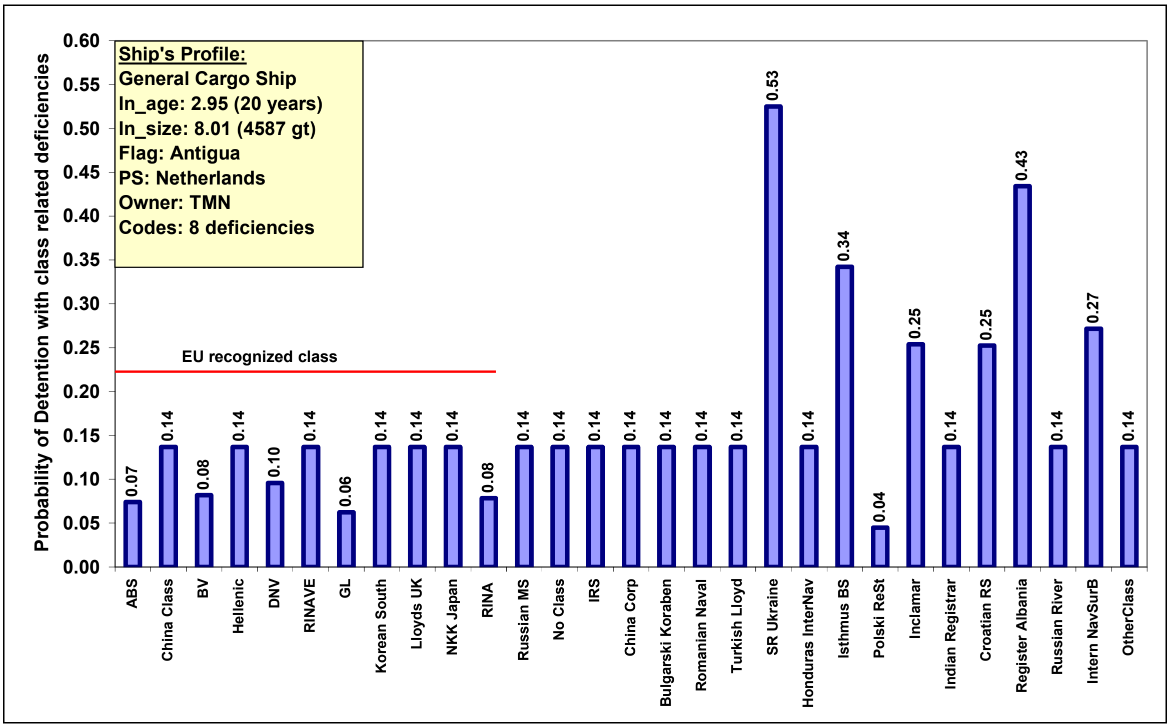
Dependent variable: detained with class related deficiencies
*) significant at the 10% significance level, otherwise significant at the 5% significance level

The model confirms that the age and the size of a vessel are significant for detention with class related deficiencies. The most interesting part is the interpretation of the coefficients of the classification societies.

In order to visualize the differences in the probabilities, a ship profile is created and the probabilities graphed using a variation in the classification societies. The result can be seen in Figure 26. Deficiencies used for this ship profile are code 100(1), 600 (1), 700 (1), 900 (1), 1500 (1), 1700 (2) and 2500 (1). The first 12 classification societies are recognized by the EU.

One can see some variation in the probabilities but not significant. On the other hand, one can easily see that some classification societies located on the right hand side of the graph contribute highly to the probability of detention with class related deficiencies. These are the Shipping Register of Ukraine (SRUkraine), Isthmus Bureau of Shipping (IsthmusBS), Inclamar, Croatian Register of Shipping (CroatianRS), Register of Shipping Albania and the International Naval Surveys Bureau (InternNavSurB).

Figure 26: Probabilities of Detention per Class



Interesting to see is that no flag states turns out to be significant and only three port states (Greece, Italy, the Netherlands and the Russian Federation) show a negative relationship to detention with class related deficiencies. This means that in these three port states, the probability of detention with class related deficiencies is lower than in other port states showing certain emphasize of the port states.

The type of deficiencies which contribute to probability of detention with class related deficiencies are code 2100 (Marpol related operational deficiencies), code 600 (life saving appliances), code 800 (accident prevention- ILO), code 900 (structural safety), code 1200 (load lines), code 1600 (radio communications) and code 2500 (ISM related deficiencies). Interesting to notice is that not all of these deficiencies are class related.

3.4.2. Type 2 Regression: Detained (Yes/No)

For the model of type 2 regression (dependent variable "detained"), all 76248 cases were used and the chosen model for the calculation of the probabilities of detention is presented here. A full printout of the software output can be seen in Appendix 15 for a detailed reference. Again, manual elimination of insignificant variables was used in various steps and a 10% significance level is used for testing the parameters.

The omnibus test (likelihood ratio test) along with the iteration history shows that the variables used in the model contribute to the model since the -2 log likelihood (= -2 x max. log likelihood value) which represents the unexplained variance in the model, decreased from 30,053.39 to 17,036.96 by adding the variables to the model. This is confirmed by the significance of 0.000 of the chi-square statistic of 13,016.43 with 71 degrees of freedom.

In this case, the Hosmer and Lemeshow Test seems to indicate that the model cannot fit the data well. This could be explained due to the fact that the amount of data points (76,248 cases) is very high. However, the contingency table for the Hosmer and Lemeshow Test which gives a comparison of the expected and the observed frequencies of the probabilities shows that the model fits well within each decile of risk[51] for ships that are not detained and within the higher decile of risk (7-10) of detained ships. In addition, the Mc Fadden R^2 of 0.432 seems to be very acceptable for the amount of cases. The Mc Fadden R^2 is not provided by the software but was computed separately[52].

The total hit rate shown in the classification table lies by 86.5% for the selected cases and at 86.4% for out of sample forecasting which is also acceptable for the given data. The hit rate for ships which are not detained is slightly higher (87%) than for ships that are detained (81%) but given the data in question, this is the best the model can predict given the cut off rate of 0.08 which is the average detention rate for the data sample. The model therefore gives a better prediction compared to a random selection of 50%. The coefficients of the model are shown in Table 15 and the Wald test is used to test for significance at the 5% and 10% significance level.

The model was tested for possible *heteroskedasticity* by using interaction dummies for all ship types and vessel age and gross tonnage respectively. Since only one variable (ship type: tanker * age) turned out to be significant and the rest of the model did not change significantly, it can therefore be concluded that the presence of heteroskedasticity is not assumed to be significant in the chosen model.

Table 15: Coefficients for Binary Logistic Model Type 2

		B	S.E.	Wald	df	Sig.	Exp(B)
1(a)	ln_vessel_age	.443	.050	77.923	1	.000	1.557
	ln_grosstonnage	-.136	.023	33.909	1	.000	.873
	CL_NoClass	.314	.074	18.145	1	.000	1.369
	CL_RINAVE	-1.296	.480	7.299	1	.007	.274
	CL_TurkischLloyd	.440	.145	9.269	1	.002	1.553
	CL_IsthmusBS	1.072	.514	4.348	1	.037	2.920
	CL_InternNavSurB	.704	.181	15.174	1	.000	2.022
	PS_Belgium	-1.362	.115	140.752	1	.000	.256

51 see Hosmer, D. and Lemeshow S. (1989). *Applied Logistic Regression*. New York: John Wiley & Sons, page 143 for further explanation of the decile of risk

52 see Franses, P.H. and Paap, R. (2000). *Quantitative Models in Marketing Research*. Erasmus University Rotterdam, Rotterdam, page 76 for further explanation of the Mc Fadden R squared

	PS_Canada	-.305	.140	4.779	1	.029	.737
	PS_Croatia	-.710	.140	25.782	1	.000	.492
	PS_Denmark	-.627	.147	18.233	1	.000	.534
	PS_Finland	-.533	.184	8.379	1	.004	.587
	PS_France	-.520	.101	26.811	1	.000	.594
	PS_Germany	-.855	.093	84.552	1	.000	.425
	PS_Greece	-1.008	.100	101.695	1	.000	.365
	PS_Iceland	-1.075	.376	8.182	1	.004	.341
	PS_Ireland	-1.357	.189	51.770	1	.000	.257
	PS_Netherlands	-1.432	.106	182.732	1	.000	.239
	PS_Norway	-.386	.146	7.027	1	.008	.680
	PS_Poland	-1.404	.149	88.454	1	.000	.246
	PS_Portugal	-.664	.100	44.326	1	.000	.515
	PS_RussianFed	-1.720	.098	308.960	1	.000	.179
	PS_Spain	-.534	.075	50.770	1	.000	.586
	PS_Sweden	-1.794	.217	68.328	1	.000	.166
	PS_UK	-1.338	.097	191.498	1	.000	.262
	ST_GeneralCargo	.385	.055	48.570	1	.000	1.469
	ST_OilTanker	.292	.107	7.474	1	.006	1.339
	ST_Passenger	-.489	.213	5.257	1	.022	.613
	ST_RoRoPax	-1.133	.213	28.290	1	.000	.322
	FS_Algeria	.411	.237	3.001	1	.083*)	1.508
	FS_Cyprus	.298	.087	11.787	1	.001	1.347
	FS_Cambodia	.491	.123	15.898	1	.000	1.634
	FS_Georgia	.347	.191	3.293	1	.070*)	1.415
	FS_KoreanDR	.578	.324	3.177	1	.075*)	1.782
	FS_Malta	.324	.077	17.603	1	.000	1.382
	FS_Panama	.235	.077	9.234	1	.002	1.265
	FS_Romania	.558	.299	3.470	1	.063*)	1.747
	FS_RussianFeder	.263	.103	6.533	1	.011	1.300
	FS_StVincentGren	.355	.085	17.578	1	.000	1.426
	FS_SaoTomePrin	.589	.332	3.154	1	.076*)	1.802
	FS_Turkey	.395	.096	16.854	1	.000	1.484
	FS_Tuvalu	1.024	.503	4.152	1	.042	2.785
	Code_0100	.523	.026	417.531	1	.000	1.687
	Code_0200	.326	.028	133.210	1	.000	1.386
	Code_0300	.114	.033	12.014	1	.001	1.121
	Code_0400	.125	.048	6.694	1	.010	1.133
	Code_0500	-.066	.039	2.780	1	.095*)	.936
	Code_0600	.251	.015	273.539	1	.000	1.286
	Code_0700	.262	.016	262.043	1	.000	1.299
	Code_0800	.006	.050	.013	1	.908**)	1.006
	Code_0900	.225	.016	196.356	1	.000	1.253
	Code_1000	.387	.096	16.404	1	.000	1.472
	Code_1100	.140	.051	7.656	1	.006	1.150
	Code_1200	.211	.023	85.029	1	.000	1.235
	Code_1300	.053	.055	.948	1	.330**)	1.055

	Code_1400	.280	.022	165.328	1	.000	1.323
	Code_1500	.184	.018	99.750	1	.000	1.202
	Code_1700	.547	.024	540.177	1	.000	1.728
	Code_1600	.303	.030	104.469	1	.000	1.354
	Code_1800	.086	.097	.782	1	.377**)	1.089
	Code_1900	.053	.224	.057	1	.811**)	1.055
	Code_2000	-.014	.039	.124	1	.725**)	.986
	Code_2100	.057	.097	.342	1	.559**)	1.059
	Code_2200	.048	.486	.010	1	.921**)	1.049
	Code_2300	-.057	.074	.606	1	.436**)	.944
	Code_2500	.510	.027	358.866	1	.000	1.665
	Code_2600	.301	.205	2.147	1	.143**)	1.351
	OW_TraditionalMN	-.302	.054	30.661	1	.000	.740
	OW_EmergingMN	-.144	.068	4.526	1	.033	.866
	OW_OldOR	-.462	.112	17.057	1	.000	.630
	Constant	-3.688	.298	152.701	1	.000	.025

Dependent variable: detained
*) significant at the 10% significance level, otherwise significant at the 5% significance level
**) not significant

The model suggests that ship age and size are both significant for detention. For the rest of the variables and since this model is more complex than regression type 1 (detention with class related deficiencies), interpretation can best be made in combination with each other in graphical form.

One can see that some classification societies are more significant for detention than others like ships with "No Class" or ships classified by Turkisch Lloyd, Ismthus BS or InternavSurB and not all of the classification societies which turned out to be significant in the type 1 regression are significant in this model.
Interesting to notice are the port states which turn out to be all with a negative contribution towards the probability of detention and some of them with a greater significance than other port states. For instance, port state controls in Canada or Norway contribute more towards the probability of detention than for instance port state controls in Russia, Sweden or Ireland. Greece shows a lower contribution towards the probability of detention than for instance Spain and Portugal. To some extend this could be interpreted to show the differences in the port state control systems taking the trade flow differences between the South, East and North of the EU into account. The graphical interpretation will be shown later on.

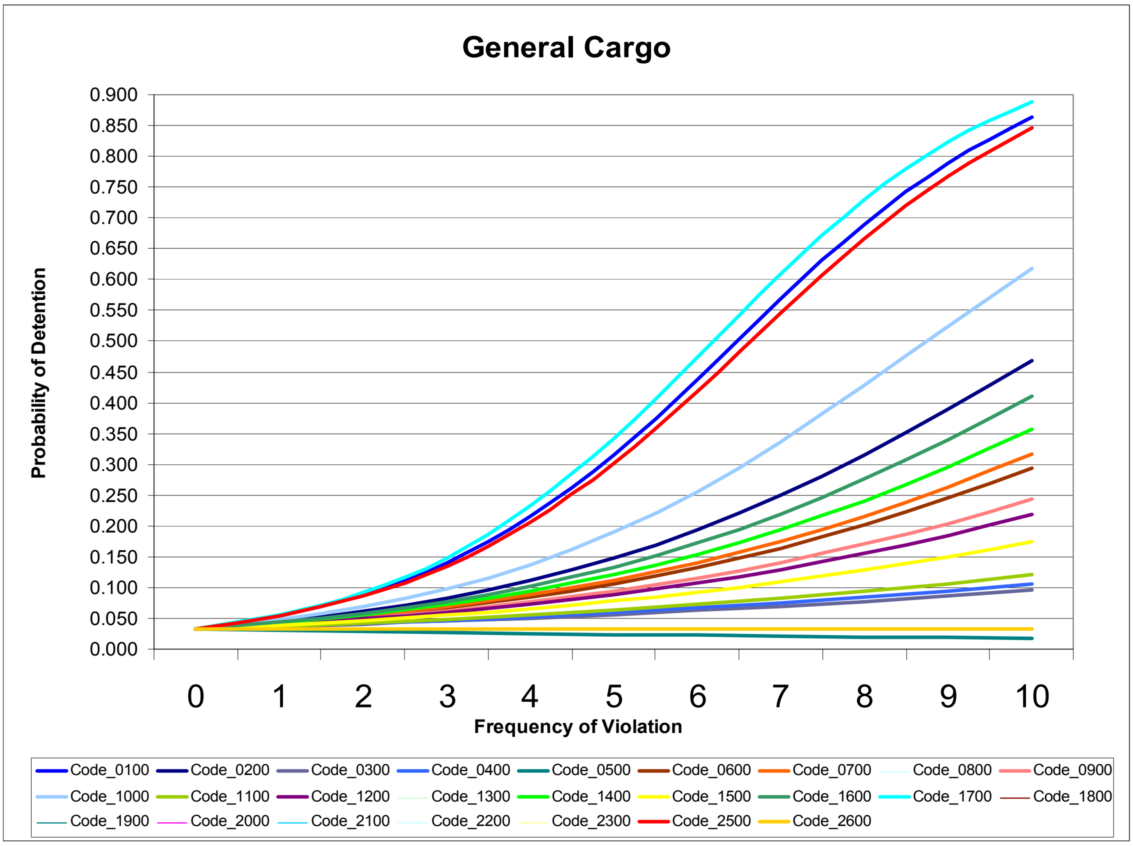
A similar pattern can be seen within the ship types and the flag states. General cargo ships show the highest contribution towards the probability of detention followed by oil tankers which is somehow unexpected. However, both ship types seems to be more likely to be detained as passenger ships or RoRo Passenger ships or any other ship types which are not significant including bulk carriers. As for the flag states, a high amount of "black" listed flag states which are significant are left in the model and show a higher contribution towards detention than other flag states.

For easier identification, all deficiency codes are left in the model to show the significance or insignificance of the codes. Code 500 (working space and accident prevention) is significant at the 10% significance level while code 800 (accident prevention), 1300 (mooring arrangements), 1800 (gas and chemical tankers), 1900 (MARPOL Annex II), 2000 (Operational deficiencies), 2100 (MARPOL related operational deficiencies), 2200 (MARPOL annex III), 2300 (MARPOL annex V) and 2600 (bulk carriers) are not significant. The next section will visualize the probabilities and give an answer to the original research question.

3.4.3. Model Interpretation and Visualization of the Results

In order to make the interpretation of the binary logistic model type 2 better understandable and to visualize the difference in importance of each of the deficiency codes, ship profiles of certain ships are created and are shown in Table 16. The corresponding probabilities of detentions based on each of the ship profiles are calculated and graphed for each deficiency code for a variety of violations (0 to 10) and the result for the general cargo ship can be seen in Figure 27.

Figure 27: Probabilities of Detention per Main Code: General Cargo Ship



It is not easy to distinguish between the differences in the individual deficiency codes since some show very similar probabilities and are therefore located closely to each other. To remedy this situation, the deficiency codes are grouped into seven main groups as shown in Table 17.

Table 16: Ship Profiles for Model Interpretation

Ship Types	Class	Flag State	Port State	Owner/Manager
Oil Tanker	DNV	Malta	Netherlands	Traditional MN
Bulk Carrier	NKK	Panama	Spain	Traditional MN
General Cargo	GL	Antigua	Italy	Traditional MN
Passenger Ship	DNV	Bahamas	UK	Old OR
Chemical Tanker	DNV	Bahamas	Netherlands	Traditional MN
Container Ship	GL	Antigua	Netherlands	Traditional MN
Ro-Ro Cargo Ship	Lloyd's UK	Panama	Belgium	Intern. OR

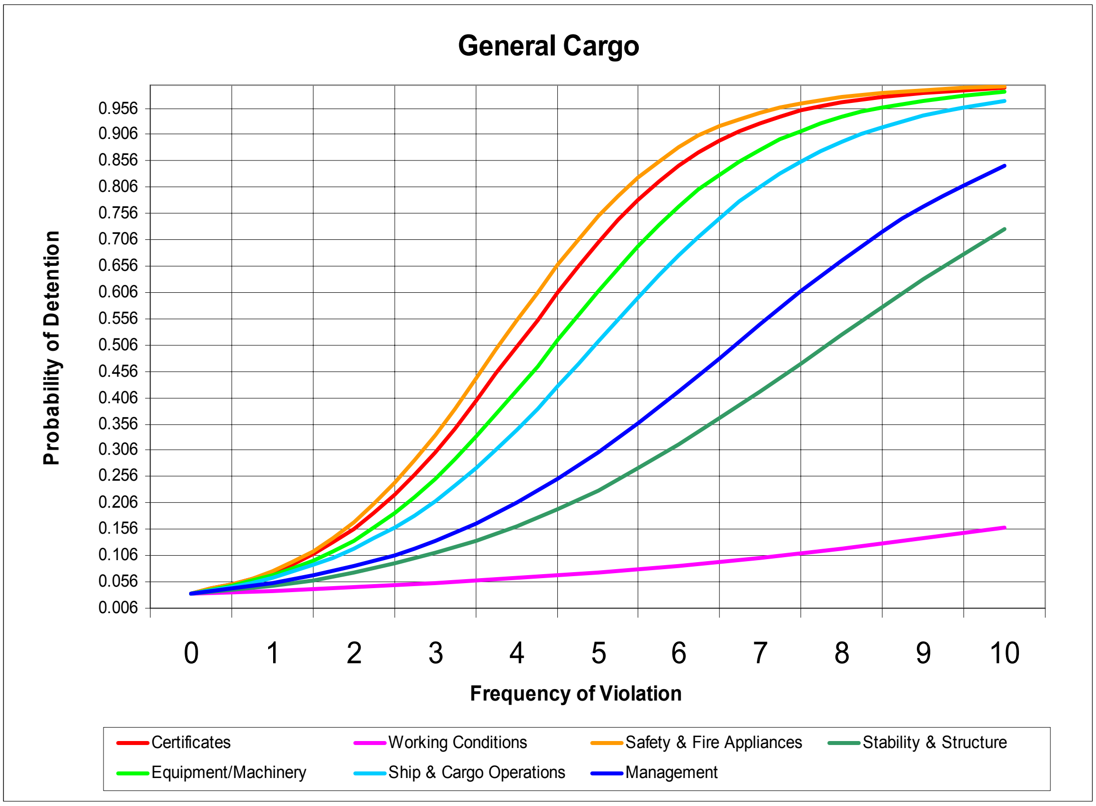
Using the same model, the associated probabilities of each main group are calculated again by adding up the individual coefficients of the deficiency codes in each group and the result is graphed again. The grouping of the codes was done to reflect the similarity of the deficiency codes by their nature (e.g. operational deficiencies or crew related deficiencies). This grouping should help in gaining a better understanding on what type of deficiency actually matters or on what type of deficiency port state control emphasized given four years of port state control data.

Table 17: Grouping of Deficiency Codes

Deficiency Main Group	Description of Codes within the Main Group	
Management	ISM related deficiencies	Code_2500
Working Conditions	Accommodation	Code_0300
	Food & Catering	Code_0400
	Working spaces, accident prevention	Code_0500
	Accident prevention	Code_0800
Safety & Fire Appliances	Life saving appliances	Code_0600
	Fire safety measures	Code_0700
	Alarm Signals	Code_1000
Stability/Structure	Stability/Structure/Equipment	Code_0900
	Load Lines	Code_1200
	Bulk Carriers, additional safety measures	Code_2600
Equipment/Machinery	Mooring Arrangements	Code_1300
	Propulsion & Aux. Machinery	Code_1400
	Safety of Navigation	Code_1500
	Radiocommunications	Code_1600
Certificates	Ship's certificates	Code_0100
	Crew certificates	Code_0200
Ship & Cargo Operations	Carriage of Cargo & Dang. Goods	Code_1100
	Marpol I: SOPEP, Oil Record Book	Code_1700
	Oil, Chemical Tankers and Gas Carriers	Code_1800
	Marpol II: P&A Manual, Cargo Record B.	Code_1900
	SOLAS related operational deficiencies	Code_2000
	Marpol related operational deficiencies	Code_2100
	Marpol III: Packaging, Documentation	Code_2200
	Marpol V: Garbage Management	Code_2300

The probabilities of the deficiency groupings for the ship profile general cargo ship can be seen in Figure 28. The resulting probabilities are based on the same model and added up together based on the outcome of the original model. Violations against working conditions have the least effect on detention and safety and fire appliances show the most important contribution towards the probability of detention.

Figure 28: Probabilities of Detention per Main Group: General Cargo

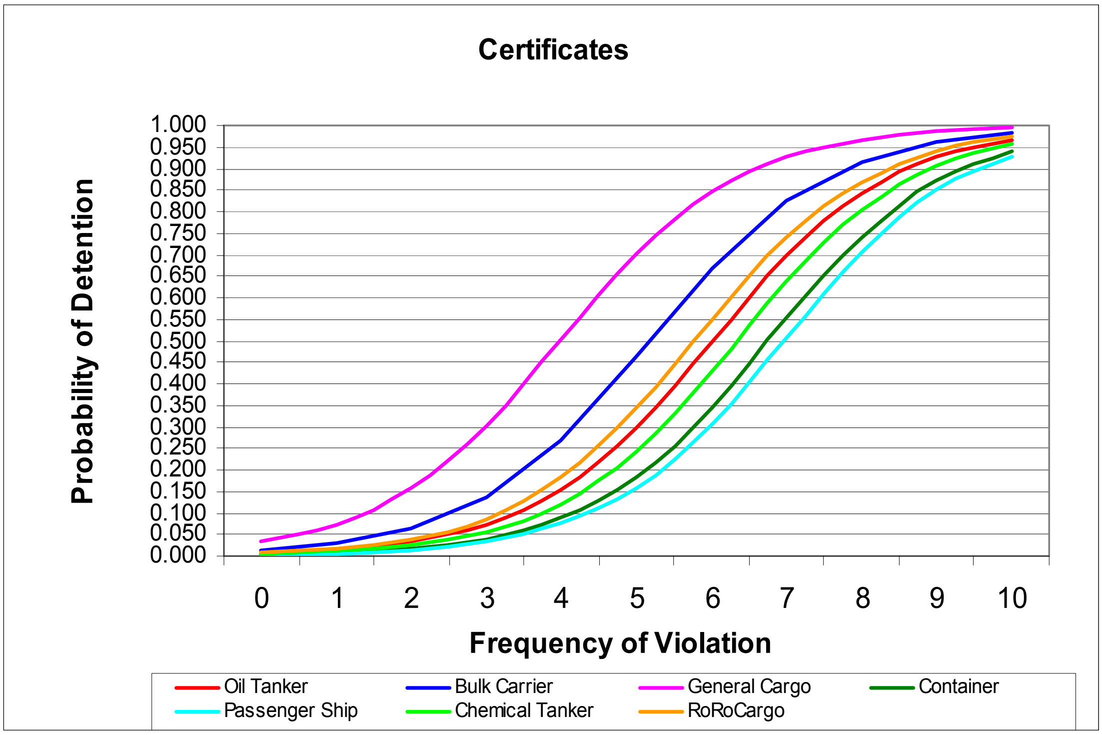


The steeper the curve, the more important the deficiency code is. Interesting to notice is the group that contains the deficiencies against the ISM code (management) which by itself represents a relative important group. The importance of the contribution of the deficiency codes towards detention does not vary across the ship types. The ranking of the groups to some extent also reflects the importance that is placed on these groups during the inspections. This is why the code of groups containing certificates might appear to be more important than stability and structure. Ship and cargo operations which are under the control of the crew onboard are also a very important group. If added together with the ISM code, these two groups become the most important group out of all of the deficiency groups.

Safety and Fire appliances are partly influenced by maintenance onboard and so is the group dealing with equipment and machinery. However, parts of these deficiencies are not only influenced by the maintenance or attitude of onboard personnel but also by the amount of money allocated to the maintenance of the safety equipment and spent by the ship's owner. The same applies for the group of codes dealing with the stability and structure of the vessel. The rest of the ship profiles can be seen in Appendix 16.

In order to show the differences of the probabilities of detention based on a certain ship profile, the probabilities are graphed against each ship profile where the number of deficiencies remains the same for all ship profiles. In this way, the risk profile of a certain ship type can be visualized and compared to each other. Two types of codes are chosen as sample codes and are shown in Figure 29 and Figure 30.

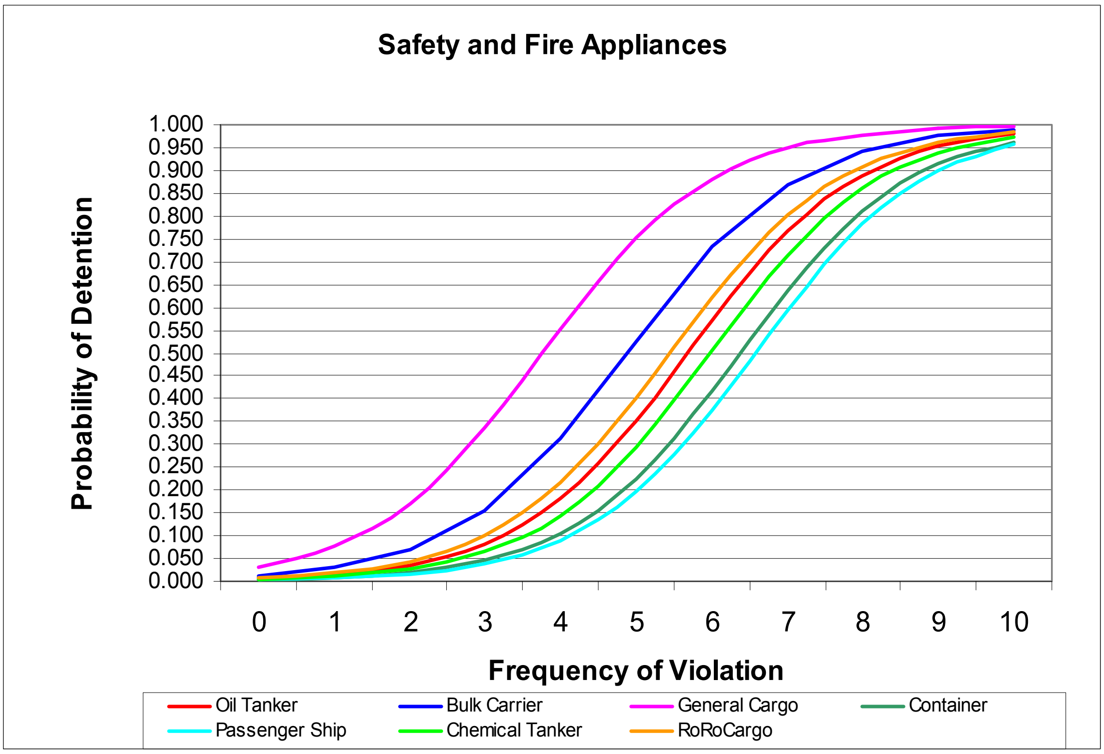
Figure 29: Ship Risk Profiles: Certificates



The series of graphs show that general cargo ships due to their overall profile have a higher probability of detention than other ship types. Second in line are the bulk carriers and RoRo cargo ships. Oil tankers and chemical tankers are similar in nature although chemical tankers are much more sophisticated and have to comply with more rules than oil tankers and normally have to show a higher safety standard depending on what kind of chemical tanker the vessel actually is. Container ships and passenger ships show the lowest probability of detention due to the lower probability that is given by their ship profiles. For passenger ships this is relative easy to explain since a passenger ship (especially when it is a cruise ship) is less likely detained due to commercial and political reasons.

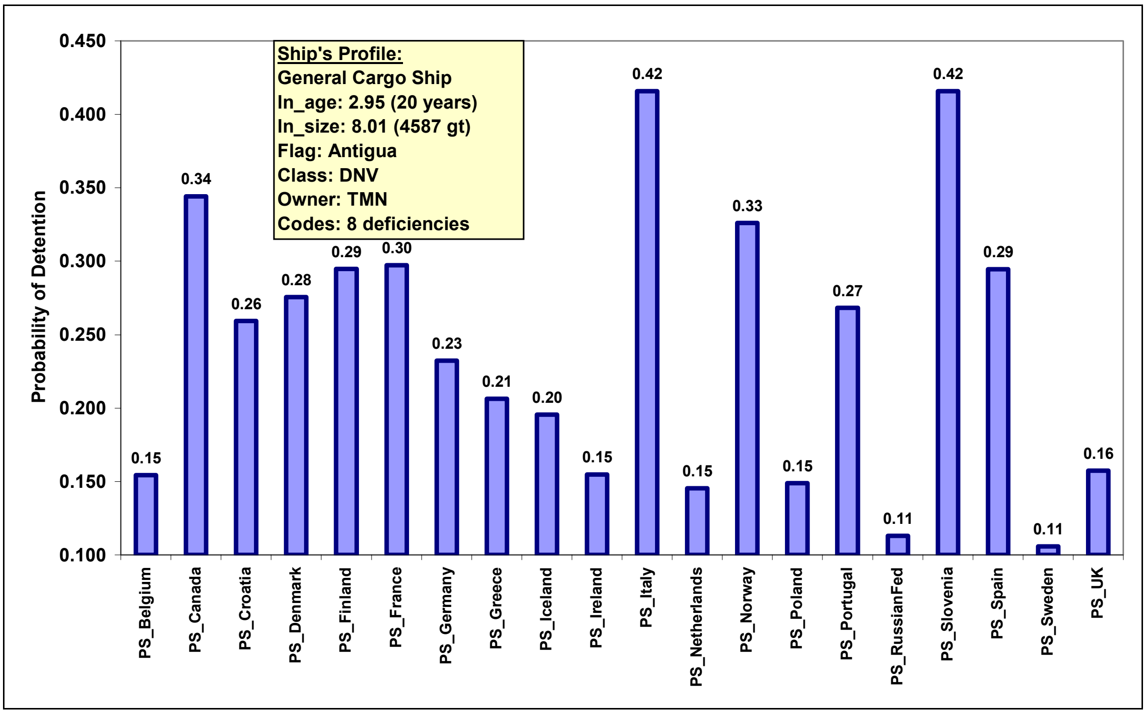
For container vessels, this could be explained due to the fact that container ships operate in a commercial environment where a higher safety standard is more likely to be encountered due to the fact that liner companies have a more complex network to operate in and cannot leave the market as fast as companies that trade in the bulk market due to the sunk cost that would be involved in leaving the market. The liner services are regular services and the relationships between the owners and charterers of the vessels are long term relationships. In addition, container ships are trading with high value cargo compared to some cargo in bulk shipping. The graphs of the rest of the main groups can be seen in Appendix 17: Ship Risk Profiles based on Main Deficiency Groups

Figure 30: Ship Risk Profiles: Safety & Fire Appliances



Another interesting interpretation of the model is to show the differences of the port states and how the probability of detention is influenced by the port state. In order to visualize these differences, a ship profile is created with a variation in port states and the result can be seen in Figure 31.

Figure 31: Probabilities of Detention: Port States



Deficiencies used for this profile are code 100(1), 600 (1), 700 (1), 900 (1), 1500 (1), 1700 (2) and 2500 (1). The graph shows that there are large variations in the probability of a certain ship type based on a port state. A general cargo ship with exactly the same ship profile has a higher probability of detention in Italy or Slovenia or Canada than for instance Belgium, Ireland, the Russian Federation, Sweden or the Netherlands. For some port states, this might be due to the different trade flows and the respective ships that call certain ports as shown already in the descriptive statistic section of this thesis. This applies for northern port states. For some of the southern ports states, this should not be the case. Belgium has many general cargo ships but shows a relative low probably of detention.

3.5. Suggestions for the Target Factor Improvement

The binary logistic model type 2 provides the scientific proof that the target factor can be improved by assigning certain weights to the deficiency codes instead of treating all codes with the same importance. In addition, incorporating the type of ownership or management into the target factor would be an additional improvement.

The last section in this analysis will try to visualize the differences of several ship profiles and compare the difference between using the total deficiencies versus each deficiency code individually in calculating out the probabilities of detention. In order to do this, a separate model was created using only the total number of deficiencies as one of the independent variable instead of each of the deficiency codes separately. The total computer printout of this model can be seen in Appendix 18 including the coefficients. Without using any graphs for interpretation, this model compared to the one containing the deficiency codes separately shows a lower hit rate (80% compared to 82%) for detained ships. This represents that the model can predict better by 2% for detained ships. The Mc Fadden R^2 is slightly lower with 0.410 compared to 0.43 of the model using the deficiency codes separately.

Ship profiles are created and shown in Table 18 and the probability based on total number of deficiencies is graphed against the probability based on individual deficiency codes.

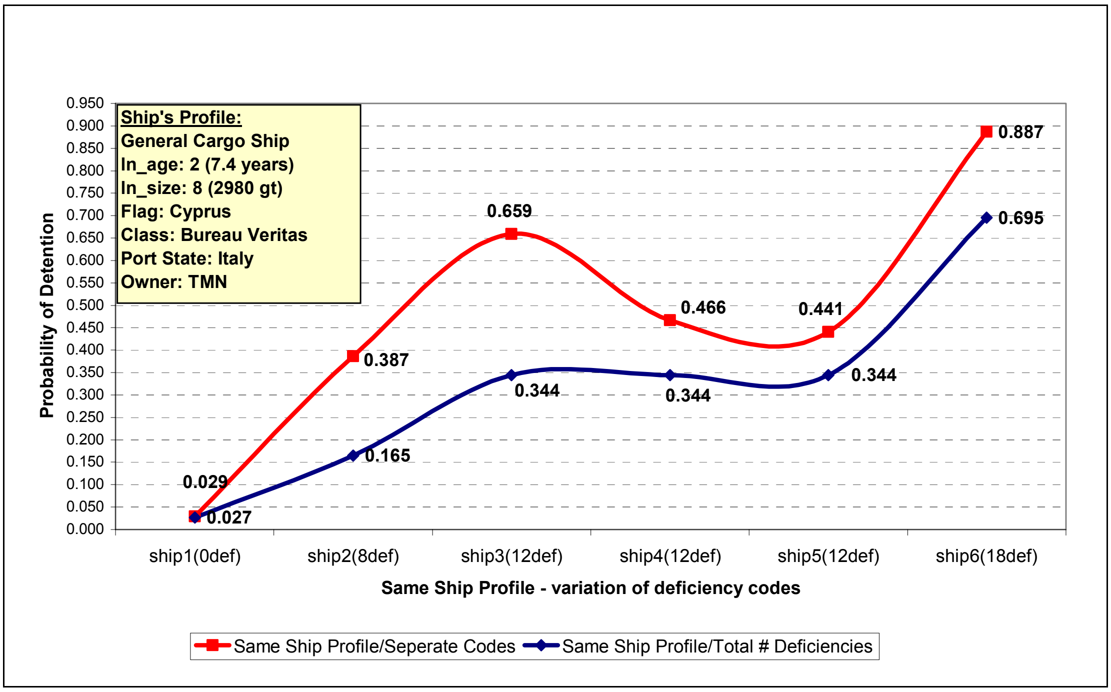
Table 18: Risk Profiles: General Cargo Ships

Ship Types	Ship 1	Ship 2	Ship 3	Ship 4	Ship 5	Ship 6
Ln(Age)	0 (0)	1 (2.7)	2 (7.4)	3 (20)	3 (20)	3.5 (33)
Ln(Size)-gt	6 (404)	7 (1096)	8 (2980)	9 (8103)	9 (8103)	9.2 (9897)
Class	GL	Lloyds UK	BV	RussianMS	IsthmusBS	InternavSB
Flag	Antigua	Bahamas	Cyprus	Malta	Russia	Turkey
Port State	Belgium	Italy	Italy	Italy	Russia	Spain
Owner	TMN	EMN	TMN	OldOR	TMN	EMN
Deficiencies	**0**	**8**	**12**	**12**	**12**	**18**
Variation of Deficiency Codes	**0**	**100 (1) 600 (1) 700 (1)**	**100 (1) 200 (1) 600 (2)**	**100 (1) 200 (1) 300 (1)**	**100 (1) 300 (1) 600 (2)**	**100 (2) 300 (2) 600 (4)**

		900 (1) 1500 (1) 1700 (2) 2500 (1)	700 (2) 900 (1) 1400 (1) 1500 (1) 1700 (2) 2500 (1)	600 (2) 700 (2) 900 (1) 1100 (1) 2000 (1) 2500 (2)	700 (1) 900 (2) 1200 (2) 1500 (1) 1600 (1) 2500 (1)	700 (2) 900 (4) 1600 (1) 1700 (1) 2500 (2)

Figure 32 shows the difference of using the same ship profile for all ships (ship profile for ship 3 is used in this case) but a variation on the type and number of deficiency codes only as explained in Table 18.

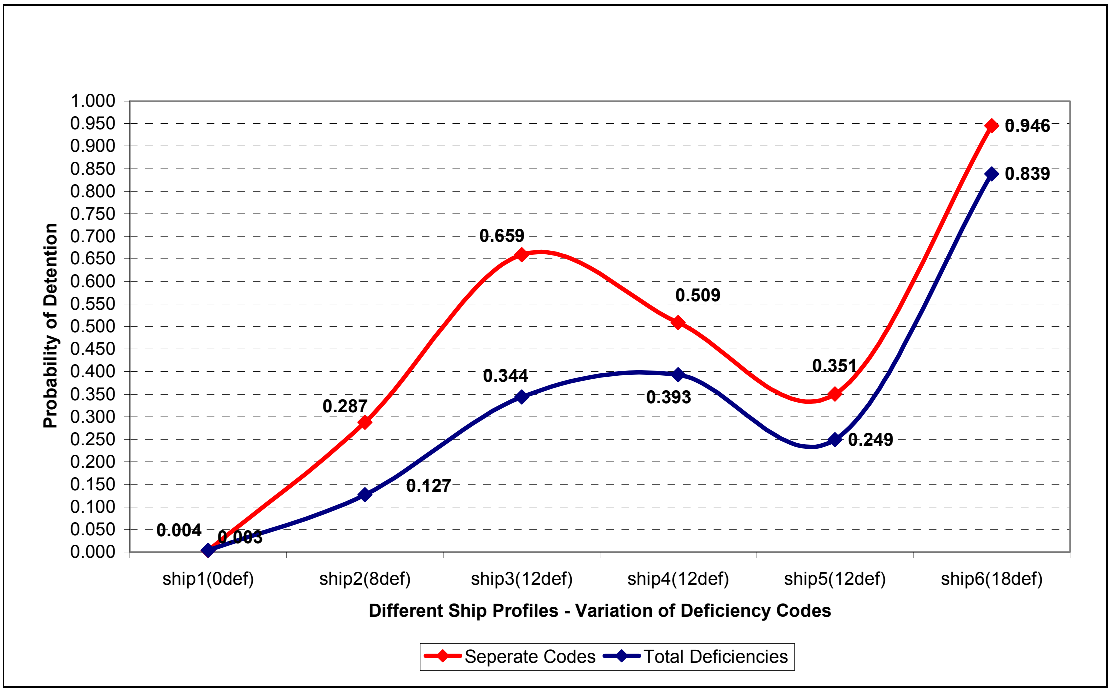
Figure 32: Probability Comparison: General Cargo Ship



It is interesting to notice the difference in the probability based on treating the deficiency codes separately and assigning a weight factor. For ship 3 with 12 deficiencies, this difference is 0.315 (0.659-0.344) while for ship 4 and 5 is it only 0.124 and 0.097 respectively. This reflects the different importance of the deficiency codes. If using only one standard weight factor for each deficiency code, the associated probability of detention for ship 3, 4 and 5 is the same at 0.344. Hence, using an individual weight factor can improve the accuracy of the probability of detention.

The next approach is to use different ship profiles instead of one ship profile. The different profiles are listed in Table 18 and are combined with the same variation of deficiency codes as used in the previous graph. This will not only show the variation in the risk profile based on the generic ship factor but also due to the difference in the deficiency codes. The outcome of graphing these probabilities for various general cargo ships is shown in Figure 33. The ship profiles are changed based on an increase in age, size and a variation of class, flag and port state in combination with a variation of deficiency codes.

Figure 33: Risk Profile Comparisons – General Cargo Ship



It is again easy to see that the probability using the deficiency codes separately is higher than the probability which treats all deficiency codes with equal importance. Both lines move in line but there are some differences especially for ship 3 to 5 where the number of deficiency remains equal but the difference between the lines is due to the different weights in the codes and vary from 0.659 to 0.351 while the probability of detention based on a total number of deficiencies lies closer together (from 0.344 to 0.249). The concept of both graphs was also applied to another chosen ship type - the oil tanker and can be seen in Appendix 19: Probability Comparison and Risk Profile: Oil Tanker

The final approach is to combine the linear model with the binary logistic model which combines the predicted number of total deficiencies with the predicted probability of detention. In order to visualize the combination of the two, several ship profiles were created and are shown in Table 19 with a variation in port states and ownership of the vessel.

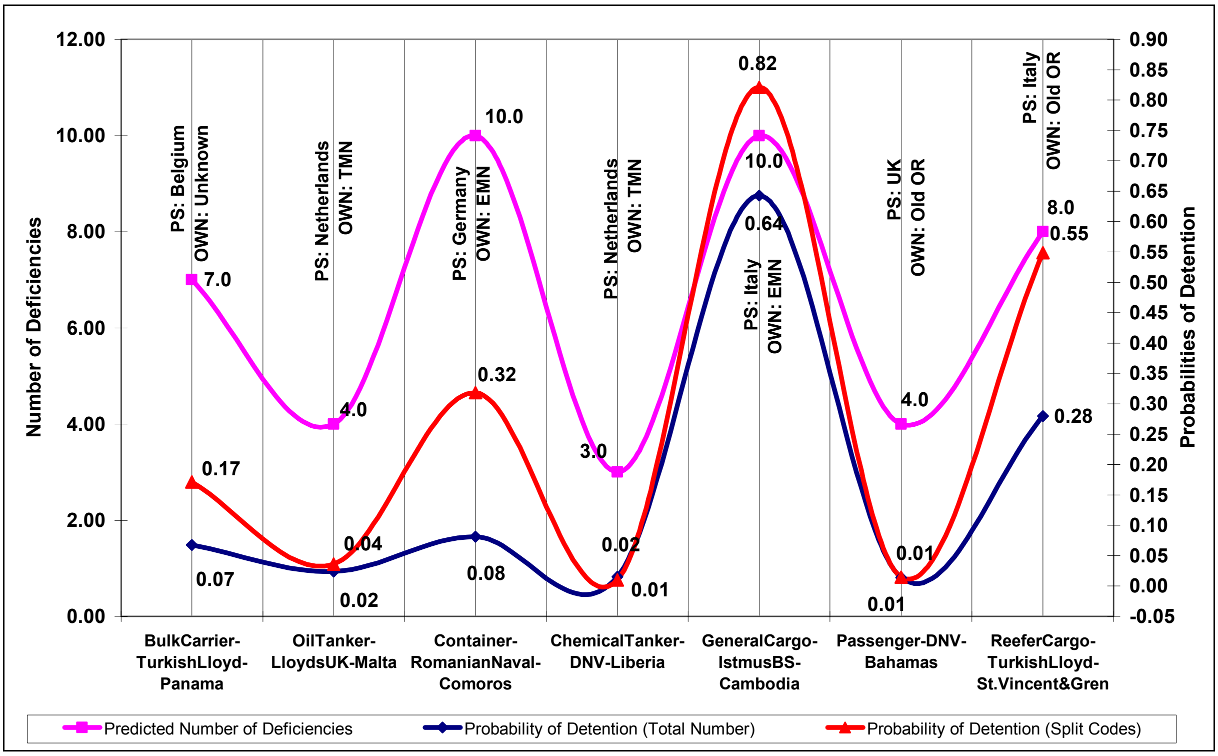
Based on these ship profiles, the linear model was used to predict the number of total deficiencies. The predicted number of total deficiencies was then used in the binary logistic model in order to predict the associated probability of detention for the same ship profile. The probability of detention was calculated for the total number of deficiencies and for deficiencies split up into the individual codes. The split up was chosen randomly since the linear model can only predict the total number of deficiencies and not each individual code separately. The result is shown in Figure 34 and gives an interesting result in many ways.

First, it shows that the higher the number of deficiencies, the higher the probability of detention. It further shows the difference in the probability of detention using a weight factor versus the probability of detention without using a weight factor for each code. Likewise, this was already demonstrated with earlier graphs. Finally, the combination of both models can best visualize that the predicted number of deficiencies and the probability of detention are based on a total combination of all variables (ship type, flag state, port state, owner of a vessel and classification society).

Table 19: Ship Profiles for Model Combination

Profiles	Ship 1	Ship 2	Ship 3	Ship 4	Ship 5	Ship 6	Ship 7
Ln(Age)	2.81 (16)	2.67 (14)	2.35 (10.5)	2.72 (15)	2.95 (19)	2.99 (20)	2.87(18)
Ln(Size) GT	9.93 (20537)	9.98 (21590)	9.95 (20952)	8.55 (5166)	8.01 (3010)	9.29 (10829)	8.68 (5884)
ST	Bulk	Oil	Container	Chemical	General	Passenger	Reefer
CL	Turk. Lloyd	Lloyds UK	Rom. Naval	DNV	Istmus BS	DNV	Turk. Lloyd
FS	Panama	Malta	Comoros	Liberia	Cambodia	Bahamas	St. Vinc. & Grenad.
PS	Belgium	Netherl.	Germany	Netherl.	Italy	UK	Italy
OWN	Unknown	TMN	EMN	TMN	EMN	Old OR	Old OR
Def. Code	**100 (2) 200(1) 600 (1) 900 (1) 1700 (1) 2500 (1)**	**100 (1) 200(1) 1600(1) 1700 (1)**	**100 (2) 600 (1) 700 (2) 1600(1) 1700 (2) 2500 (2)**	**600 (1) 1700(1) 1800(1)**	**100 (1) 200(1) 300 (1) 400(1) 600 (1) 700 (1) 1000(1) 1500(1) 2500(2)**	**100 (2) 700 (1) 1000 (1)**	**100(1) 600(2) 900(1) 1000(1) 1700(1) 1600(1) 2500(1)**
Total	**7**	**4**	**10**	**3**	**10**	**4**	**8**

Figure 34: Model Combination and Ship Types



To conclude the analysis, Figure 35 gives a suggestion on how to revise the target factor. In this model, the generic factor is based on risk profiles of ships based on all variables which influence the safety culture onboard a ship and the history factor contains a split up of the types of deficiencies with associated weight factors. In assigning the final weight factors, one has to take into consideration that the results of the model are biased to a certain extent since the data by itself is a result of the present target factor and the emphasis of the port state control inspectors. The weight factors given by the model should therefore only be seen as an indication while keeping these two main points in mind.

Figure 35: Revised Target Factor

GENERIC FACTOR *Based on Ship's Risk Profile*	**HISTORY FACTOR** *Based on Ship's Inspection History of the previous 12 months*
Ship's Risk Profile ***Probability of detention based on a combination of the following variables:*** ***1. vessel age*** ***2. vessel size*** ***3. flag state*** ***4. the classification society*** ***5. the ship type*** ***6. owner/manager of the vessel***	**Time span since last inspection** **Type and Number of deficiencies** ***Weighted deficiency codes either per deficiency code individually or by main deficiency groups as follows in order of contribution:*** ***1. Fire & Safety Appliances*** ***2. Certificates*** ***3. Equipment/Machinery*** ***4. Ship & Cargo Operations*** ***5. Management*** ***6. Stability & Structure*** ***7. Working Conditions***
Total Probability of Detention – Split up in various steps of risks (e.g. high – medium – low)	

These weight factors can either on an individual basis or on a main group basis. The previous graphs have given an insight on how the target factor can be improved by assigning weight factors to the deficiency codes. The final section of this chapter will explain the limitations of the analysis and will give some additional ideas on possible extensions to the analysis.

3.6. Possible Extensions and Limitations of the Analysis

A limitation to the analysis was the inability to use each the 25 main deficiency codes for the linear regression instead of the total number of deficiencies. Since the frequency of the individual codes show a very high amount of zero violations (around 80-90%), this cannot be done with standard linear regression for a prediction of each of the number of deficiency codes. Other advanced techniques can be used but are beyond the scope of this analysis.

A further limitation of this present analysis with the respect to the binary logistic and linear model was the inability to transform the 483 sub codes into their respective frequencies. This could be done with the frequencies of the 25 main codes by means of using some computer programming but the same routine could not be performed with 483 sub-codes due to the limitation of time and resources for this thesis. In addition, the resulting size of the matrix (approx. 76248 cases by 650 variables) could reach certain limitations to the software that can be used for data preparation and analysis. For the present analysis, four types of software[53] were used in combination for the data merges, descriptive statistics, correspondence analysis and the regression analyses itself since neither program could handle the amount of data by itself.

A further suggestion is to repeat the analysis with all 483 sub-codes and once the predicted number of deficiency is known, it can be incorporated into the probability obtained by the binary logistic model and further refine the target factor. This applied for the linear model and the binary logistic model. By doing this, the grouping used to graph the probabilities (e.g. management, operations, certificates, working conditions) could be further refined to obtain a more accurate split between the groups to determine the weights for the deficiency codes.

Another extension for the analysis would be to include the amount of bans into the analysis and possibly the target factor[54]. At present, this information was not used in the analysis due to the lack of data.

Besides the variable which was chosen to reflect the safety culture of the company (ship owner), two other variables might proof to be useful to be included into the analysis – this is information about the charterer and the technical management. Another possible variable to reflect the quality of the human factor would be to include GDP information of the country of ownership or management or nationality of the crew which is indeed very difficult to obtain. The human factor is essential for the safety quality onboard a vessel and it is difficult to model this factor since it is based on the quality of the crew (education, attitude, motivation, experience) and the safety culture of the company who owns or operates the vessel. These factors are not easy to model in econometrics and data needed to do so is not readily available.

Finally, another approach and extension to the analysis would be to repeat the analysis using port state control data from various memoranda of understanding such as the Tokyo MoU or the Coast Guard in conjunction with the data from the Paris MoU. This would provide a wider approach and level out possible bias of the data since the memoranda of understanding have different emphasis.

[53] Access for the database work, Excel for descriptive statistics, MathLab for the correspondence analysis and SPSS for the regression models

[54] this was already proposed by a member state of the Paris MoU

Chapter 4: Conclusion

The final chapter of this analysis will give a summary of the major findings of the analysis. In addition, the author explains some of the critiques of the system and makes suggestions on how to improve it. The thesis will end with highlighting ideas for further research to be conducted in the area of maritime safety.

4.1. Major Findings and Conclusions of the Analysis

Finding 1: Flag States are not the only indication for safety quality

Overall the analysis shows that the quality of safety expressed either in number of deficiencies or by the probability of detention can be explained based on a relationship between age, size, flag, port states, classification society and ownership of a vessel. The flag state alone cannot be seen as a quality indicator since there are measurable differences within the open registries. The overall expectation that ships flying a "black" listed flag and ships which are classified by non EU recognized classification societies perform worse is confirmed by the analysis.

Although age and size are significant, some older ships with good maintenance can perform better than younger ships with worse maintenance. The human factor which is reflected by the safety culture onboard is the key to safety and is primarily influenced by the crew onboard as well as the overall management and how this management is enforced onboard. Around 60% of all ships that were inspected were owned by owners from traditional maritime nations.

Finding 2: Differences in inspections across port states

Most ships inspected during the time period of the analysis were general cargo ships (47%), bulk carriers (18%) and container ships (7%). Detention rate and the average number of deficiencies were highest with general cargo ships although general cargo ships are not on the list of ships that can be banned. Detention rate is higher in the South of Europe where most general cargo ships can be found due to the differences in the trade flows in the EU.

The correspondence analysis and the binary logistic model both reflect the different emphasis made during port state control inspections. This can be seen by the fact that there is a higher correlation of operational deficiencies with "white" flagged ships than with "black" flagged ships which are closely correlated to structural or safety related deficiencies. In addition, the ranking of the main deficiency groups explained earlier reflects the importance that was placed on the types of deficiencies during an inspection by the port state control inspectors. This is also confirmed by the differences in the contribution towards the probability of detention amongst the port states since some contribute more than others.

It also reflects the differences in the trade flows and the ship types between the north, west and south of Europe. The combination of the two might give an indication of the level of quality of the inspections conducted across the port states. In total, 6% of ships that were not detained had 10 or more deficiencies. The percentage of deficiencies with 10 or more deficiencies of ships that were not detained varies from 10.3% (Russian Federation) to 0.6% (Finland) across the port states. On the other hand, the percentage of ships detained with more than 10 deficiencies also varies substantially across the port states with as little as 20% (Sweden) to 83.3% (Belgium).

Finding 3: Differences in performance of classification societies

87% of all inspected ships were classified by EU recognized classification societies while the remaining 13% accounted for almost 3 times of the % of detentions compared to EU recognized classification societies.

The analysis further shows that there is a difference in how classification societies perform based on a certain flag state or owner. Although the probability of detention with class related deficiencies does not vary significantly across EU recognized classification societies, it does compared to non EU recognized classification societies.

The variation of EU recognized classification societies can best be seen when comparing detention rates and average number of deficiencies for the same class across white, grey of black flag states. The detention rate turns out to be almost higher for black flag states than for the other two groups within the same classification society.

Finding 4: Ship's Risk Profiles

The binary logistic model provides the scientific proof that the type of deficiency matters and not only the number of deficiency. The probability of detention can be split up into a generic factor which is a ship's risk profile and a history factor which gives an indication on what type of deficiency contributes more towards the probability of detention. In order of contribution, this would be as follows:

1. Fire & Safety Appliances
2. Certificates
3. Equipment/Machinery
4. Ship & Cargo Operations
5. Management
6. Stability & Structure
7. Working Conditions

Comparing the risk profiles of various ship types reveals that general cargo ships have a higher probability of detention followed by bulk carriers, Ro-Ro cargo ships, oil and chemical tankers, container ships and passenger ships. This ranking might have been expected but it also reflects the present target factor and how it has been applied over the years. This might also explain the lowest contribution to the probability of detention of the category "working conditions" which should have a much higher importance. It could be interpreted as a low emphasis given during the inspections on living and working conditions of the crew.

Finding 5: Target Factor Improvement

The target factor used by the Paris MoU can be improved by creating ship risk profiles based on the probabilities of detention and by assigning weights of importance either to the individual deficiency main codes or the six main deficiency groups listed above. In doing so, one should take into consideration that the dataset used for the analysis is to a certain extent biased since it reflects the selection of ships based on the present target factor. The findings are therefore an indication on the performance of the port state control and the emphasis that was given to certain inspection. Nevertheless, due to the size of the dataset, the models are expected to give a good indication on the relationships and the importance of the deficiency codes. The model suggests that by assigning different weight factors to the deficiency codes, the accuracy of targeting a substandard ship can be improved by around 2%.

4.2. Critique on the Present System and Ideas to improve it

Besides the quantitative part of this thesis, the research conducted to understand the variables that are involved in the analysis has given the input to the author to come up with some suggestions on how to improve the safety regime in general. The first part of this thesis has shown the complexity and amount of safety regulations a prudent ship owner has to comply with. Lack of trust, transparency and cooperation within the industry and the absence of adequate rewards for good ship owners to comply with existing and future safety regulations all represent obstacles in the effort to eliminate substandard ships. In addition, more emphasize should be given to the human element and the proper training of seafarers since most accidents are believed to be due to human error (80%). The analysis has shown that this has not been the case in the past since working and living conditions turn out to show the lowest contribution towards the probability of detention.

Port State control is not the remedy to the problem as the problem should be tackled at the source – the flag states and not be passed onto the port state to act as a police force since in this way, the enforcement is only happening at the ship level. Port state control has been proven to be effective in the effort to target substandard ships. The idea of the EU Commission to change the 25% target to a broader Union wide approach is a good start to improve the system since the analysis by itself has already shown that due to the different trade flows between the South and North of Europe, an equal application of 25% of inspection target within each member state is not effective on the long run. Ships should be inspected when they need to be inspected and not due to a set, arbitrary target. In addition and since general cargo ships seem to perform worst, it might be useful to include general cargo ships into the list of ships that can be banned from EU ports.

Any possible system should help to decrease and harmonize the amount of inspections instead of increasing them. Self regulating systems such as the vetting system used by the bulk industry (dry and liquid bulk and chemicals) also show the effort to improve the safety but to a certain extent also reflect the pressure major oil companies can put on ship owners who have to pay for these vetting inspections. The amount of inspections a ship has to deal with can be plentiful ranging from port state control to inspections from class of flag surveyors to vetting inspections - all for the "benefit" of increased safety but to the cost of the industry. Harmonization of inspections would be beneficial to all players involved.

Since it is very difficult to increase the pressure on flag states, commercial incentives for ship owners might be another possible solution. A good example for this approach is the Green Award certification for tankers and bulk carriers and possible short sea shipping in the future[55]. Another initiative to decrease the amount of inspections and therefore to provide a commercial incentive to comply is the Qualship21 initiative of the US Coast Guard based on quality registries and performance ratings of ship owners with possible inclusion of the charterer in the future.

Legislation should not be created to punish good ship owners in an effort to eliminate substandard ships but should also allow the industry to come up with commercial solutions to increase the pressure on non-performing flag states and non-prudent ship owners. On the long run and to improve this system, the flag state needs to meet certain requirements to be a quality flag states. Since the main reason for a ship owner to use an open registry is crew and maintenance related costs, existing flag states have to try to provide a commercially attractive environment for the ship owner.

4.3. Suggestions for Further Research

During the course of this thesis, many ideas crossed the author. The most burning question is how to achieve the ideas raised in the previous paragraph – how to improve the system and how to create a solution which the industry can work out by itself without extensive regulation and increased legislative burden for the prudent ship owner?

In essence, this would mean to come up with a sustainable quality shipping policy for the European Union. Research in this area would not only include the variables used for the target factor of the port state control regime but additional variables such as for instance a correlation of casualties with port state control data or other casualty statistics for either the EU or on a global scale. On a global scale, another idea would be to use data from various port state control regimes in order to do the analysis on a data set which is less biased. It would be interesting to see if detention really correlates with the probability of a casualty. In addition, it would be interesting to find out how these competitive advantages of ship owners who do not comply can be eliminated by commercial incentives for good ship owners.

Finally, the most burning and most difficult question is to find out how incentives for flag states can be created in order to enhance the enforcement of international legislation. Since this cannot be done by jurisdiction at the moment, the only other possible way is through the market itself. All these questions and areas explained above show that the subject of maritime safety constitutes a very interesting field for conducting further research.

[55] Interview conducted by author with Green Award

Bibliography

<u>Data Resources and Related Information:</u>

Paris MoU Port State Control Inspection Data from May 2000 to May 2004

Lloyd's Register - Fairplay *"World Shipping Encyclopedia CD"*. March and April 2004, Center for Maritime Economics and Logistics, Erasmus University, Rotterdam, The Netherlands

Snijders, I., Sindram, A., Droppers, C., Schiferli, R. (2004). Several Meetings for Data Preparations and Interpretations with the author. Secretariat of the Paris MoU on Port State Control, The Hague.

<u>Interviews</u>

Bergot, G., Barbeira-Gordon, S., (2004). Interview by author, European Commission, Directorate-General for Energy and Transport, Brussels

Blankestijn, P., Capt. Lehmann-Taylor, N., Elskamp H., (2004). Interview by author, P&O Nedlloyd, Rotterdam

De Graeve, W. (2004). Interview by author. Federal Public Service Mobility and Transport, Maritime Transport, Maritime Inspectorate, Antwerp.

Fransen, J. and Capt. Den Heijer, R. (2004). Interview by author, Green Award Foundation, Rotterdam.

Harts, P. (2004). Interview by author. Inspectorate Transport and Water Management, Netherlands Shipping Inspectorate, Rotterdam.

Huisink, G. (2004). Interview by author, Royal Association of Netherlands' Shipowners, Rotterdam.

Janssen, P. Capt. (2004). Interview by author. Federal Public Service Mobility and Transport, Maritime Transport, Maritime Inspectorate, Antwerp.

Kamstra, P.C. (2004). Interview by author. Inspectorate Transport and Water Management, Netherlands Shipping Inspectorate, Rotterdam.

Koorneef, C.W. (2004). Interview by author. Department of Noxious and Dangerous Goods, Port of Rotterdam, Rotterdam

Koert, C. (2004). Interview by author. Department of Noxious and Dangerous Goods, Port of Rotterdam, Rotterdam

Salwegter, A. (2004). Interview by author. Inspectorate Transport and Water Management, Netherlands Shipping Inspectorate, Rotterdam.

Scheres, G. (2004). Interview by author. Inspectorate Transport and Water Management, Netherlands Shipping Inspectorate, Rotterdam.

Port State Control Inspections and Ship Visits:

PSC Inspection: Ship Name: *Marfret Provence*, IMO# 9152789, Flag: Luxembourg, Ship Type: Containership, Surveyor: Mr. Aarnout Salgweter, Rotterdam, 29th June 2004

PSC Inspection: Ship Name: *Rima S, IMO# 7712327*, Flag: Syria, Ship Type: General Cargo, Surveyor: Mr. De Graeve Walter, Antwerp, 16th July 2004

PSC Inspection: Ship Name: *Agat, IMO# 7817373*, Flag: Cyrpus, Ship Type: General Cargo, Surveyor: Mr. De Graeve Walter, Antwerp, 16th July 2004

Marpol Inspection: Ship Name: *Nordic Yukon, IMO# 9002386*, Flag: Norway, Ship Type: Oil Tankship, Superindendent: Mr. Cees-Willem Koorneef, Rotterdam, 25th August 2004

Marpol Inspection: Ship Name: *Ruhr Ore., IMO# 8410108*, Flag: Panama, Ship Type: Ore/bulk/oil carrier, Superindendent: Mr. Cees-Willem Koorneef, Rotterdam, 25th August 2004

Visit: Ship Name: *Stolt Achievement*, IMO# 9124469, Flag: Cayman Islands, Ship Type: Chemical Tankship, Contact: Peter Maasland, Stolt Nilsen, 20th August 2004

Books, Periodicals, Articles and Internet Resources

Alderton T. and Winchester N (2002). "Flag States and Safety: 1997-1999". *Maritime Policy and Management*, Vol 29, No. 2, pp 151-162

Bergantino A. and Marlow P. (1998), Factors influencing the choice of flag: empirical evidence. *Maritime Policy and Management,* Vol 25, No. 2, pp 157-174

Bergantino A. and Sullivan P. (1999), Flagging Out and International Registries: Main Developments and Policy Issues, *International Journal of Transport Economics*, Vol. 26, No. 3, pp 447-470

Cedre – Centre de Documentation de Recherche et d'expérimentation sur les pollutions accidentelles des Eaux, *http://www.le-cedre.fr/, 01/07/2004*

European Commission, *White Paper on Environmental Liability*, COM (2000) 66 final

Hawkins, J. (2001) "Quality Shipping in the Asia Pacific Region". *International Journal of Maritime Economics*, No. 2, pp 79-101

IMO (2000). *Basic Facts about IMO*. Focus on IMO, London, *www.imo.org*, *15/06/2004*

IMO (2001) *A summary of IMO conventions*. Focus on IMO, London, *www.imo.org*, *15/06/2004*

International Associations of Classification Societies, (2004). *What are Classification Societies? http://www.iacs.org.uk/index1.htm, 27/07/2004*

International Associations of Classification Societies (2004), *Code of Ethnics*: *http://www.iacs.org.uk, 27/07/2004*

International Association of Dry Cargo Shipowners, *www.intercargo.org, 03/07/2004*

International Tanker Owners Pollution Federation (2004), *Oil Tanker Spill Statistics, 2003, http://www.itopf.com/stats.html, 30/06/2004*

International Transport Federation (2004), Flags of Convenience Campaign Update: Maritime Safety, *http://www.itf.org.uk/english/flagsconvenience/reports/2002/ section03, 28/06/2004*

Mediterranean Agreement on Port State Control, *www.medmou.org/PSC-main.htm, 16/06/2004*

Naftika Chronika, European Commission proposal for an "Erika III" package on maritime safety, *www.Naftikachronika.gr/viewmore.asp?ArticleID=961&lang=en&cat=17,25/06/2004*

Nieuwpoort, G. (2002). The importance of strengthening flag state cooperation. Speech at *Mare Forum*. (September 2002: Athens, Greece).

Paris Memorandum of Understanding on Port State Control (2002). Annual Report 2002, *www.parismou.org/ParisMOU/Organisation/Annual+reports/xp/menu 3944/ default. aspx*, *03/07/2004*

Psarafitis, H.N. (2003). Menage a trios. Comments to Session 1 at *Mare Forum* (November 2003: Amsterdam, The Netherlands)

Peijs, K. (2003). Menage a trois. Speech at *Mare Forum* (November 2003: Amsterdam, The Netherlands)

Snijders, I (2004), *Port State Control in Europe – Past Successes and Future Challenges*. Presentation. Erasmus University Rotterdam, Rotterdam, The Netherlands

Stares, J. EU Transport and Energy face four ways split. *Lloyd's List*: *http://www.lloydslist.com/NASApp/cs/ContentServer?GXHC_gx_session_id_=23c5648dc908a032&pagename=LloydsList/Home&element=LloydsList/content/dynamic/generic/viewArticle&areaTitle=Front+Page+News&articleId=1084814662235, 28/07/2004*

Smit, S., Lei, G., Seemakucp, A. and Wang F. (2004). *"Maritime Safety in an Enlarged EU"*. Working Paper for International Economics, Erasmus University, Rotterdam.

UNCTAD (2003), *Review of Maritime Transport 2003*, UNCTAD Secretariat, Geneva, *www.unctad.org/Templates/StartPage.asp?intItemID=2614&lang=1, 27/07/2004*

UN (1992). *Report of the United Nations Conference on Environment and Development*, Rio de Janeiro, *www.un.org/esa/sustdev/documents/agenda21, 15/07/2004*

Resources for the Regression Analysis and Correspondence Analysis

Clausen, S. E. (1998). *Applied Correspondence Analysis* – An Introduction (Sage University Papers Series on Quantitative Applications in the Social Sciences, series no. 07-121). Thousand Oaks, CA: Sage

Franses, P.H. and Paap, R. (2000). *Quantitative Models in Marketing Research*. Erasmus University Rotterdam, Rotterdam, The Netherlands.

Hosmer, D. and Lemeshow S. (1989). *Applied Logistic Regression*. New York: John Wiley & Sons

Hill, C., Griffiths, W. and Judge G. (2001). *Undergraduate Econometrics*, 2nd Edition, New York: John Wiley & Sons, Inc.

Keller, G. and Warrack, B. (2003). *Statistics for Management and Economics*, 6th Edition, USA: Brooks/Cole – Thomson Learning

Spence, L. and Vanden, E. (1990). *Calculus with Applications to the Management, Life and Social Sciences*. Illinois: Scott, Foresman/Little, Brown Higher Education (A Division of Scott, Foresman and Company)

Thomas, R.L. (1997). *Modern Econometrics – An introduction*. Harlow: Addison Wesley

Legislative Resources in General

A summary of IMO Conventions, 2001, London, IMO, *http://www.imo.org/home.asp, 27/06/2004*

Convention on the International Maritime Organization, 1948, (Art. 1), Geneva, IMO, *http://www.imo.org/home.asp, 27/06/2004*

Mutual Legal Assistance in Criminal Matters and Extradition – The principle of Reciprocity: *www.oas.org/juridico/MLA/en/ven/en_ven-mla-gen-reciprocity.html, 28/08/2004*

United Nations Convention on the Law of the Sea, 1982, Part 7, (Art. 91 and 94), UN, *www.un.org/Depts/los/convention_agreements/texts/unclos/part7.htm, 28/07/2004*

United Nations Convention on Conditions for Registration of Ships, 1986, UN *http://www.admiraltylawguide.com/conven/registration1986.html, 28/07/2004*

C147 Merchant Shipping (Minimum Standards) Convention, 1976, Geneva, ILO *http://www.ilo.org/ilolex/english/convdisp1.htm, 28/06/2004*

P147 Protocol of 1996 to the Merchant Shipping (Minimum Standard) Convention, 1976, Geneva, ILO, *www.ilo.org/ilolex/english/convdisp1.htm, 28/06/2004*

Paris Memorandum of Understanding on Port State Control, 1982, Paris, Paris MoU, *http://www.parismou.org/ParisMOU/Organisation/Memorandum+of+Understanding/xp/menu.3945/default.aspx, 17/07/2004*

Legislative Resources from EUR-Lex - the portal to EU Law
(Relevant home page address: http://europa.eu.int/eur-lex/en/index.html)

EC Treaty Article 3, 95, 80 and 175

Directive 106/2001/EC of the European Parliament and of the Council of 19 December 2001 amending Council Directive 95/21/EC concerning the enforcement, in respect of shipping using Community ports and sailing in the waters under the jurisdiction of the Member States, of international standards for ship safety, pollution prevention and shipboard living and working conditions (port State control)

Directive 25/2001/EC of the European Parliament and of the Council of 4 April 2001 on the minimum level of training of seafarers

Directive 57/1994/EC of 22 November 1994 on common rules and standards for ship inspection and survey organizations and for the relevant activities of maritime administrations and *Directive 105/2001/EC* of the European Parliament and of the Council of 19th December 2001 amending Council Directive 57/1994/EC.

Commission Decision 221/2002/EC of 14 March 2002 amending Decision 587/96/EC on the publication of the list of recognized organizations which have been notified by Member States in accordance with Council Directive 94/57/EC

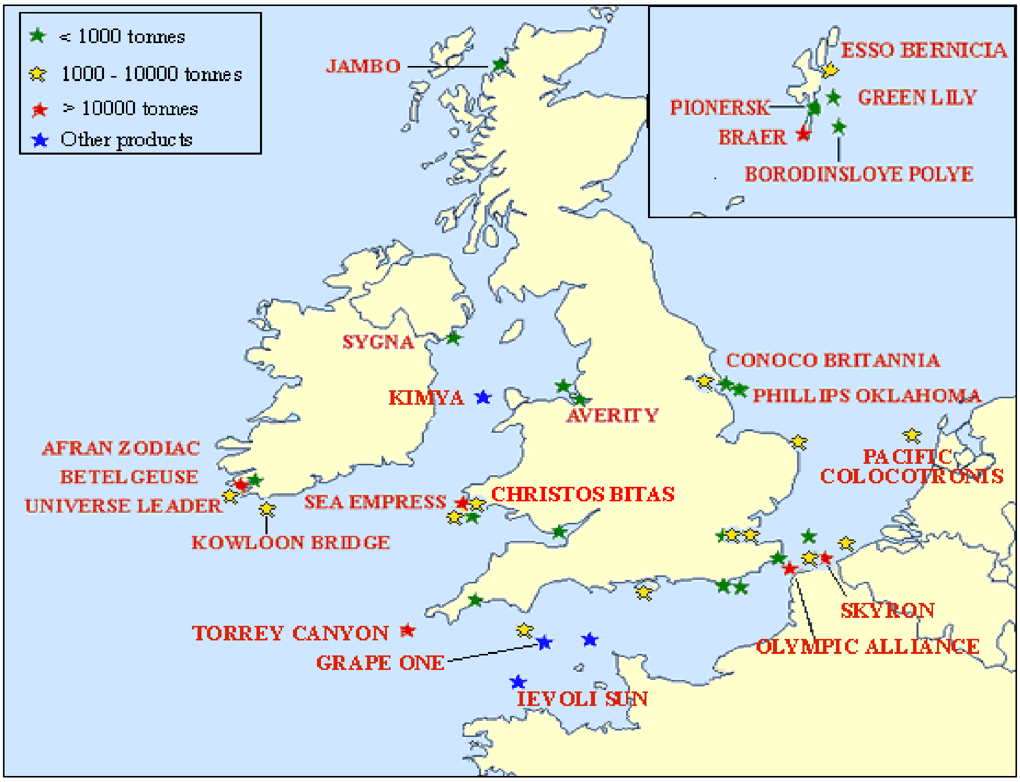
Appendices

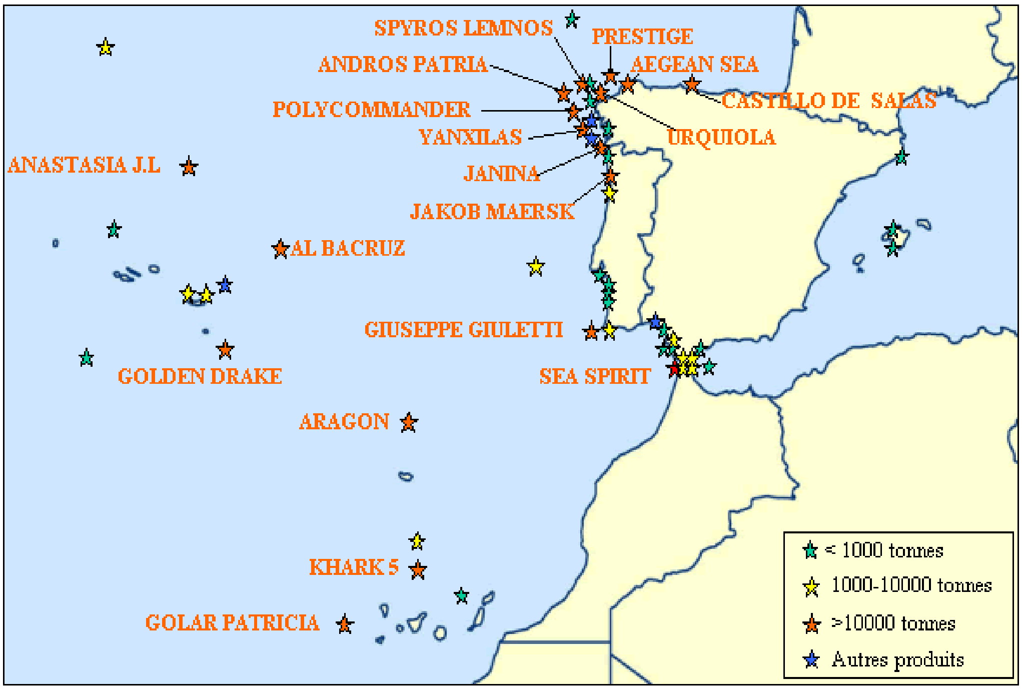
Appendix 1: Port State Control Regimes Worldwide

Paris MOU	Indian Ocean MOU	Tokyo MOU	Abuja MOU
Belgium	Australia	Australia	Angola
Canada (East Coast)	Bangladesh	Canada	Benin
Croatia	Djibouti	Chile	Cameroon
Denmark	Eritrea	China	Cape Verde
Finland	Ethiopia	Fiji	Congo
France	India	Hong Kong	Cote d'Ivoire
Germany	Kenya	Indonesia	Gabon
Greece	Maldives	Japan	Gambia
Iceland	Mauritius	Republic of Korea	Ghana
Ireland	Mozambique	Malaysia	Guinea
Italy	Myanmar	New Zealand	Guinea-Bissau
Netherlands, the	Oman	Papua New Guinea	Equator al Guinea
Norway	Seychelles	Philippines	Liberia
Poland	Singapore	Russia Federation	Mauritania
Portugal	South Africa	Singapore	Namibia
Russian Federation	Sri Lanka	Solomon Islands	Nigeria
Slovenia	Tanzania	Thailand	Senegal
Spain	Yemen	Vanuatu	South Africa
Sweden		Vietnam	Togo
United Kingdom			
Mediterranean MOU	**Acuerdo de Vina del Mar**	**Caribbean MOU**	**Black Sea MOU**
Algeria	Argentina	Antigua and Barbuda	Bulgaria
Cyprus	Bolivia	Aruba	Georgia
Egypt	Brazil	Bahamas, the	Romania
Israel	Chile	Barbados	Russian Federation
Lebanon	Colombia	Cayman Islands	Turkey
Malta	Cuba	Grenada	Ukraine
Morocco	Ecuador	Guyana	
Tunisia	Honduras	Jamaica	
Turkey	Mexico	Netherlands Antilles	
Palestinian Authority	Panama	Trinidad and Tobago	
	Peru		
	Uruguay		
	Venezuela		

Sources: Mediterranean Agreement on Port State Control and "Maritime Safety in an Enlarged EU" (International Economics Paper, Erasmus University, Rotterdam)

Appendix 2: Selected Oil Spills in Britain, France and Spain





Source for both maps: Cedre - http://www.le-cedre.fr/

Appendix 3: Paris MoU Black, Grey and White List

Flag State	Inspections 2000-2002	Detentions 2000-2002	Black to Grey Limit	Grey to White Limit	Excess Factor
BLACK LIST					
Albania	126	69	14		14,35
Bolivia	76	40	9		12,88
Sao Tome and Principe	97	46	11		11,59
Tonga	103	41	12		9,26
Lebanon	237	77	24	very	7,84
Algeria	200	61	20		7,07
Korea, Democratic Rep.	43	16	6		7,05
Honduras	226	68	23		7,04
Cambodia	911	230	77	high	6,30
Georgia	212	56	21		5,85
Turkey	2440	545	192		5,65
Syrian Arab Republic	394	89	36	risk	5,07
Libyan Arab Jamahiriya	57	16	8		4,90
Romania	170	37	18		4,25
Belize	358	71	34		4,16
St Vincent & Grenadines	2365	403	186	high	3,93
Morocco	201	39	21	risk	3,67
Ukraine	748	100	64	mthr[3]	2,47
Egypt	209	30	21		2,21
Panama	5213	541	396		1,90
Malta	5000	481	380	medium	1,65
India	209	24	21		1,38
Bulgaria	293	32	28	risk	1,38
Tunisia	44	7	6		1,35
Cyprus	3991	347	306		1,33
GREY LIST					
Croatia	166	17	18	6	0,96
Iran	210	19	21	8	0,83
Kuwait	48	5	7	0	0,74
Tuvalu	60	6	8	0	0,74
Cayman Islands	314	25	30	14	0,69
Russian Federation	2524	184	198	155	0,67
Azerbaijan	132	11	15	4	0,67
Portugal	676	50	59	36	0,62
Brazil	34	3	5	-1	0,61
Qatar	34	3	5	-1	0,61
Taiwan	63	5	8	1	0,58
Lithuania 383	28	36	18	0,57	
Gibraltar	273	20	27	12	0,56
Faroe Islands	40	3	6	0	0,53
Estonia	326	23	31	15	0,51
Thailand	106	7	12	3	0,46
Latvia	62	4	8	1	0,46
Ethiopia	34	2	5	-1	0,44

Source: Paris MoU Annual Report, 2002

Appendix 3: continued

Flag State	Inspections 2000-2002	Detentions 2000-2002	Black to Grey Limit	Grey to White Limit	Excess Factor
GREY LIST					
Malaysia	150	9	16	5	0,37
Myanmar, Union of	37	1	6	0	0,24
Korea, Republic of	92	4	11	2	0,23
United Arab Emirates	40	1	6	0	0,21
Vanuatu	117	5	13	3	0,18
Philippines	202	10	21	8	0,18
Spain	188	8	19	7	0,09
Poland	211	9	21	8	0,06
Austria	103	3	12	2	0,06
Barbados	267	12	26	11	0,05
Saudi Arabia	67	1	9	1	0,03
WHITE LIST					
Switzerland	50	0	7	0	-0,04
Japan	75	1	9	1	-0,08
Italy	780	40	67	42	-0,11
Marshall Islands	509	23	46	26	-0,20
Antigua and Barbuda	3506	198	271	220	-0,22
France	273	10	27	12	-0,25
Greece	1422	73	116	83	-0,26
Bahamas	3157	172	245	197	-0,28
Antilles, Netherlands	384	15	36	18	-0,33
U.S.A.	133	3	15	4	-0,34
Israel	59	0	8	0	-0,40
Bermuda	194	5	20	7	-0,50
Singapore	635	24	56	33	-0,56
China, People's Rep.	281	8	27	12	-0,61
Hong Kong, China	474	16	43	24	-0,62
Luxembourg	187	4	19	7	-0,67
Denmark	1309	49	107	76	-0,75
Liberia	2652	104	208	164	-0,80
Norway	2601	100	204	160	-0,82
Netherlands, the	2861	100	223	177	-0,96
Ireland	189	2	20	7	-1,18
Germany	1415	36	115	83	-1,22
Man, Isle of	546	10	49	28	-1,30
Finland	508	8	46	26	-1,39
Sweden	852	15	72	47	-1,44
United Kingdom	807	8	69	44	-1,74

Source: Paris MoU Annual Report, 2002

Appendix 4: Paris MoU Target Factor Calculation in Detail

Paris MOU
on Port State Control

TARGET FACTOR*)

The calculation of the Target Factor is divided into two parts:

1. **Generic Factor** - based on elements of the ships profile.
2. **History Factor** - based on the ships inspection history in the Paris MOU.

1. Generic Factor

The Generic Factor for an individual ship is calculated by adding together the applicable elements of its profile according to the elements below:

Targeted flag
A flag whose number of detentions in the last three years exceed its allowable limit based on a fixed yardstick (=7%). Graduated by increasing yardstick in steps of 3%. For example "medium to high risk" means detentions exceeded allowable limit using a yardstick of 10%.
(for detention % ref. Paris MOU Annual report)

Medium risk	(yardstick + 3%)	TF +4
Medium to High risk	(yardstick + 6%)	TF +8
High risk	(yardstick + 9%)	TF +14
Very High risk	(yardstick +12%)	TF +20

Targeted ship type TF +5
(ie liable to expanded inspection)

- i Bulk carrier more than 12 years old.
- ii Gas Carrier more than 10 years old.
- iii Chemical Tanker more than 10 years old.
- iv Oil tanker GT>3000 and more than 15 years old.
- v Passenger ship/ro-ro ferry more than 15 years old (other than ro-ro ferries and HS passenger craft operating in regular service under the provision of Council Dir. 1999/35/EC)

Non - EU recognised classification society TF +3
A class society not appearing on the list of recognised societies published by EC Commission. If no class is recorded in the database (other than withdrawal / suspension of class for safety reasons) the ship will be assumed to be classed with an EU recognised class society.

Ships more than 12 years old
Graduated for non-targeted ship types (ref. above) and passenger ships
Age:

>25 years	TF +3
21-24	TF +2
13-20	TF +1

Flag State has not ratified all conventions TF +1
Flag states who have not ratified all main conventions.
(Ref. Relevant instruments in Paris Memorandum text, ratification information can be found on www.imo.org & www.ilo.org)

Targeted Class
Class with a 3-yr average record of detentions above the average class detention value using the excess of average rate as yardstick. A classification society whose number of detentions with class related deficiencies in the last three years exceeds the average class detention rate. Graduated by increasing the "excess of average" in steps of 2%. E.g. the overall class detention

rate is 2.1% and the detention rate of a classification society is 4.1%, the "excess of average" value is 2%.
(for detention % ref. Paris MOU Blue Book)

≤0%	TF 0
0% - 2%	TF +1
>2% - 4%	TF +2
>4%	TF +3

The Generic Factor is updated when the particulars of the ship change or the status of its existing flag or class change.

2. HISTORY FACTOR

The History Factor is applied to the Generic Factor to reflect the actual condition of the ship found by inspection.
The History Factor is calculated by applying the elements below to each Paris MOU inspection of the ship carried out *in the previous 12 months*

Entering a region port for the first time in the last 12 months TF +20
No inspection recorded in the database in the last 12 months.

Not inspected in last 6 months TF +10
No inspection recorded in the database in the last 6 months.

Detained TF +15

Number of deficiencies:

0	TF -15
1 to 5	TF 0
6 to 10	TF +5
11 to 20	TF +10
21+	TF +15

Outstanding deficiencies from last inspection
The value for the outstanding deficiencies is applied only in respect of the latest inspection.
- for each listed 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 (specify in clear text)" TF+1
- in case "all deficiencies rectified" is noted on the report TF -2

The History Factor is updated at the end of each day.

Overall Target Factor

The Overall Target Factor is calculated by adding the Generic and History Factor but *cannot be less than the Generic Factor.*

The overall Target Factors are re-calculated at the end of each day.

***) The TF is in use within the Paris MOU on PSC as a tool for selecting ships eligible for an inspection only. The TF is not an indication of the quality of the ship.**

Source: Paris Memorandum of Understanding, www.parismou.org

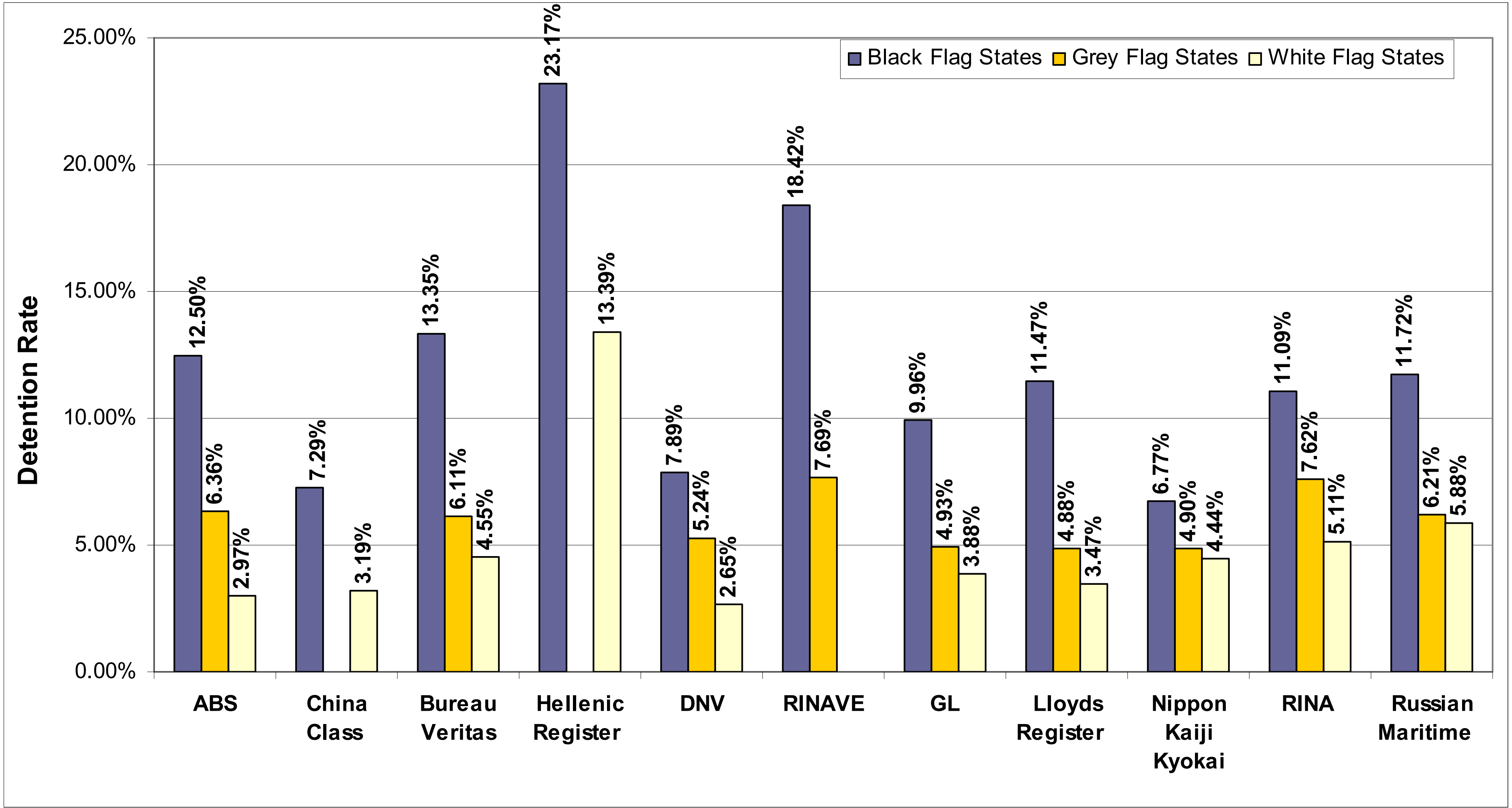
Appendix 5: Deficiency Main and Relevant Sub codes

Code	Deficiency Code Description	Nature of Defects
100	Ship's certificates and documents	missing, expired, invalid, withdrawn, etc.
200	Crew certificates	missing, expired, invalid, withdrawn, etc.
300	Accommodation	safety, hygiene, parasites, damages
400	Food and catering	safety, hygiene, parasites, damages
500	Working spaces and accident prevention	safety, equipment
600	Life saving appliances	lifeboats, life rafts, lifebuoys, lifejackets, onboard training, maintenance
700	Fire Safety measures	prevention, fire doors, detection, patrol, fire fighting systems, dampers, ventilation, fire control plan
800	Accident prevention (ILO147)	equipment, improper use
900	Structural Safety	watertight doors, signs, indicators, damage control plan, stability, strength, steering, hull damage, tanks, emergency
1000	Alarm signals	alarm systems
1100	Cargoes	stowage of cargo, loading and unloading equipment, dangerous codes
1200	Load lines	overloading, marks, railing, catwalks, hatches, doors, ventilators
1300	Mooring arrangements (ILO 147)	mooring devices and ropes
1400	Propulsion & auxiliary engine	main engine, auxiliary engine, pumps, UMS[56]
1500	Safety of navigation	equipment, emergency steering, lights, charts, AIS, VDR[57], all nautical equipment
1600	Radio communications	main installations, IMMARSAT, VHF
1700	MARPOL annex I	Ship oil emergency plan (SOPEP), oil record book, segregation, SBT, CBT, COW[58], double hull
1800	Gas and chemical carriers	cargo area segregation, all other areas specific to gas and chemicals
1900	MARPOL annex II	P&A manual, residue discharge, tank washing, pollution report
2000	Operational deficiencies	SOLAS related operational deficiencies - muster list, communication, all drills, cargo operations
2100	MARPOL related operational deficiencies	MARPOL related operational deficiencies - sludge, loading/unloading
2200	MARPOL annex III	packaging, making and labeling, stowage
2300	MARPOL annex V	garbage management and record book
2500	ISM related deficiencies	ISMC - crew responsibilities
2600	Bulks carriers	additional safety for bulk carriers - bulkhead strength, cargo booklet
630	Launching arrangements for survival craft	Seized, not as required, improperly used, obstructed, not properly maintained, broken, improperly fitted
739	Emergency Fire Pump	Inoperative, not properly maintained, insufficient pressure

Source: compiled from data provided by the Paris MoU, Code 630 and 739 are sub-codes

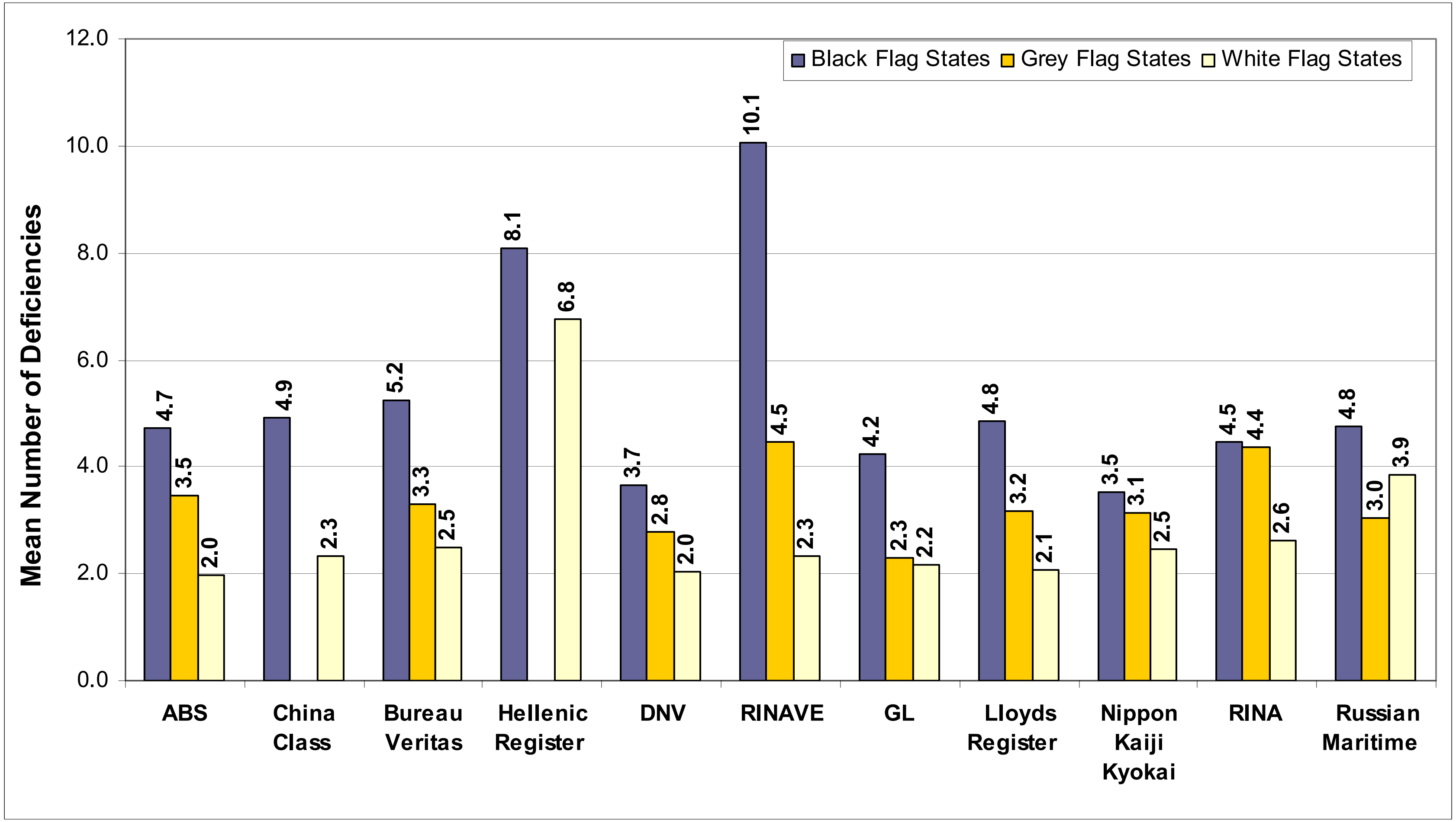
[56] unmanned machinery spaces
[57] AIS: automatic identification system, VDR:voyage data recorder
[58] SBT: separate ballast tanks, CBT: clean ballast tanks, COW: crude oil washing

Appendix 6: Performance Differences of Class: Detention Rate



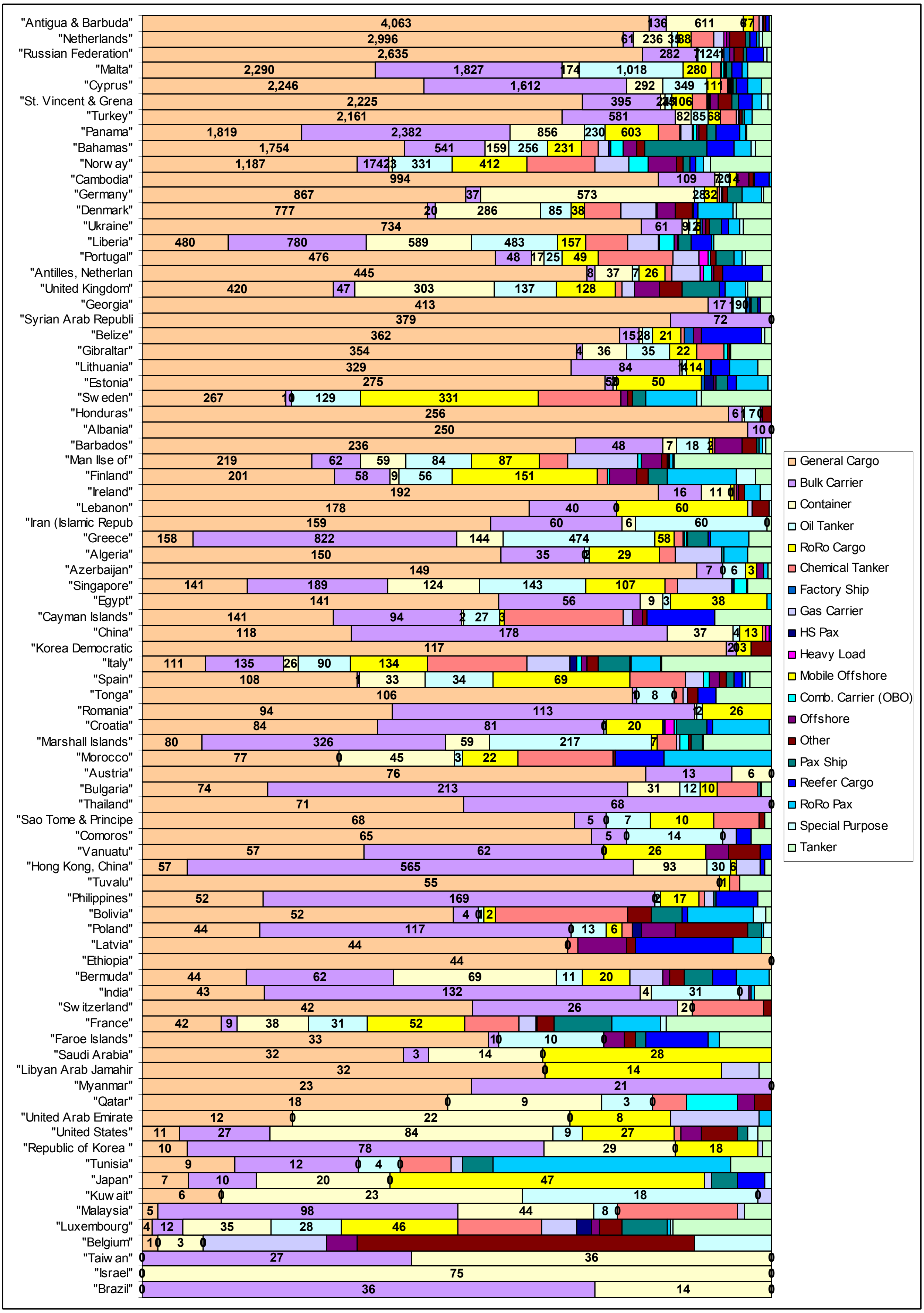
Source: Based on whole dataset (May 2000 – May 2004)

Appendix 7: Performance Differences of Class: Deficiencies



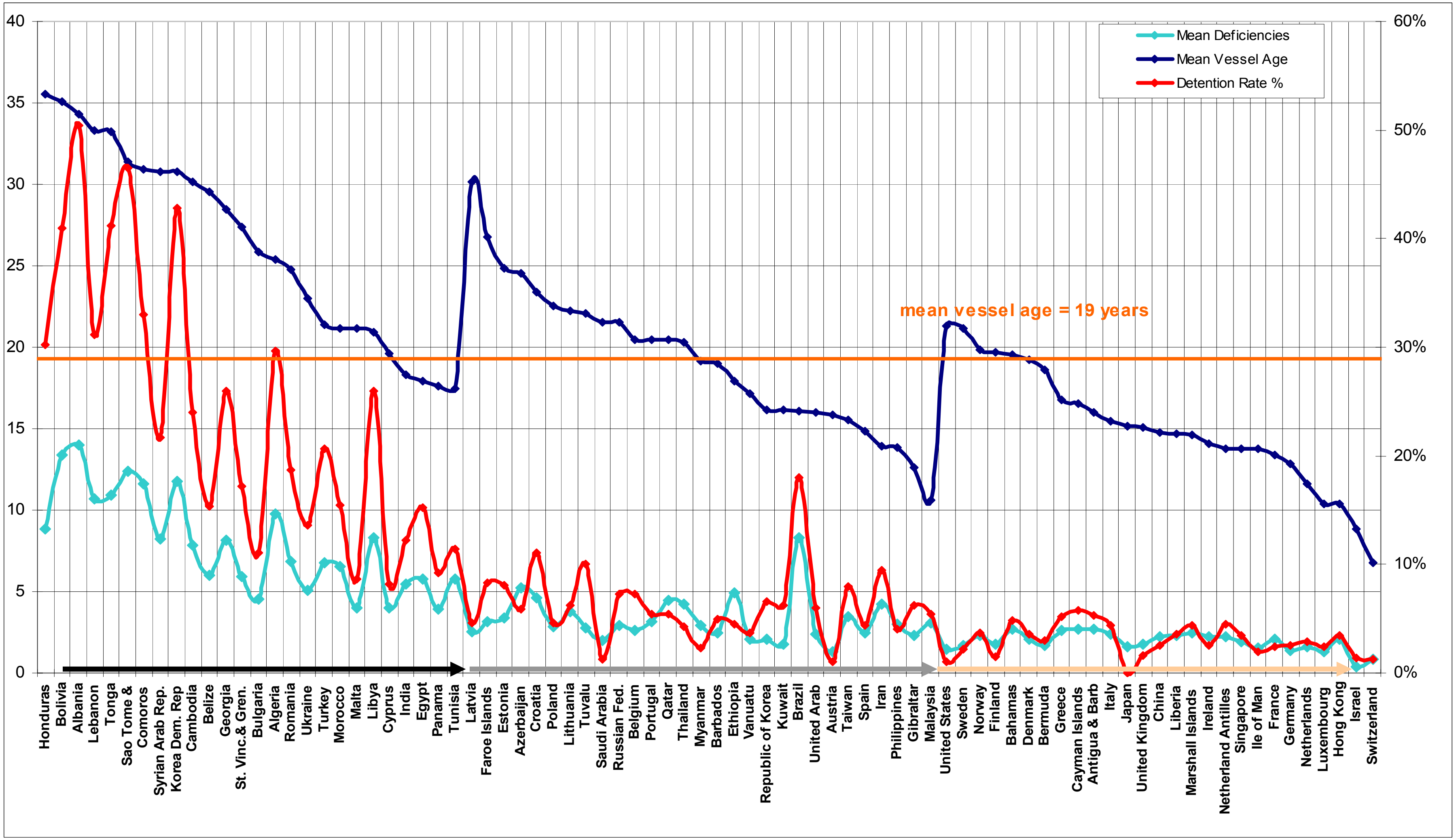
Source: Based on whole dataset (May 2000 – May 2004)

Appendix 8: Ship Type and Flag States



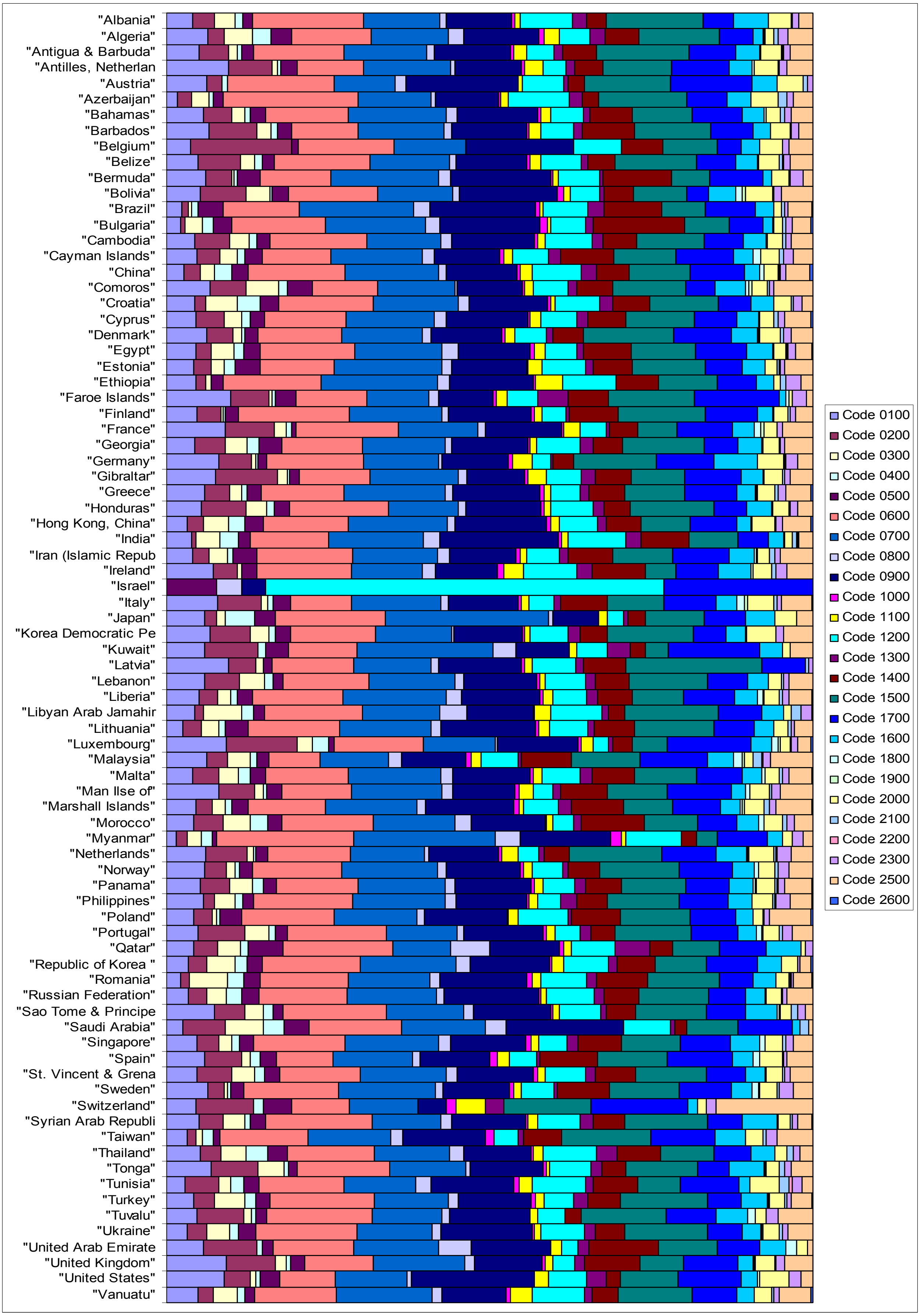
Source: Based on whole dataset (May 2000 – May 2004)

Appendix 9: Deficiencies, Age, Detention Rate per Flag State



Source: Based on whole dataset (May 2000 – May 2004)

Appendix 10: % of Deficiencies to Total Deficiencies per Flag State



Source: Based on whole dataset (May 2000 – May 2004)

Appendix 11: Correspondence Analysis Computer Output

Explained Variance	
0.7687	Dim 1
0.1036	Dim 2
0.0433	Dim 3
0.0387	Dim 4
0.0271	Dim 5
0.0089	Dim 6
0.0068	Dim 7
0.0029	Dim 8

Rows	Absolute Contribution		Relative Contribution		
Variable	**Dim1**	**Dim2**	**Dim1**	**Dim2**	**Quality:**
Black FS	0.1427	0.0174	0.921	0.0152	0.9362
Grey FS	0.0043	0.0505	0.0995	0.1563	0.2557
White FS	0.3446	0.1044	0.9291	0.0379	0.9671
Rec. Class	0.0452	0.1297	0.7028	0.2716	0.9744
Not Rec. Class	0.1527	0.4379	0.7028	0.2716	0.9744
Traditional MN	0.1446	0.0083	0.8785	0.0068	0.8853
Emerging MN	0.0967	0.102	0.724	0.103	0.827
Old Open Reg.	0.0054	0.0026	0.376	0.024	0.4
New Open Reg.	0.0021	0.0092	0.1597	0.0938	0.2536
International OR	0.0075	0.0578	0.2144	0.2228	0.4372
Unknown Owner	0.054	0.0802	0.6069	0.1214	0.7283

Columns	Absolute Contribution		Relative Contribution		
Variable	**Dim1**	**Dim2**	**Dim1**	**Dim2**	**Quality:**
'C0100'	0.056	0.1732	0.6923	0.2884	0.9807
'C0200'	0.0066	0.0929	0.1888	0.3606	0.5494
'C0300'	0.2716	0.0166	0.9642	0.0079	0.9721
'C0400'	0.0382	0.1826	0.5735	0.3689	0.9424
'C0500'	0	0.0891	0.0003	0.5279	0.5282
'C0600'	0.0259	0.0014	0.6252	0.0045	0.6297
'C0630'	0.1387	0.0745	0.9199	0.0666	0.9865
'C0700'	0.064	0.0971	0.8242	0.1687	0.9929
'C0800'	0.0033	0.0497	0.1951	0.3969	0.5921
'C0900'	0.0037	0.0257	0.1977	0.1837	0.3814
'C1000'	0.0003	0.002	0.0545	0.0585	0.1131
'C1100'	0.0321	0.0033	0.8797	0.0124	0.892
'C1200'	0.0749	0.0123	0.7977	0.0177	0.8154
'C1300'	0.0385	0.0099	0.9257	0.0321	0.9578
'C1400'	0.0016	0.0028	0.2384	0.0554	0.2938
'C1500'	0.0033	0.0081	0.3077	0.1021	0.4098
'C1700'	0.1453	0.0157	0.97	0.0142	0.9842
'C1600'	0.0003	0.0277	0.0409	0.537	0.5779
'C1800'	0.024	0.0181	0.5079	0.0516	0.5595
'C1900'	0.001	0.0001	0.4853	0.0035	0.4889
'C2000'	0.0285	0.0058	0.8047	0.0221	0.8268
'C2100'	0	0.0039	0.002	0.1211	0.1231
'C2200'	0.0014	0.0003	0.7438	0.0234	0.7672
'C2300'	0.0271	0.0193	0.8672	0.0834	0.9506
'C2500'	0.0136	0.0456	0.5218	0.2365	0.7583
'C2600'	0	0.0221	0.0045	0.3202	0.3246

Appendix 12: Computer Output, Model D – Linear

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.421(a)	.177	.175	.65799

a Predictors: (Constant), OW_OtherUnk, CL_RussianRiver, FS_SyrianAraRep, PS_Iceland, FS_Comoros, CL_CroatianRS, FS_Ethiopia, FS_Brazil, FS_Georgia, FS_Azerbaijan, CL_ChinaClass, ST_GasCarrier, CL_IsthumsBS, FS_MarshallIslands, PS_Norway, FS_Egypt, FS_CaymanIslands, FS_Morocco, FS_Gibraltar, CL_KoreanSouth, PS_Denmark, FS_Algeria, ST_SpecialPur, FS_Libya, CL_RomanianNaval, FS_NetherlandsAntilles, ST_Factory, PS_Ireland, FS_Tunisia, FS_SaoTomePrin, FS_Greece, FS_KoreanDR, CL_RINA, FS_Albania, FS_Singapore, PS_Sweden, FS_Cambodia, FS_Germany, FS_Malaysia, PS_Canada, ST_ReeferCargo, FS_Thailand, PS_France, FS_Tonga, FS_Belize, PS_Poland, FS_India, OW_OldOR, FS_Honduras, FS_Liberia, FS_Bolivia, FS_Iran, PS_Croatia, PS_Finland, FS_StVincentGren, FS_Lebanon, PS_Belgium, ST_RoRoPax, FS_Ukraine, FS_Bahamas, CL_PolskiReSt, CL_ABS, PS_Netherlands, FS_Norway, PS_Greece, CL_BureauVeritas, FS_Cyprus, PS_Germany, CL_NKKJapan, OW_NewOR, FS_Malta, FS_RussianFeder, PS_Spain, CL_NoClass, ST_BulkCarrier, ln_vessel_age, FS_Antigua, FS_Turkey, CL_DNV, PS_RussianFed, FS_Italy, CL_LloydsUK, FS_Panama, PS_Italy, ST_GeneralCargo, CL_RussianMS, OW_TraditionalMN, CL_GermanischerLloyd
b Dependent Variable: ln_totaldeficiencies

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4020.507	88	45.688	105.527	.000(a)
	Residual	18695.115	43181	.433		
	Total	22715.622	43269			

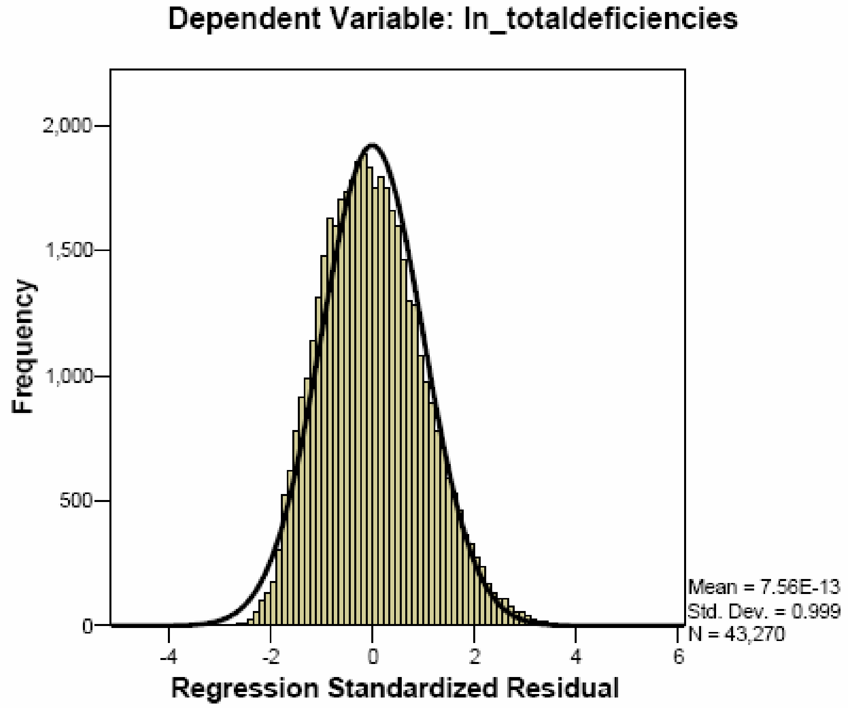
a Predictors: (Constant), OW_OtherUnk, CL_RussianRiver, FS_SyrianAraRep, PS_Iceland, FS_Comoros, CL_CroatianRS, FS_Ethiopia, FS_Brazil, FS_Georgia, FS_Azerbaijan, CL_ChinaClass, ST_GasCarrier, CL_IsthumsBS, FS_MarshallIslands, PS_Norway, FS_Egypt, FS_CaymanIslands, FS_Morocco, FS_Gibraltar, CL_KoreanSouth, PS_Denmark, FS_Algeria, ST_SpecialPur, FS_Libya, CL_RomanianNaval, FS_NetherlandsAntilles, ST_Factory, PS_Ireland, FS_Tunisia, FS_SaoTomePrin, FS_Greece, FS_KoreanDR, CL_RINA, FS_Albania, FS_Singapore, PS_Sweden, FS_Cambodia, FS_Germany, FS_Malaysia, PS_Canada, ST_ReeferCargo, FS_Thailand, PS_France, FS_Tonga, FS_Belize, PS_Poland, FS_India, OW_OldOR, FS_Honduras, FS_Liberia, FS_Bolivia, FS_Iran, PS_Croatia, PS_Finland, FS_StVincentGren, FS_Lebanon, PS_Belgium, ST_RoRoPax, FS_Ukraine, FS_Bahamas, CL_PolskiReSt, CL_ABS, PS_Netherlands, FS_Norway, PS_Greece, CL_BureauVeritas, FS_Cyprus, PS_Germany, CL_NKKJapan, OW_NewOR, FS_Malta, FS_RussianFeder, PS_Spain, CL_NoClass, ST_BulkCarrier, ln_vessel_age, FS_Antigua, FS_Turkey, CL_DNV, PS_RussianFed, FS_Italy, CL_LloydsUK, FS_Panama, PS_Italy, ST_GeneralCargo, CL_RussianMS, OW_TraditionalMN, CL_GermanischerLloyd
b Dependent Variable: ln_totaldeficiencies

Residuals Statistics(a)

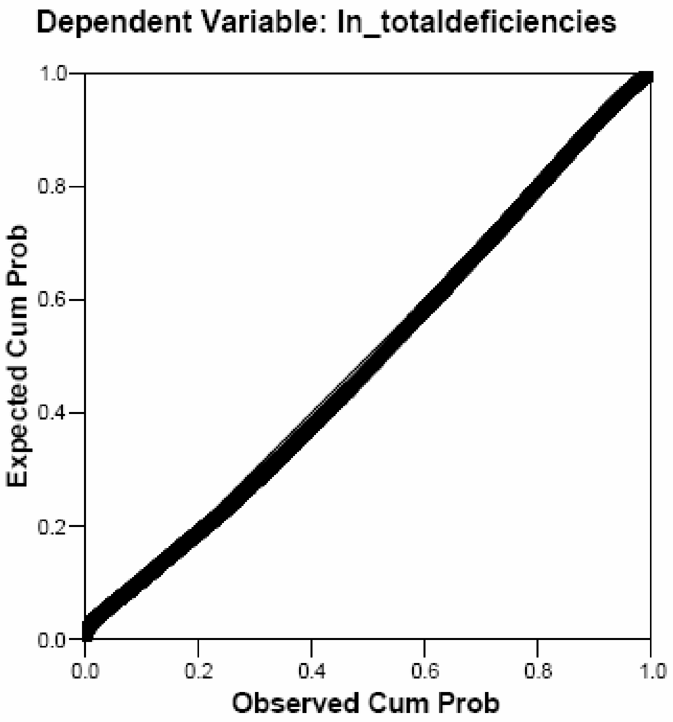
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.2983	3.0129	1.6905	.30483	43270
Std. Predicted Value	-4.567	4.338	.000	1.000	43270
Standard Error of Predicted Value	.013	.126	.027	.012	43270
Adjusted Predicted Value	.2975	3.0532	1.6905	.30484	43270
Residual	-2.00414	2.73315	.00000	.65732	43270
Std. Residual	-3.046	4.154	.000	.999	43270
Stud. Residual	-3.053	4.156	.000	1.000	43270
Deleted Residual	-2.01358	2.73585	.00000	.65876	43270
Stud. Deleted Residual	-3.053	4.157	.000	1.000	43270
Mahal. Distance	16.503	1573.680	87.998	112.452	43270
Cook's Distance	.000	.002	.000	.000	43270
Centered Leverage Value	.000	.036	.002	.003	43270

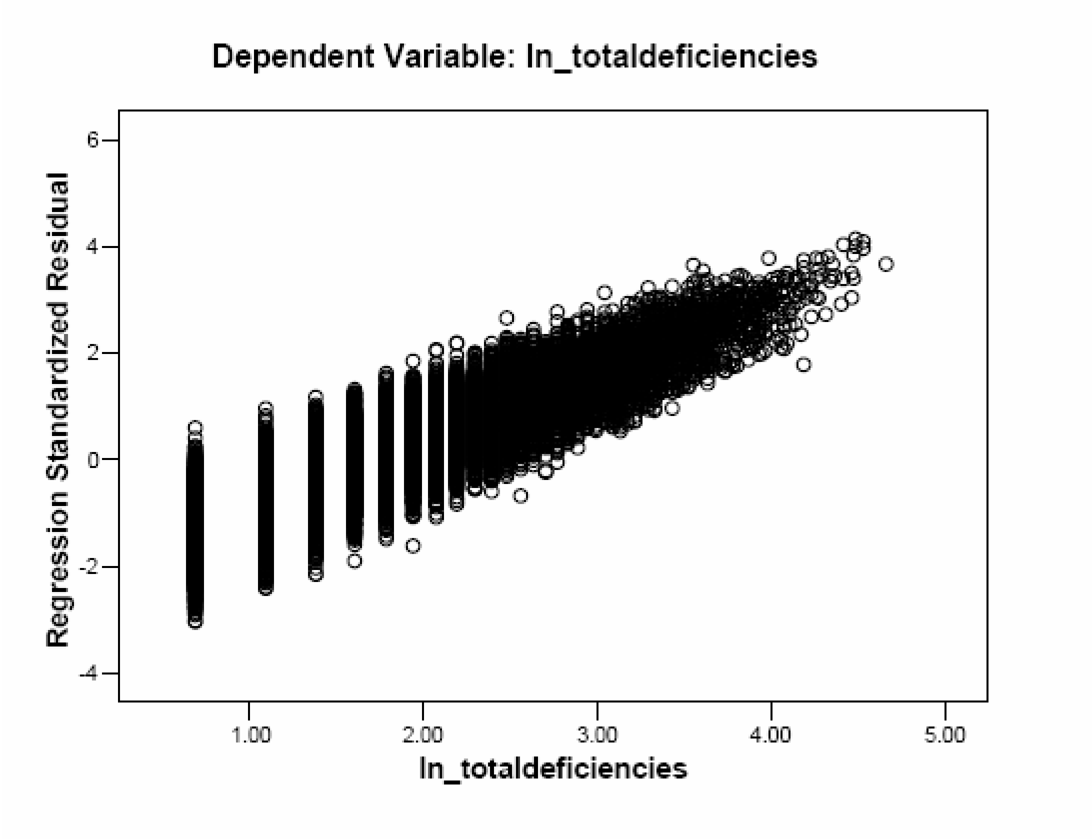
a Dependent Variable: ln_totaldeficiencies

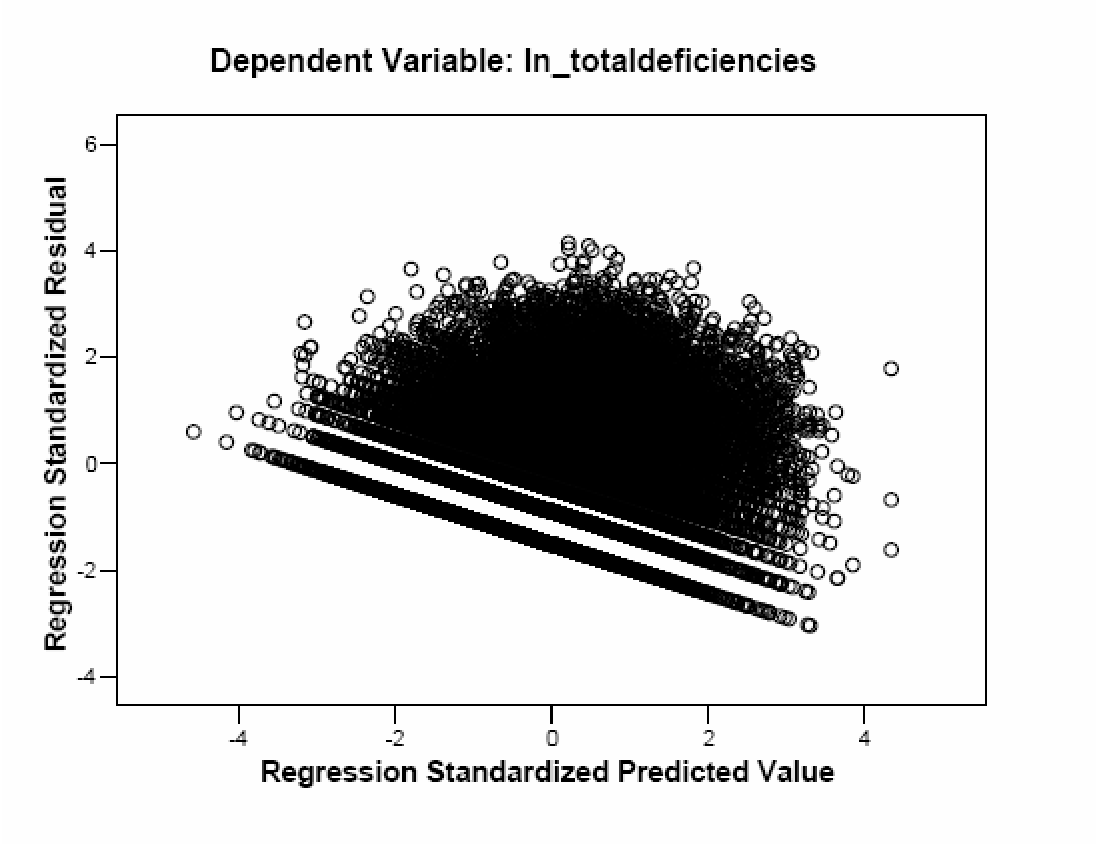
Histogram



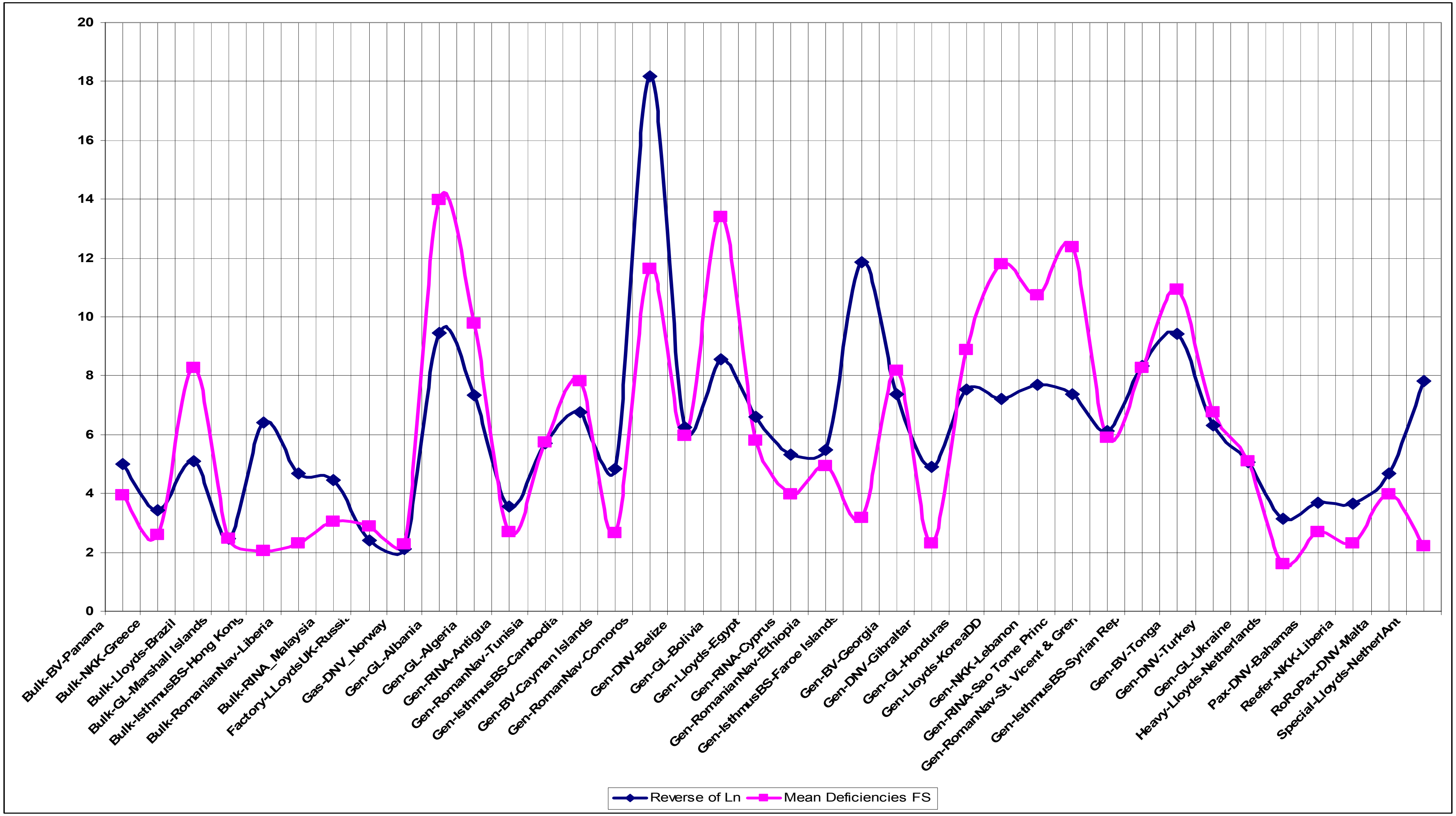
Normal P-P Plot of Regression Standardized Residual




Dependent Variable: ln_totaldeficiencies
Regression Standardized Residual
6
4
2
0
-2
-4
1.00
2.00
3.00
4.00
5.00
ln_totaldeficiencies


Dependent Variable: ln_totaldeficiencies
Regression Standardized Residual
6
4
2
0
-2
-4
-4
-2
0
2
4
Regression Standardized Predicted Value

Appendix 13: Coefficient Testing, Model D - Linear



Appendix 14: Computer Output: Binary Logistic Model Type 1

Case Processing Summary

Unweighted Cases(a)		N	Percent
Selected Cases	Included in Analysis	4401	70.2
	Missing Cases	0	.0
	Total	4401	70.2
Unselected Cases		1872	29.8
Total		6273	100.0

a If weight is in effect, see classification table for the total number of cases.

Iteration History

Iteration		-2 Log likelihood	Coefficients				
			Constant	ln_vessel_age	ln_grosstonnage	CL_ABS	CL_BureauVeritas
Step 1	1	3810.438	-2.529	.174	.073	-.341	-.291
	2	3657.800	-3.879	.371	.126	-.593	-.504
	3	3643.960	-4.391	.470	.143	-.677	-.570
	4	3643.201	-4.442	.481	.144	-.684	-.573
	5	3643.189	-4.443	.481	.144	-.684	-.574
	6	3643.189	-4.443	.481	.144	-.684	-.574

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	606.841	27	.000
	Block	606.841	27	.000
	Model	606.841	27	.000

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	3643.189(a)	.129	.208

a Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	4.404	8	.819

Contingency Table for Hosmer and Lemeshow Test

		detained_withclass_new = 0		detained_withclass_new = 1		Total
		Observed	Expected	Observed	Expected	
Step 1	1	430	428.444	10	11.556	440
	2	416	412.611	24	27.389	440
	3	397	402.135	43	37.865	440
	4	390	391.188	50	48.812	440
	5	377	380.006	63	59.994	440
	6	377	368.237	63	71.763	440
	7	360	354.806	80	85.194	440
	8	339	335.043	101	104.957	440
	9	295	300.537	145	139.463	440
	10	194	201.994	247	239.006	441

Classification Table(c)

	Observed		Predicted					
			Selected Cases(a)			Unselected Cases(b)		
			detained_withclass_new		% Correct	detained_withclass_new		% Correct
			0	1		0	1	
Step 1	detained_withclass_new	0	2538	1037	71.0	1058	472	69.2
		1	282	544	65.9	120	222	64.9
	Overall Percentage				70.0			68.4

a Selected cases sample EQ 1
b Unselected cases sample NE 1
c The cut value is .190

Appendix 15: Computer Output: Binary Logistic Model Type 2

Case Processing Summary

Unweighted Cases(a)		N	Percent
Selected Cases	Included in Analysis	53333	69.9
	Missing Cases	0	.0
	Total	53333	69.9
Unselected Cases		22915	30.1
Total		76248	100.0

a If weight is in effect, see classification table for the total number of cases.

Iteration History

Iteration		-2 Log likelihood	Coefficients				
			Constant	ln_vessel_age	ln_grosstonnage	CL_NoClass	CL_RINAVE
Step 1	1	25387.588	-1.703	.014	-.020	.123	-.254
	2	18876.710	-2.437	.079	-.053	.238	-.594
	3	17312.873	-3.007	.220	-.097	.315	-1.015
	4	17076.594	-3.482	.376	-.128	.323	-1.252
	5	17065.763	-3.673	.438	-.136	.315	-1.295
	6	17065.718	-3.688	.443	-.136	.314	-1.296
	7	17065.718	-3.688	.443	-.136	.314	-1.296

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	12987.676	70	.000
	Block	12987.676	70	.000
	Model	12987.676	70	.000

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	17065.718(a)	.216	.502

a Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	122.358	8	.000

Contingency Table for Hosmer and Lemeshow Test

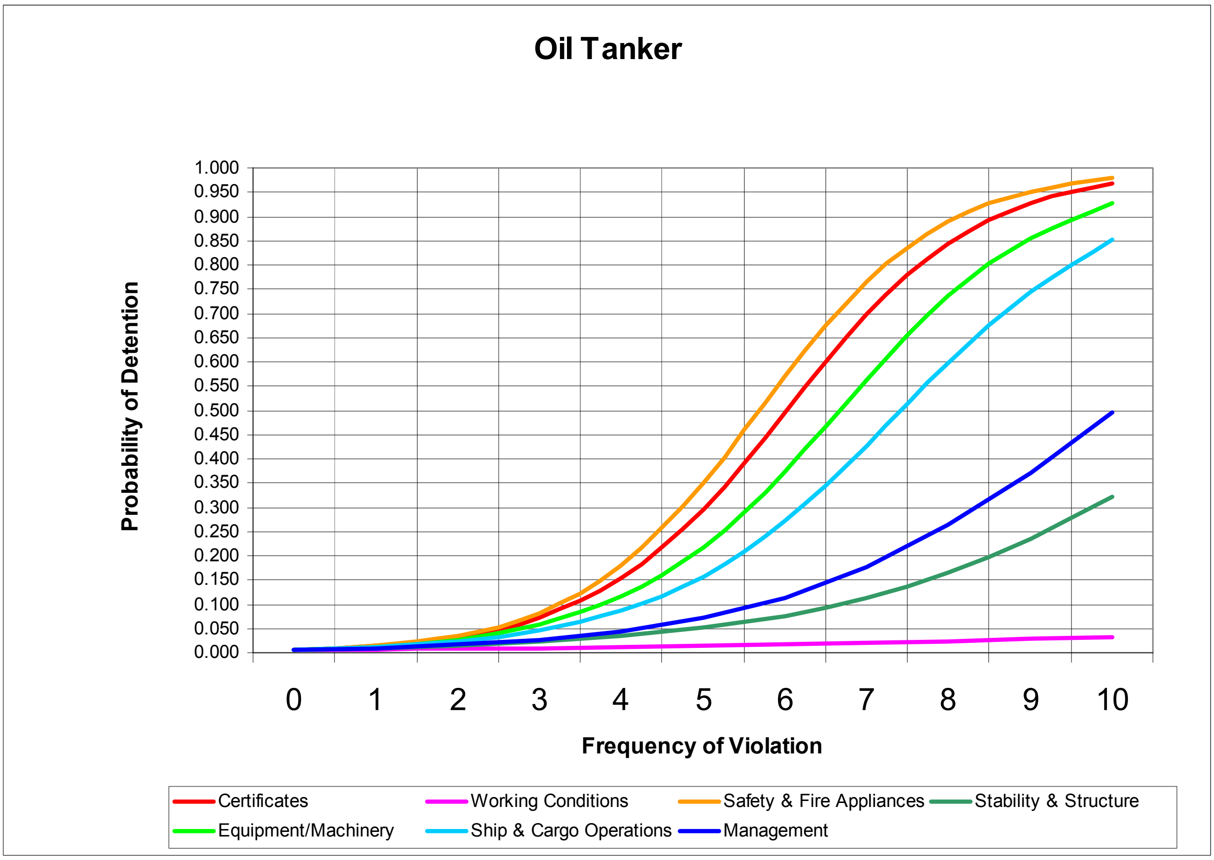
		detained_new = 0		detained_new = 1		Total
		Observed	Expected	Observed	Expected	
Step 1	1	5330	5313.970	3	19.030	5333
	2	5320	5299.135	13	33.865	5333
	3	5314	5282.943	18	49.057	5332
	4	5292	5266.094	41	66.906	5333
	5	5273	5243.439	61	90.561	5334
	6	5239	5209.139	94	123.861	5333
	7	5168	5155.392	165	177.608	5333
	8	5010	5045.266	323	287.734	5333
	9	4561	4714.038	772	618.962	5333
	10	2494	2471.584	2842	2864.416	5336

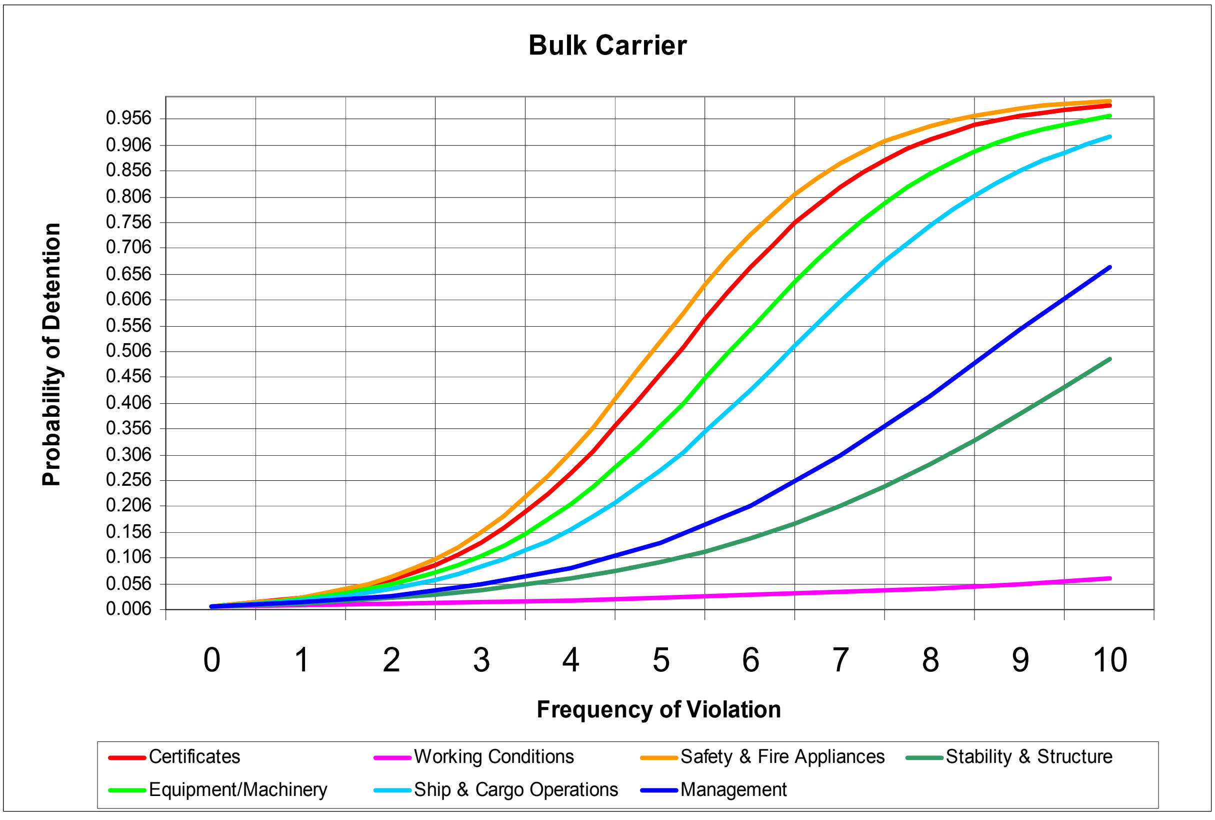
Classification Table(c)

Observed		Predicted					
		Selected Cases(a)			Unselected Cases(b)		
		detained_new		% Correct	detained_new		% Correct
		0	1		0	1	
detained_new	0	42608	6393	87.0	18235	2739	86.9
	1	789	3543	81.8	371	1570	80.9
Overall Percentage				86.5			86.4

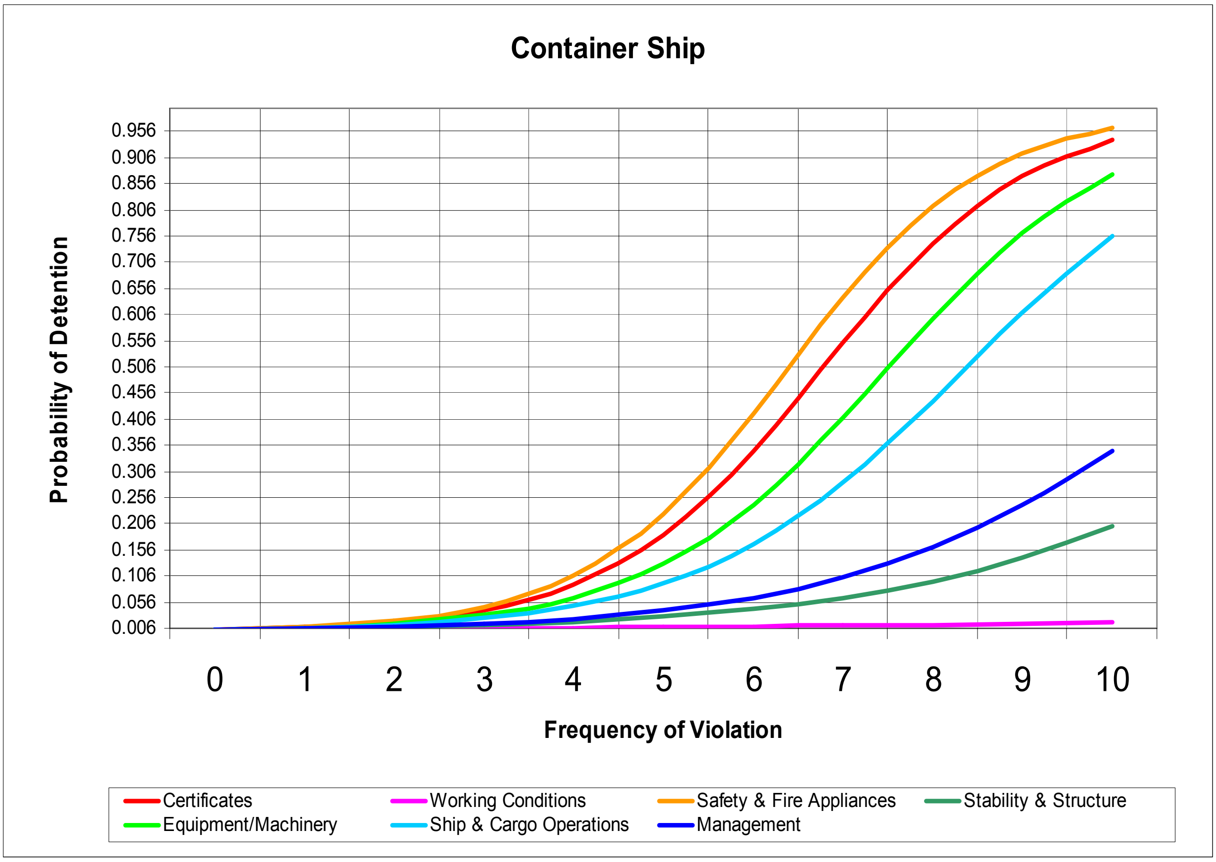
a Selected cases sample EQ 1
b Unselected cases sample NE 1
c The cut value is .080

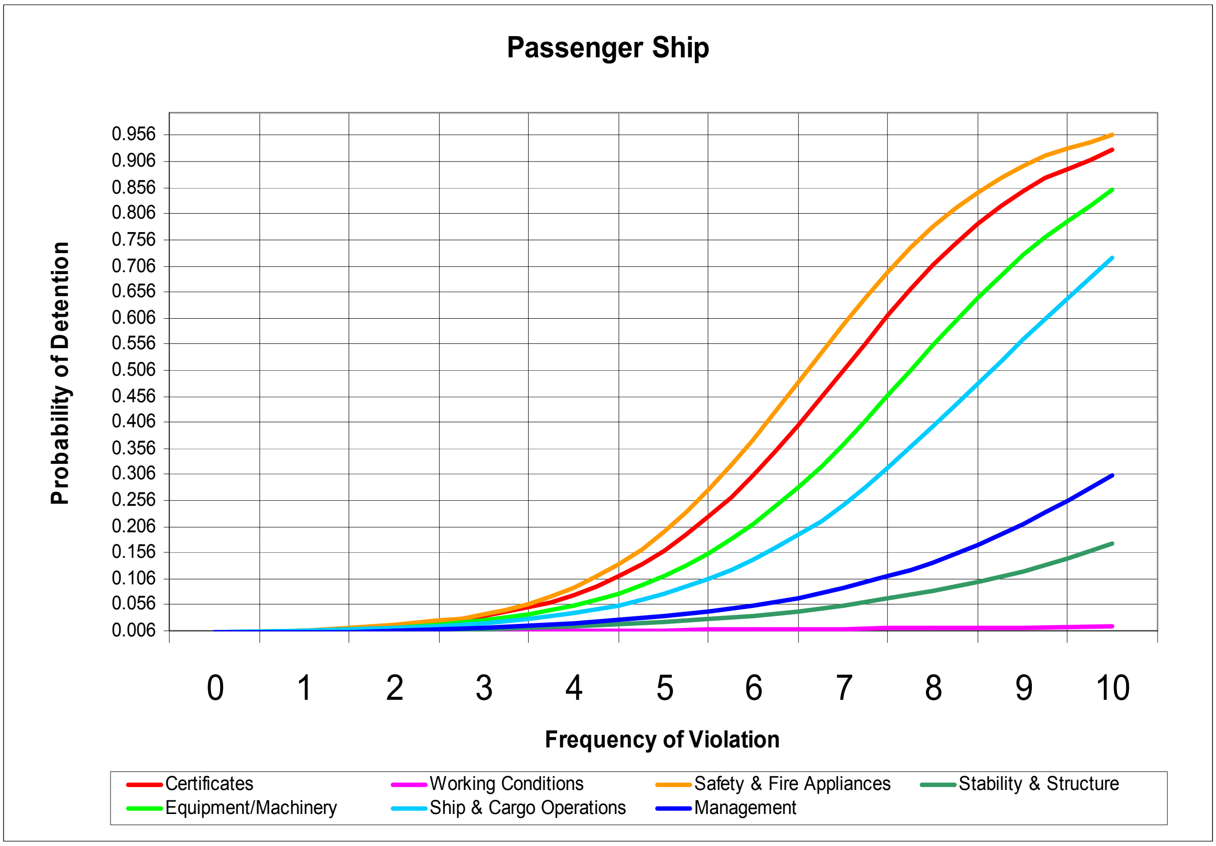
Appendix 16: Probabilities of Detention for Major Ship Types



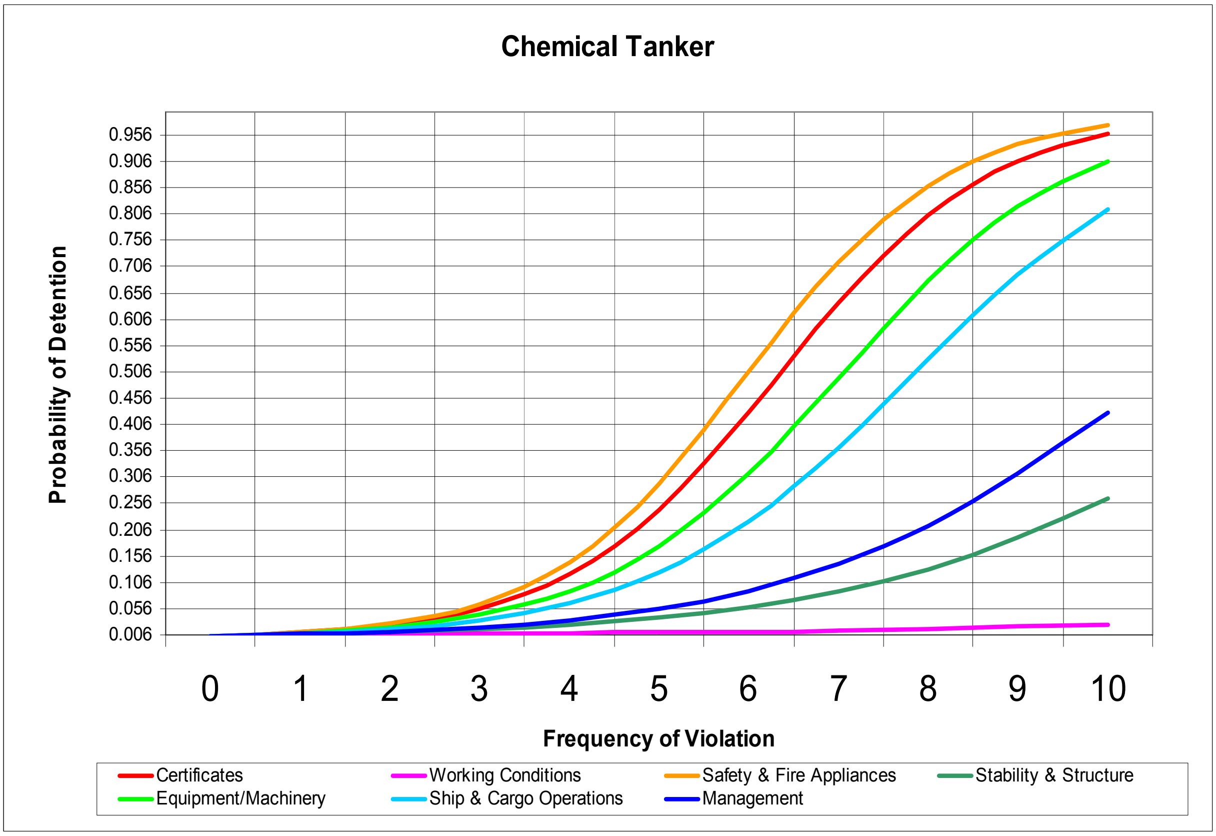


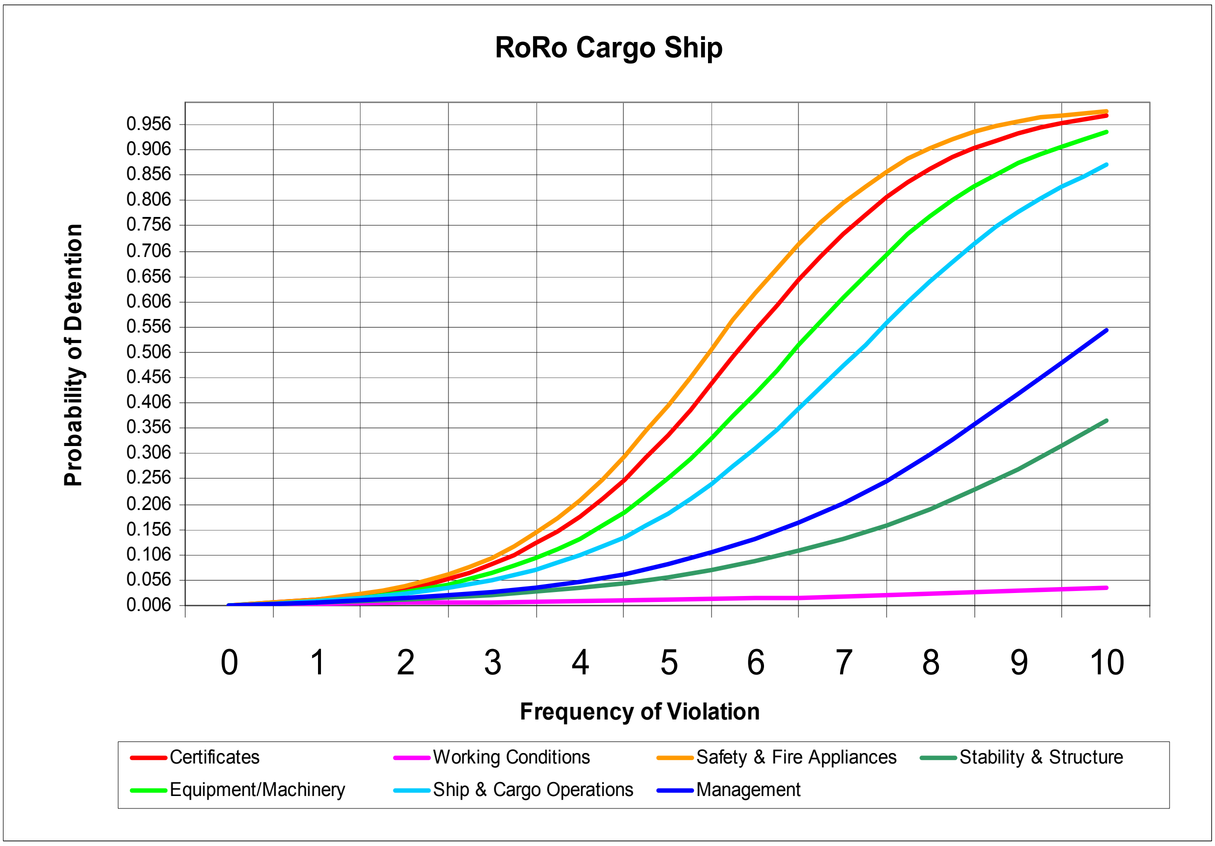
Appendix 16 continued: Probabilities of Detention for Major Ship Types



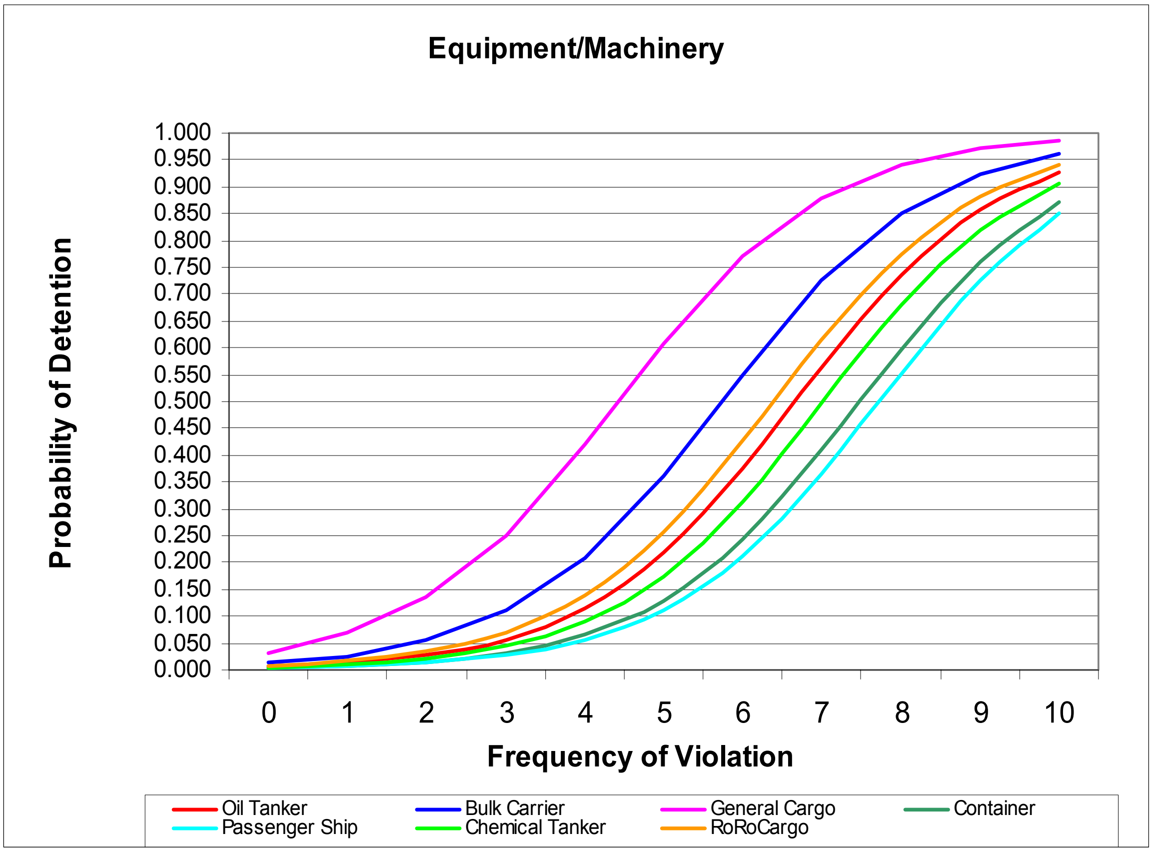


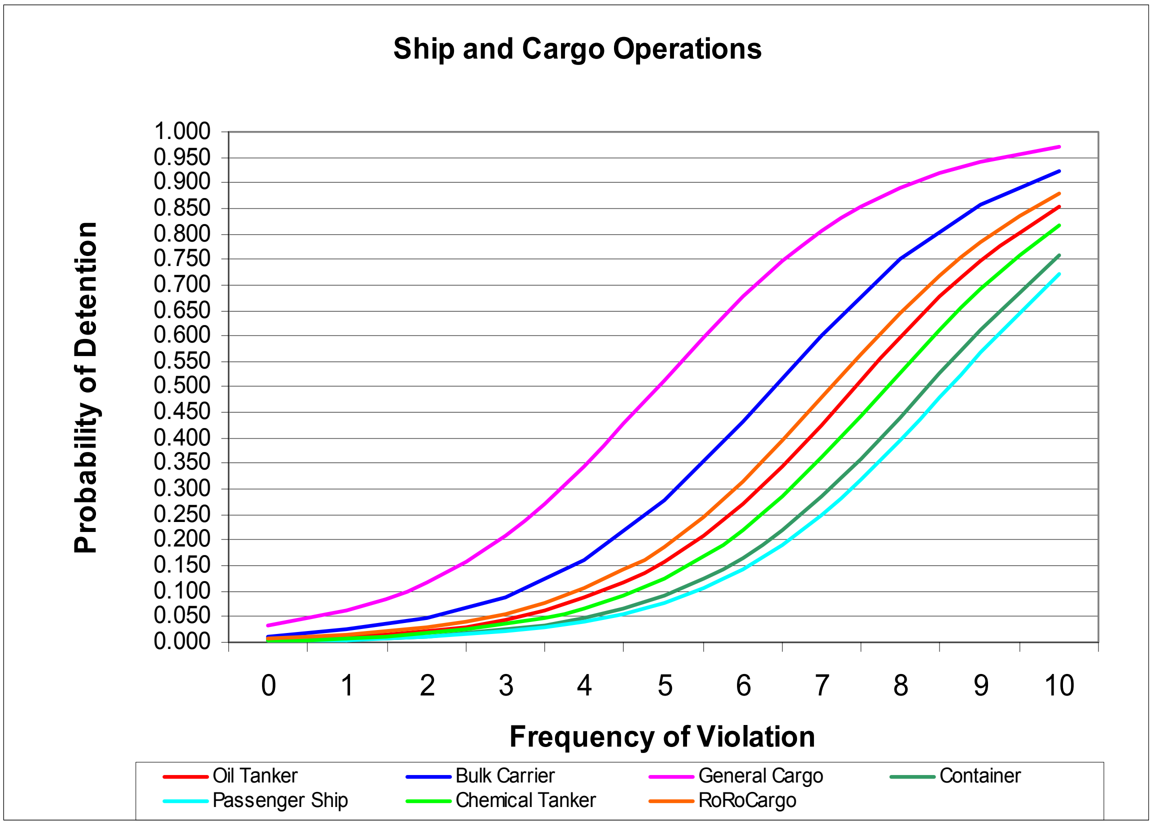
Appendix 16 continued: Probabilities of Detention for Major Ship Types



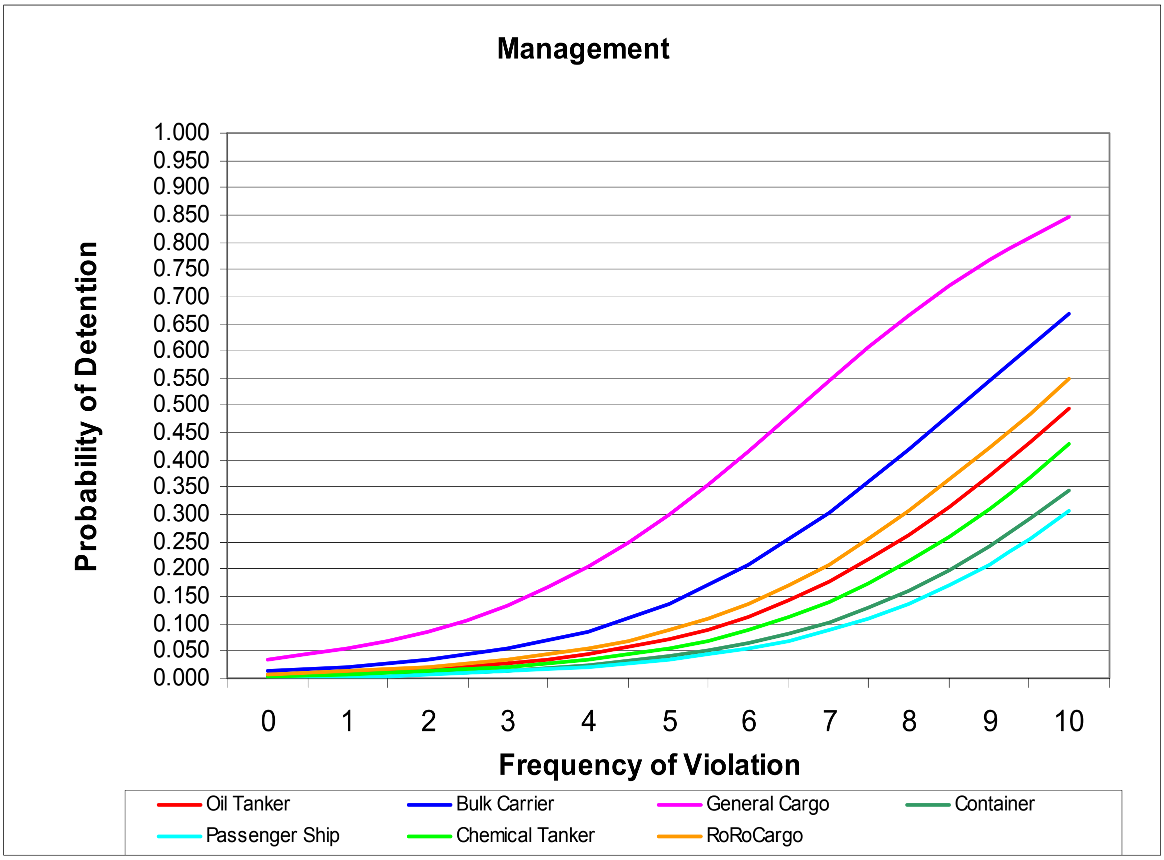


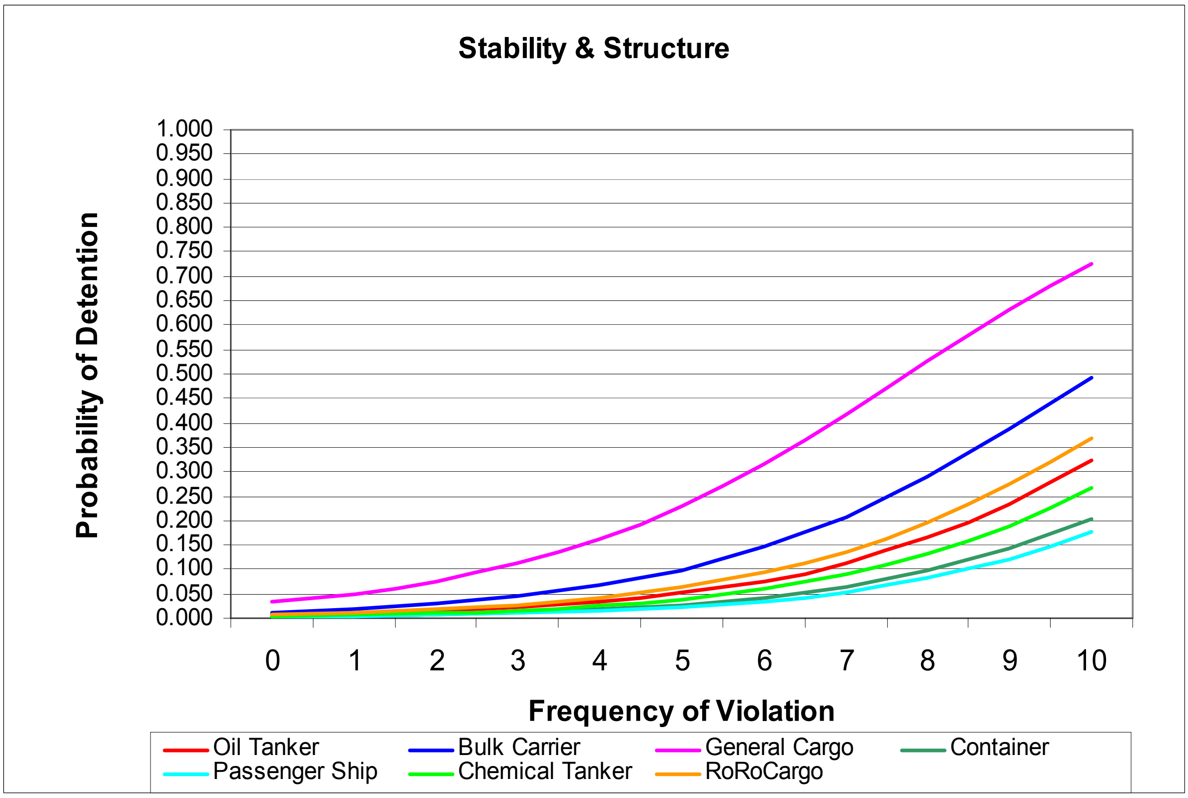
Appendix 17: Ship Risk Profiles based on Main Deficiency Groups



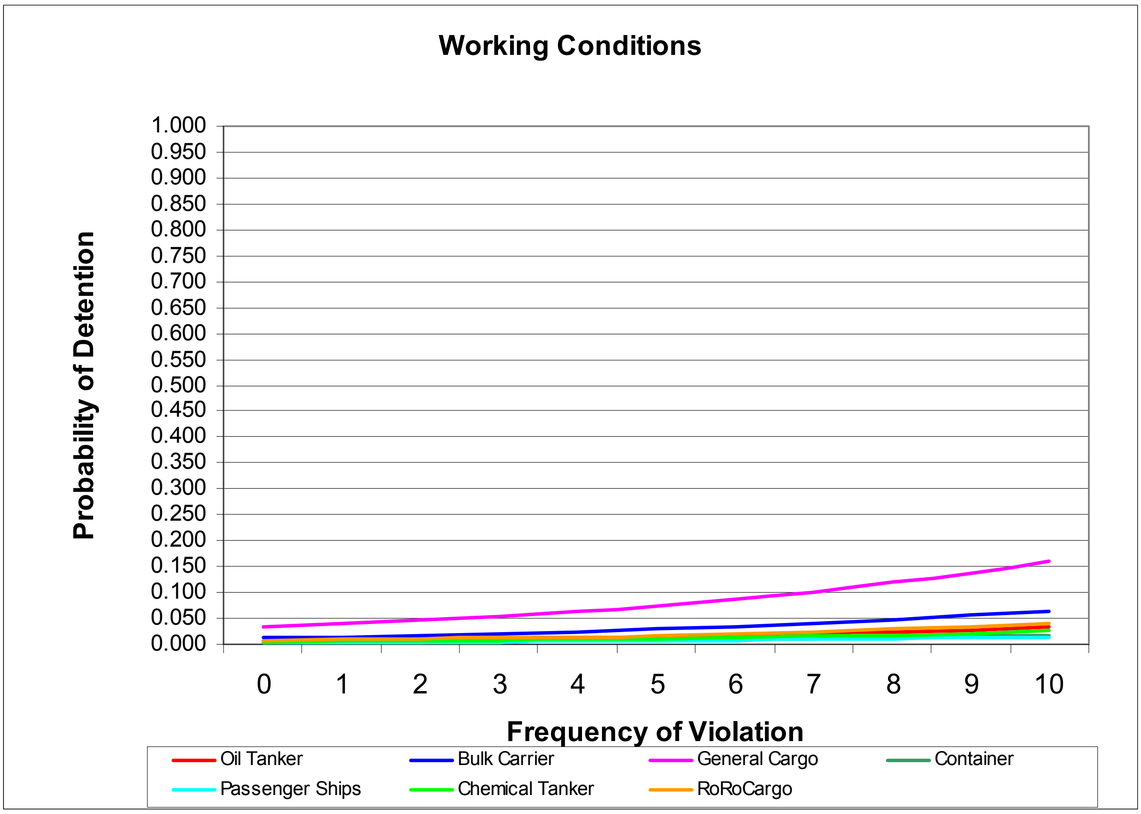


Appendix 17 continued: Ship Risk Profiles based on Main Deficiency Groups





Appendix 17 continued: Ship Risk Profiles based on Main Deficiency Groups



Appendix 18: Computer Output: Type 2-total # of deficiencies

Case Processing Summary

Unweighted Cases(a)		N	Percent
Selected Cases	Included in Analysis	53333	69.9
	Missing Cases	0	.0
	Total	53333	69.9
Unselected Cases		22915	30.1
Total		76248	100.0

a If weight is in effect, see classification table for the total number of cases.

Iteration History

Iteration		-2 Log likelihood	Coefficients				
			Constant	ln_vessel_age	ln_grosstonnage	CL_NoClass	CL_TurkischLloyd
Step 1	1	25714.443	-1.745	.014	-.019	.134	.272
	2	19386.395	-2.518	.078	-.051	.260	.390
	3	17935.877	-3.086	.213	-.093	.340	.412
	4	17735.269	-3.515	.353	-.120	.347	.404
	5	17727.104	-3.670	.403	-.126	.339	.400
	6	17727.068	-3.680	.406	-.126	.339	.400
	7	17727.068	-3.680	.406	-.126	.339	.400

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	12326.326	41	.000
	Block	12326.326	41	.000
	Model	12326.326	41	.000

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	17727.068(a)	.206	.479

a Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	125.069	8	.000

Contingency Table for Hosmer and Lemeshow Test

		detained_new = 0		detained_new = 1		Total
		Observed	Expected	Observed	Expected	
Step 1	1	5328	5310.522	5	22.478	5333
	2	5319	5293.278	14	39.722	5333
	3	5303	5276.424	30	56.576	5333
	4	5295	5256.599	38	76.401	5333
	5	5265	5230.805	68	102.195	5333
	6	5222	5194.573	111	138.427	5333
	7	5150	5138.602	183	194.398	5333
	8	4971	5031.808	362	301.192	5333
	9	4588	4718.667	745	614.333	5333
	10	2560	2549.723	2776	2786.277	5336

Classification Table(c)

Observed			Predicted					
			Selected Cases(a)			Unselected Cases(b)		
			detained_new		Percentage Correct	detained_new		Percentage Correct
			0	1		0	1	
1	detained_new	0	42422	6579	86.6	18165	2809	86.6
		1	880	3452	79.7	403	1538	79.2
	Overall Percentage				86.0			86.0

a Selected cases sample EQ 1
b Unselected cases sample NE 1
c The cut value is .080

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1(a)	ln_vessel_age	.406	.048	70.767	1	.000	1.501
	ln_grosstonnage	-.126	.022	31.599	1	.000	.882
	CL_NoClass	.339	.072	21.912	1	.000	1.403
	CL_TurkischLloyd	.400	.144	7.721	1	.005	1.492
	CL_IsthmusBS	1.114	.519	4.608	1	.032	3.045
	CL_RussianRiver	.470	.218	4.661	1	.031	1.601
	CL_InternNavSurB	.673	.180	13.944	1	.000	1.960
	PS_Belgium	-1.132	.108	109.798	1	.000	.322
	PS_Canada	-.300	.137	4.784	1	.029	.741
	PS_Croatia	-.486	.134	13.207	1	.000	.615
	PS_France	-.331	.094	12.277	1	.000	.718
	PS_Germany	-.575	.086	44.795	1	.000	.563
	PS_Greece	-.910	.095	92.303	1	.000	.403
	PS_Iceland	-.848	.369	5.288	1	.021	.428
	PS_Ireland	-1.220	.184	43.862	1	.000	.295
	PS_Netherlands	-1.164	.101	134.121	1	.000	.312
	PS_Poland	-1.230	.142	75.501	1	.000	.292
	PS_Portugal	-.329	.090	13.305	1	.000	.720
	PS_RussianFed	-1.626	.094	300.292	1	.000	.197
	PS_Spain	-.460	.070	43.302	1	.000	.631
	PS_Sweden	-1.679	.216	60.491	1	.000	.187
	PS_UK	-1.182	.087	182.665	1	.000	.307
	ST_ChemicalTanker	.231	.136	2.896	1	.089	1.260
	ST_GeneralCargo	.383	.055	48.760	1	.000	1.466
	ST_OilTanker	.375	.104	13.075	1	.000	1.455
	ST_RoRoPax	-.931	.197	22.207	1	.000	.394
	FS_Azerbaijan	-1.673	.602	7.736	1	.005	.188
	FS_Cyprus	.228	.085	7.246	1	.007	1.256
	FS_Cambodia	.455	.119	14.499	1	.000	1.576
	FS_Malta	.266	.075	12.562	1	.000	1.305
	FS_Panama	.178	.075	5.607	1	.018	1.195
	FS_Portugal	-.761	.227	11.221	1	.001	.467
	FS_StVincentGren	.303	.082	13.525	1	.000	1.354
	FS_SaoTomePrin	.595	.326	3.332	1	.068	1.813
	FS_Turkey	.299	.093	10.372	1	.001	1.348

	FS_Tuvalu	.910	.499	3.335	1	.068	2.486
	FS_UK	-.932	.299	9.684	1	.002	.394
	total_deficiencies	.245	.004	4874.384	1	.000	1.278
	OW_TraditionalMN	-.321	.053	36.494	1	.000	.726
	OW_EmergingMN	-.118	.066	3.200	1	.074	.889
	OW_OldOR	-.429	.109	15.498	1	.000	.651
	Constant	-3.680	.287	164.535	1	.000	.025

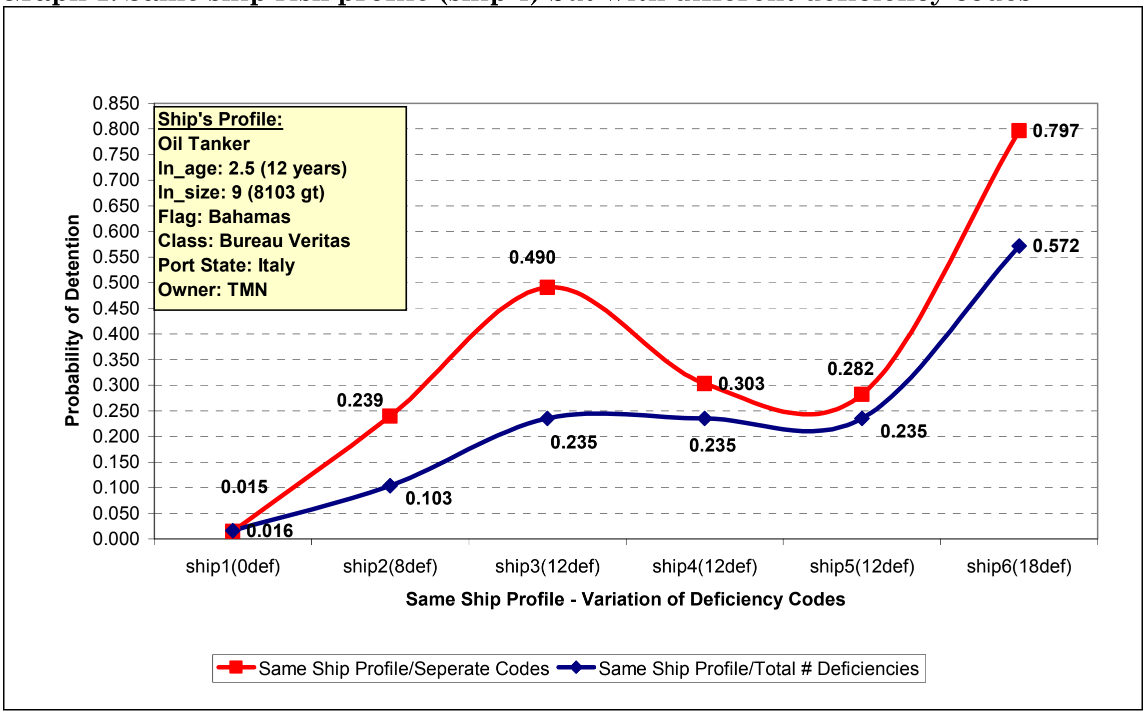
a Variable(s) entered on step 1: ln_vessel_age, ln_grosstonnage, CL_NoClass, CL_TurkischLloyd, CL_IsthmusBS, CL_RussianRiver, CL_InternNavSurB, PS_Belgium, PS_Canada, PS_Croatia, PS_France, PS_Germany, PS_Greece, PS_Iceland, PS_Ireland, PS_Netherlands, PS_Poland, PS_Portugal, PS_RussianFed, PS_Spain, PS_Sweden, PS_UK, ST_ChemicalTanker, ST_GeneralCargo, ST_OilTanker, ST_RoRoPax, FS_Azerbaijan, FS_Cyprus, FS_Cambodia, FS_Malta, FS_Panama, FS_Portugal, FS_StVincentGren, FS_SaoTomePrin, FS_Turkey, FS_Tuvalu, FS_UK, total_deficiencies, OW_TraditionalMN, OW_EmergingMN, OW_OldOR.

Appendix 19: Probability Comparison and Risk Profile: Oil Tanker

Ship Risk Profiles for Graph 1 and Graph 2:

Ship Types	Ship 1	Ship 2	Ship 3	Ship 4	Ship 5	Ship 6
Ln(Age)	0 (0)	1 (2.7)	2 (7.4)	2.5 (12)	2.5 (12)	3 (20)
Ln(Size)-gt	6 (404)	7 (1096)	8 (2980)	9 (8103)	10 (22026)	11 (59874)
Class	DNV	LloydsUK	ABS	BV	GL	No Class
Flag	Norway	Liberia	Greece	Bahamas	Cyprus	Malta
Port State	Netherlands	Belgium	Canada	Italy	Russian Fed.	UK
Owner	TMN	TMN	TMN	TMN	TMN	TMN
Deficiencies	**0**	**8**	**12**	**12**	**12**	**18**
Split Up of Deficiency Codes	**0**	**100 (1) 600 (1) 700 (1) 900 (1) 1500 (1) 1700 (2) 2500 (1)**	**100 (1) 200 (1) 600 (2) 700 (2) 900 (1) 1400 (1) 1500 (1) 1700 (2) 2500 (1)**	**100 (1) 200 (1) 300 (1) 600 (2) 700 (2) 900 (1) 1100 (1) 2000 (1) 2500 (2)**	**100 (1) 300 (1) 600 (2) 700 (1) 900 (2) 1200 (2) 1500 (1) 1600 (1) 2500 (1)**	**100 (2) 300 (2) 600 (4) 700 (2) 900 (4) 1600 (1) 1700 (1) 2500 (2)**

Graph 1: Same ship risk profile (ship 4) but with different deficiency codes



Graph 2: Different ship risk profiles and different deficiency codes