A STUDY OF SHIPPING ACCIDENTS VALIDATES THE EFFECTIVENESS OF ISM-CODE

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Abstract:

The purpose of this paper is to examine human reliability with reference to all accidents involving Greek-flagged ships in restricted waters (ports, canals, straits, anchorages, coastal waters etc) through a 17-years time period (1995-2011). In this context, the effectiveness of enforced International Safety Management Code will be assessed.

The data analysis, using a Validation data set (upgrade data over the years from 2007 to 2011), revealed that the implementation of the ISM-Code led to an overall reduction of human-induced accidents in restricted waters.

Conclusively, the ISM-Code constitutes an effective policy measure for shipping safety. The results of the analysis reported in the present work can be used by decision makers in companies and international organizations to augment their information in the field of safety policy and management.

Key Words: Shipping safety, accidents in restricted waters, human error, ISM-Code

Introduction

The International Safety Management Code (ISM Code) was enforced by the International Maritime Organisation (IMO) in 1998, in order to provide an international standard for safe management and operation of ships and for prevention of pollution.

Accidents in shipping and marine environmental pollution are attributed to various factors. The UK Marine Accident Investigation Branch states that "*one factor still dominates the majority of maritime accidents: human error*" (MAIB, 2000). To this extent, a statistical analysis of shipping accidents attributed to "human error" in order to check if an increase or a decreasing pattern is observed through a 17-years time period. Thus, the ISM-Code impact and the effectiveness of its enforcement will be assessed.

A lot of researchers worldwide have been devoted in estimating dependency of shipping accidents from various factors (Celik, M., Lavasani, S.M., and Wang, J., 2010; Tzannatos, E., 2005).

Many researchers have used classical statistical analysis. Researchers (Giziakis et al., 1996) applied classical statistical analysis techniques in the records of vessel detentions and deficiency notices produced within the framework of inspections performed by the relevant authorities. These techniques produced a thorough shipping accidents analysis giving of human influence upon shipping accidents. Others researchers (Robert, S.E., Marlow, P.B. and Jaremin, B., 3012) have applied multi-factorial risk analyses revealing that the most important risk factors for ships foundering and for crew fatalities.

The study of shipping accidents using data mining techniques (Kokotos X.D and Linardatos, D.S., 2011; Kokotos, X.D and Smirlis, G.Y., 2005) may reveal additional information, for example, for the human influence upon accidents.

Researchers, within the human element domain, (Hetherington, C., Flin, R. and Mearns, K., 2006; O'Neil, W.A., 2003) provided analyses of the human element as a basic factor for accidents. Previous research in this area (Psaraftis et al., 1998) provided an 'in-depth' analysis of the human element as a factor in Greek shipping accidents during the 1984-1994.

A lot of effort from researchers worldwide has been devoted in assessing the effectiveness (Bhattacharya S, 2012; Knudsen OF and Hassler B, 2011; Tzannatos and Kokotos, 2009) of the measure of the enforcement of the ISM-Code.

The current work aims at estimating the dependency of the source of accidents due to human error upon the year of accident. The information will be used to assess the role of the ISM-Code, to measure the effectiveness of the enforcement of the ISM-Code and mainly to check if a decreasing pattern is observed through a 17-years time period.

Main Text

Data set description

The current work utilizes the information included in the official investigation reports of the Hellenic Coast Guard (HCG) referring to accidents of Greek-flagged ships in "restricted waters" [117] over the years 1995-2011.

With respect to the choice of flag administration, it is assumed that Greek shipping, by virtue of its size and diversity, constitutes a valuable reference for the analysis of accidents

Prerequisites for the inclusion of an accident in HCG's official investigation reports are the situations that were encountered in the accident as: total (or partial) ship loss, permanent (or temporary) abandonment of ship by the crew, ship is taken-over by insurers, cargo loss, failure (more than 25%), prolonged loss of ship (command due to serious failure), loss of life (or serious injury to a crew member/passenger) or at least one of mentioned before them.

The variable *Source or Cause of accident* accepts values of ‘‘human error” (MAIB) or ‘‘non-human error”. These values represent the conclusion of the reports based upon the formal investigation of the shipping accidents, with regard to whether a human entity (Ship's Master or 1st Engineer, Pilot, Offshore Personnel etc.) was ultimately responsible for the accident or otherwise (Random Event, Act of God, Unidentified Source).

For every year from 1995 to 2011, the accidents dataset includes the information depicted in Table 1. In this table, the percentages of human-error / total cases for each year and the 95% confidence intervals for each year are given.

YEAR	lower	Human error / Total cases Percentages	upper
1995	50,80%	69,00%	82,70%
1996	43,60%	60,00%	74,40%
1997	51,50%	70,40%	84,10%
1998	39,10%	57,10%	73,50%
1999	33,50%	52,00%	70,00%
2000	29,00%	50,00%	71,00%
2001	30,70%	50,00%	69,30%
2002	49,70%	76,90%	91,80%
2003	23,30%	40,90%	61,30%
2004	24,50%	42,90%	63,50%
2005	38,80%	64,30%	83,70%
2006	26,80%	50,00%	73,20%
2007	25,50%	50,00%	74,50%
2008	16,93%	42,86%	68,78%
2009	21,71%	50,00%	78,29%
2010	16,03%	45,45%	74,88%
2011	9,64%	40,00%	70,36%
Total	51,10%	54,98%	62,90%

Table 1 Percentages of human-error / total cases[118].

[117] "Restricted waters" are defined as ports, canals, straits, anchorages, coastal waters etc (Kokotos, X.D., 2003, PhD Thesis, University of Piraeus, Piraeus) and represent the position of the vessel at the time of the accident.

For analysis, the variable *Year* have been grouped to check if an increase or a decreasing pattern is observed through a 17-years time period. In this respect, the variable Year from 1995 to 2011 grouped in three classes: "Test period A" (1995-1998), "Test period B" (1999-2006) and "Validation period C" (2007-2011).

The two classes "Test period A" and "Test period B" have been grouped in such a manner because the International Safety Management Code was enforced in 1998 by the International Maritime Organisation. Researchers in this area, (Tzannatos, E. and Kokotos, X.D., 2009) state that "*It is also early to assess the impact of ISM on the safety of the ships on which the Code has been implemented. This will take years to ascertain and the analysis to do so will not be trivial*". In recognition of this statement, the period from 2007 to 2011, named "Validation period C", was added to the last two periods (from 1995 to 1998 and from 1999 to 2006) in order to validate the effectiveness of the ISM Code through a 17-years time period.

In table 2, the percentages of human-error / total cases for each class and the 95% confidence intervals for each class are given.

Period	Lower	Human error / Total cases Percentages	Upper
"Test period A"	55,23%	63,87%	72,50%
"Test period B"	43,65%	51,68%	59,70%
"Validation period C"	33,72%	46,03%	58,34%
Total	51,10%	54,98%	62,90%

Table 2 Percentages of human-error / total cases for class *A, B, C.*

Data analysis and discussion of results

In the Figure 1, was given Graphical presentation of the trends and the trend line of the percentages of human-error / total cases over the years from 1995 to 2011 with statistical 95% confidence limits for dataset depicted in Table 1.

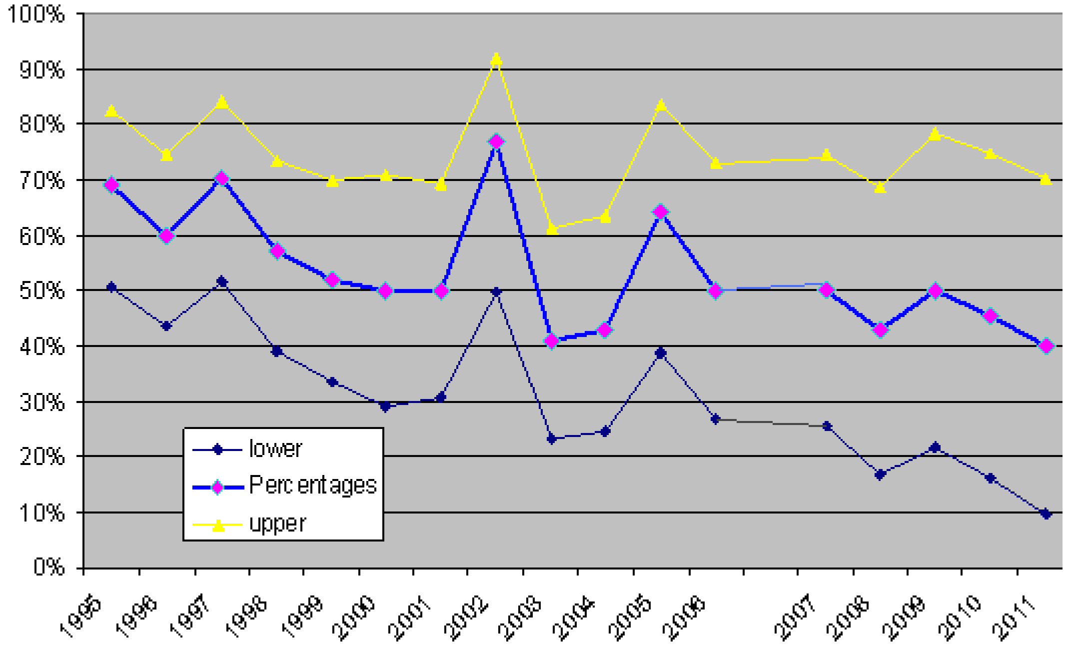

Figure 1 Trend line of the percentages of human-error/total cases (1995-2011).

[118] All accidents involving vessels under 500 grt were discarded from the dataset because ships under 500 grt have been exempted of ISM-Code compliance.

According to the Graphical presentation in Figure 1, there is reduction in shipping accidents attributed to human error over the years from 1995 to 2011. More specifically, as depicted in Figure 1, the percentage of human errors/ Total cases seems to decrease by year.

The trend observed in Figure 1 was further explored using Chi-Square Tests in order to understand whether there is a statistically significant difference between (a) "Test period A" and "Test period B", (b) "Test period A" and "Test period C", and (c) "Test period B" and "Test period C" or no.

More specifically:

Hypothesis 1: Shipping accidents attributed to human error are decreased between "Test period A" and "Test period B".

In table 3, is given the Chi-Square Test output (Pearson Chi-Square = 4,012, df =1, p= 0,45). From Fisher's Exact Test (Exact Sig. $_{2\text{-sided}}$: 0,048), there is statistically significant difference between "Test period A" and "Test period B".

	Value	Df	Asymp.Sig.(2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4,012(b)	1	,045		
Continuity Correction(a)	3,530	1	,060		
Likelihood Ratio	4,034	1	,045		
Fisher's Exact Test				,048	,030
Linear-by-Linear Association	3,997	1	,046		
N of Valid Cases	268				

a. Computed only for a 2x2 table

b. 0 cells (,0%) have expected count less than 5. The minimum expected count is 51, 06.

Table 3 Chi-Square Test: "Test period A" and "Test period B"

Shipping accidents attributed to human error decreased between "Test period A" and "Test period B" because the ISM Code was enforced and consequently the policy of marine safety changed.

Hypothesis 2: Shipping accidents attributed to human error are decreased between "Test period A" and " Validation period C ".

In table 4, is given the Chi-Square Test output (Pearson Chi-Square = 5,367, df =1, p= ,021). From Fisher's Exact Test (Exact Sig. $_{2\text{-sided}}$: ,027), there is statistically significant difference between "Test period A" and " Validation period C ".

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5,367(b)	1	,021		
Continuity Correction(a)	4,662	1	,031		
Likelihood Ratio	5,345	1	,021		
Fisher's Exact Test				,027	,016
Linear-by-Linear Association	5,338	1	,021		
N of Valid Cases	182				

a Computed only for a 2x2 table

b 0 cells (,0%) have expected count less than 5. The minimum expected count is 26,65.

Table 4 Chi-Square Test: "Test period A" and " Validation period C ".

Shipping accidents attributed to human error are decreased between "Test period A" and "Validation period C" because the ISM Code was enforced and consequently the policy of marine safety changed.

Hypothesis 3: Shipping accidents attributed to human error are decreased between "Test period B" and "Validation period C".

In table 5, is given the Chi-Square Test output (Pearson Chi-Square = ,565, df =1, p= ,452). From Fisher's Exact Test (Exact Sig. $_{2\text{-sided}}$: ,548), there is statistically significant difference between "Test period B" and "Validation period C".

	Value	df	Asymp.Sig. (2-sided)	ExactSig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	,565(b)	1	,452		
Continuity Correction(a)	,361	1	,548		
Likelihood Ratio	,565	1	,452		
Fisher's Exact Test				,548	,274
Linear-by-Linear Association	,562	1	,453		
N of Valid Cases	212				

a Computed only for a 2x2 table

b 0 cells (,0%) have expected count less than 5. The minimum expected count is 31,50.

Table 5 Chi-Square Test: "Test period B" and "Validation period C"

Shipping accidents attributed to human error are decreased between "Test period B" and "Validation period C" because the policy of marine safety changed.

Conclusion

The current work validated the ISM-Code impact. Shipping accidents, in restricted waters, attributed to human error were decreased between period 1995-1998 and 1999-2006 because the ISM Code was enforced in 1998 and the policy of marine safety was changed. Shipping accidents were decreased between period 1995-1998 and 2006-2011 because of the same reason. Also**,** shipping accidents attributed to human error are decreased between time period 1999-2006 and 2007-2011 because of the policy of marine safety was changed. Overall, there is a reduction in shipping accidents attributed to human error over the years from 1995 to 2011. Human error was found to be dependent on the year of shipping accident.

Human error was found to be dependent on the year of shipping accident in restricted waters. Shipping accidents attributed to human error were decreased between period 1995-1998 and 1999-2006 because the ISM Code was enforced in 1998 and the policy of marine safety was changed. Shipping accidents were decreased between period 1995-1998 and 2006-2011 because of the same reason. Also**,** shipping accidents attributed to human error are decreased between test period 1999-2006 and validation period 2007-2011. Overall, there is a reduction in shipping accidents attributed to human error over the years from 1995 to 2011. Thus the current work validated the ISM-Code impact.

The analysis of the Greek shipping accidents in restricted waters produced a validation of the ISM Code effectiveness. It was shown that the ISM Code constitutes an effective policy measure for shipping safety. It is indicated that the ISM-Code constitutes an effective policy measure for shipping safety, particularly for human safety. Although the ISM-Code implementation led to significant reduction of human-induced accidents, additional reduction is necessary. Further studies in this field will led to the adoption of additional regulations for the shipping safety.

The results of the analysis reported in the present work can be used by decision makers in companies and international organizations to build knowledge-based expert systems and augment their information in the field of safety policy and management.

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