The economics of oil spills

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Summary:

Vessel oil spills are very serious natural hazards that have affected coasts worldwide for many decades. Although oil spills from tankers are highly publicized, very little is known about the role played by the incentives and the regulatory instruments in place to prevent them. In this application, we have collected data worldwide on large oil spills from multiple databases over the last 45 years, which we have merged with other socio-economic records. We find that large oil spills have been undercompensated over time with respect to the damages caused. We conduct a meta-analysis in order to assess relevant factors affecting the damage caused by oil spills and the claims received by the affected parties. Secondly, meta-regression results show that the legislation applied (strict unlimited liability *versus* limited liability) played a crucial role in terms of affecting both the amount claimed and the final compensation received. Thirdly, time-trend variables are determining factors for both the damages and claims that are finally paid. As future recommendations, and in order to correct for the large gap between damage and compensation scenarios, we emphasize the need to strengthen compensation funds, while carrying out more comprehensive assessment studies which apply valuation methods comparable with those proposed by green capital initiatives for marine ecosystem services, and which could be used successfully during the litigation process.

Keywords: oil spills, compensation, damage claims, strict liability, IMO

1. Introduction

Oil spills can be caused by vessels, industrial facilities, oil platforms, or in other ways. Due to the lack of data related to many of these incidents, and in order to conduct a systematic review of the causes and consequences of the oil spills that have occurred over the last 40 years, we will focus our attention in this chapter on vessel oil spills. These kinds of incidents cause a major impact on the environment and the economy of the affected areas (Alló and Loureiro, 2013).

According to data from the International Tanker Owners Pollution Federation Limited (ITOPF; 2016)[1], the total number of oil spills has decreased in the last 45 years worldwide. The ITOPF database contains records on spills since the 1970s, and has found a significant decrease in both the number of accidents and the total amount spilled over the years (Alló and Loureiro, 2013). However, in spite of recording fewer spills recently, these are much larger in terms of the size of the oil spilt. Since 2000, a total of 223 vessel oil spills have been registered worldwide, resulting in 229,000 tons of oil being lost. Specifically, and with recent data, the ITOPF (2016) highlights that during the period from 2010 - 2015, 42 accidents were recorded with a spillage of around 33,000 tonnes, while emphasizing that 86% of total oil spilt was caused by only 10 accidents. The seriousness of the damage caused by oil spills has been highlighted by various impact assessment studies conducted after these catastrophic events, such as those from the Exxon Valdez (Carson et al. 1992), Erika (Bonnieux and Rainelli; 1993), Sea Empress (Moore et al. 1998), American Trader (Chapman and Haneman; 2001) and Prestige oil spill (Loureiro et al. 2006), among others.

[1]The International Tanker Owners Pollution Fund is a not-for-profit organization involved in all aspects related to ship-source spills of oil, chemicals and other substances in the marine environment.

The present chapter illustrates several key findings related to the economics of vessel oil spills over the last 45 years. Firstly, it provides a historical overview of the most important changes that have taken place in terms of compensation bodies and compensatory regulations worldwide. Secondly, via a meta-analysis, it assesses the causing factors of vessel oil spills, in order to understand the damage caused by these incidents. Thirdly, it investigates the compensation received by the affected parties. And finally, it concludes with a number of recommendations in order to correct for differences in terms of compensations and damage claims.

Several key findings emerge from the review of vessel oil spills from the 1970s to the present. Firstly, a review of the historical data reveals major discrepancies between damage claims and the compensation finally awarded. For the largest oil spills, in some cases the final compensation paid was nearly 10 times lower than the damage claimed. Historically, the revision and subsequent updating of compensation limits has usually come about as a result of political concerns and public awareness after very large oil spills, the majority of which were not covered by the existing compensation funds. Secondly, meta-regression results show that the legislation applied (strict unlimited liability *versus* limited liability) played a crucial role in terms of affecting both the amount claimed and the final compensation received. Thirdly, time-trend variables are determining factors of both the damages and claims finally paid. As future recommendations, and in order to correct for the large gap between damage and compensation scenarios, we emphasize the need to strengthen compensation funds, while carrying out more comprehensive assessment studies which apply valuation methods comparable with those proposed by green capital initiatives for marine ecosystem services, and which could be used successfully during the litigation process.

The structure of this chapter is as follows: firstly, we describe the data used in the following analysis, with a special section dedicated to damages and compensation; next, from a historical perspective, we disentangle the role of the legislation applied and compensation funds worldwide; we then continue with a review of the literature that discusses factors that cause oil spills; next, we present a description of the empirical model in the meta-analysis, following with the results section. The chapter ends with a series of concluding remarks and recommendations.

2. Data Description

In order to collect data about vessel oil spills, we reviewed a number of different databases, including the French *Centre de Documentation de Recherche et d´Expérimentations sur les Pollutions accidentelles des eaux* (Cedre; 2016), the Damage Assessment, Remediation & Restoration Program (DARRP) database and the International Tanker Oil Pollution Fund (ITOPF; 2016). This latter database provides information on incidents that have taken place in International Marine Organization member countries, providing data on claims filed by countries and individuals, as well as the final compensation paid by the ITOPF. In addition, information about the technical characteristics of the ships which is highly relevant in order to assess the damage was collected from the Center for Tank Ship Excellence (CTX-4). We recorded information about the date and the place of the incident, the tons spilled, whether the vessels had signed flags of convenience (FOC), whether the ship had a single or double hull, and the cause of the accidents. We also registered the economic damages claimed and the compensation finally paid after each oil spill. We merged all of the previous datasets, creating a final database that contains information about oil spill incidents around the world from 1968 to 2013. In addition to the aforementioned variables, we also collected information about the characteristics of the country where the accident took place. Specifically, we identified whether the country has a strict regulation (based on strict liability), and the income level expressed by the Gross Domestic Product (GDP) in Power Purchasing Parity (from the World Bank, 2011). A previous version of this dataset was used by Alló and Loureiro (2013).

It is also important to note that some of the observations collected were removed from the final dataset, due to a large amount of missing values in several explanatory variables. As a result, the final data used for this meta-analysis covers 114 oil spills worldwide[2]. The information collected reports the damage caused and the compensation paid in different currencies ($, €, JPY, etc.) and different time periods (from 1968-2013 in the case of the damages, and from 1975-2007 in the case of the economic compensations). In order to homogenize all of the information, monetary amounts were converted to a standard measure ($ 2010). For this reason, we have inflated the total damages of each accident in the year of the spill to their original currency at 2010 prices[3], transforming this amount to $2010[4].

[2] To analyse the compensation paid in each oil spill, the data is taken from 52 accidents from the period 1975 - 2007, due to the existence of missing values.
[3] We have used the currency converter https://www.oanda.com/lang/es/currency/converter/ where there are historical data available.
[4] The inflation calculator is available at: http://www.bls.gov/data/inflation_calculator.htm/

With respect to the data that have been analysed for the compensation finally paid, we find that the mean economic compensation from an oil spill is around $106 million, and the mean quantity of oil spilled is around 8,975 tons. Around 85% of vessels had a single hull and about 86% were sailing under a flag of convenience. In terms of the cause of the accident, 18.50% were related to grounding, 5.5% various sources of error, 29.60% collisions, 3.70% explosions (in some cases the explosion could have happened after the accident) and 42% were due to other diverse causes (including loading, storm damage or swamping). In terms of the damage claimed, around 22% of oil spills caused considerable impacts to the environment, 46% caused damage to fisheries, 20% to the tourism sector, and 26% caused damage in other areas.

3. Damage Claims and Compensation: A historical overview

Table 1 provides a historical overview of damages and compensation for all incidents, reporting both magnitudes. These are reported in 2010 prices. The average damages claimed per spill during this period amount to 231 million, while the compensation awarded stands at 107 million per accident. The discrepancies between both magnitudes are quite significant for the largest oil spills occurring in International Marine Organization (IMO) country members. For example, in the Haven oil spill, total damages were claimed for $1604 million, while final compensation was granted for $178.97 million. For the Aegean Sea and Hebei Spirit spills, damages were claimed respectively for $370.84 million and $362.55 million, while the final compensation was $90.68 million and $178.97 million for each. Several reasons justify these differences, but the most relevant are related to the compensation limits established by the different compensation funds ratified by the IMO countries. In addition, at times the lack of relevant assessments providing a clear link to the cause-effect relationship between the occurrence of the spill and the damages claimed prevented compensation from being paid. Due to the relevance of the legal environment on the economics of oil spills, we will now examine the main compensation mechanisms that exist, and how they have evolved during the study period.

3.1 Oil Spill Compensation Funds

In terms of regulating oil spills, there are currently two quite different regimes: one is a common international regime applied by all IMO country members, and the other is the strict liability regime applied by the US and regulated by the Oil Pollution Act (OPA) enacted in 1990. Most other countries in the world apply the international IMO regime. The IMO is a specialized agency of the United Nations which deals with marine affairs and pollution. This organization was set up in 1982, and has drawn up numerous conventions and restrictions in order to increase marine safety and reduce pollution. However, the IMO has no enforcement capacity over signatory states of the protocols, and the safety standards are voluntary for each nation. Since 1992 and up until the present date, two protocols known as the Convention on Civil Liability for Oil Spill Damage (1992 CLC) and the International Fund for Compensation for Oil Pollution Damage (1992 Fund Convention) are applied.

The international regime emerged after the Torrey Canyon oil spill in 1967, while the US regime was established after the Exxon Valdez oil spill in 1989. Both dramatic incidents confirmed the need for legislation on liability and financial responsibility in oil spill accidents and on compensation regimes (Kim; 2003). However, the US regime imposes unlimited liability and compensates damage to natural resources, while the international IMO regime imposes a system of limited liability with similar characteristics to a negligence system, and excludes compensation for environmental damage.

The overall international compensation regime for damage caused by spills of persistent oil from laden tankers was based initially on two IMO conventions: 1) the 1969 International Convention on Civil Liability for Oil Spill Damage (1969 CLC), and 2) the 1971 International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (1971 Fund Convention). These two conventions were amended in 1992 by two Protocols, which increased the compensation limits and widened the scope of the original Conventions. The 1969 CLC came into force in 1975 and laid down the principle of strict liability (i.e. liability even when no fault is proven) for tanker owners, and creates a system of compulsory liability insurance. However, this strict liability was linked to the tonnage of the tanker causing the pollution (IMO, 2006). The 1971 Fund Convention provided for the payment of supplementary funds to those who could not obtain full payment from the International Oil Pollution Compensation Fund (1971 IOPC Fund). This 1971 IOPC Fund convention came into force in 1978.

In 1992, a Diplomatic conference adopted two protocols amending the 1969 CLC and 1971 Fund Convention. The 1992 Fund came into force in 1996. As in the case of the original conventions, the tanker owner and the principal and interest (P&I) insurer are liable for payment of compensation under the 1992 CLC and oil receivers in countries that are party to the 1992 Fund Convention. The 1971 Fund Convention was terminated completely on

24 May 2002. In October 2000, the contracting states to the 1992 CLC and 1992 Fund Convention approved a proposal to increase the amount of compensation available under the terms of these Conventions by about 50% (to around US$260 million). This Fund, which came into force on 1 November 2003, was reinforced by other additional Supplementary Compensation Funds that increase the international regime for the compensation of victims of oil pollution from oil tankers. This Supplementary Fund does not replace the existing 1992 Fund, but will make additional compensation available to victims in the States which accede to the Protocol. In total, about $1,158.5 million ($2005) are available for compensation for each incident in the States which are Members of the Supplementary Fund. This Supplementary Fund covers accidents that occur after the entry into force of the Protocol on the 3 March 2005. Graph 1 shows the limits of Compensation funds over time. Although the deterrence effects associated with monitoring and liability regimes were studied on several occasions in the economics literature (see for example Opaluch and Grigalunas, 1984; and Wayne and Kite-Powell, 2005), to our knowledge there is no evidence of whether these international conventions (which involve different levels of compensation based on the strict liability of ship owners) have a deterrence effect on oil spill occurrence. In the following empirical study, we control for the unlimited liability regime *versus* the limited liability IMO regime.

Although we acknowledge that oil spills internationally are seriously underreported, due to diverse errors and omissions, (particularly for spills in remote areas and minor spills), in recent years, the majority of the largest oil spills occurred in European waters. In particular, there were three large oil spills in European waters, including the Erika oil spill in the French Coast (1999), the Baltic Carrier (2001) in Denmark, and the Prestige oil spill in

Spain (2002). In the following analysis, we will assess whether the strict liability had any deterrence effect on the occurrence of oil spills. The answer to this question is of vital importance, as if IMO international protocols do not have a deterring effect in reducing oil spills, then additional or alternative measures should be considered by IMO country members. The approval of the OPA-90 has strengthened accountability for vessel oil spills occurring in US waters. Moreover, the OPA-90 has increased penalties for polluters, broadened the response of the authorities, and preserved state authority to establish laws governing oil spill prevention and response (US Environmental Protection Agency; 2011). Table 2 presents a summary of the different conventions and dates of the various regulatory changes behind this international limited liability protocols in place in all IMO countries.

Thébaud et al. (2005) have already shown that there is a significant difference between the amounts claimed as damages and the payments received as compensation from the CLC funds. In particular, the maximum amount of compensation paid by the 1992 Fund Convention with respect to an incident that occurred prior to 1 November 2003 was set at US$ 205.6 million, which increased to US$ 309.1 million in November 2003[5]. However, due to a shortage of funds for compensation, and in the wake of the multiple complaints following the Prestige oil spill in Spain in November 2002, this Fund has been reinforced by an additional Supplementary Compensation Fund that increases the compensation of victims of oil pollution from oil tankers to US$ 1,159 million. This Supplementary Fund covers accidents occurring after the entry into force of the Protocol on 3 March 2005 (ITOPCF; 2011). In the following analysis, we assess the marginal contribution of the various causing factors of accidental oil spills to the total damage.

[5] This information is available at: http://www.iopcfund.org/compensation.htm

4. Causing factors of oil spills

White and Molloy (2003) reviewed the factors affecting the costs of oil spills in a database containing more than 300 cases. They show that in addition to the type of oil and the characteristics of the location where the spill takes place, other factors such as the amount spilled, the weather and sea conditions, as well as the time of the year, are crucial determining factors of the costs the oil spill. In terms of the causes, Ogus (1999) found that when an accident happens due to collision or grounding, the spill size is on average smaller. In terms of ship characteristics, Alló and Loureiro (2013) found that single hull ships cause larger oil spills than double hull ships. Furthermore, the effect of the flag of convenience is another aspect of interest. An OECD report states of many of these countries allowing for FOC have generally been less rigorous in their surveillance of high safety standards (OECD; 2001). Also, Levantino (1982) highlights that vessels sailing under an FOC are responsible for most oil pollution in the high seas, posing a major threat to the environment. In terms of surveillance efforts, Goodstein (1992) observed that certain types of spills happen much more frequently over the weekend (on Saturdays) due to the lack of surveillance.

The explanatory variables for the following empirical exercise were selected following this review of the literature. Table 3 shows the description of the variables contained in this meta-dataset and their respective summary statistics, for each of the independent regressions, modelling 1) the damages claimed and 2) the compensation received.

5. Model Specification and Research Hypotheses

The aim of this section is to bring together information on the factors affecting both the damage caused by vessel spills, and the compensation paid in oil spills worldwide. In doing so, we focus our attention on the role of legislation, which has proven to be crucial, as well as other structural characteristics of vessels, while including the weather and time-related variables. Furthermore, we control for institutional performance, including the DGP per capita. In order to assess the effects of these explanatory factors, we model the economic damage caused in each incident and the compensation received as a function of the countries' characteristics, the ship's characteristics, the characteristics of the accident and the liability regime applied, among other variables.

First, we estimate a baseline function model through an Ordinary Least Squares (OLS) meta-regression, and a Tobit model in order to check the robustness of the results. We run two independent regressions, the first modelling the economic damage of each accident while the second assesses the total compensation paid. Dependent variables are labelled as ($log(Y)$), while the vectors of explanatory variables (X_i) (see Table 3 for description variables), are grouped into five categories, as previously described, including: the country's characteristics, X_c; the circumstances of the accident, X_a; the vessel's characteristics X_v and the claims presented X_c, and whether the country where the accident occurred has strict liability in place X_{li}.

The baseline meta-regression OLS models correspond with the estimation of the following equation:

$$\log(Y)_i = \beta_0 + \beta_v X_{vi} + \beta_a X_{ai} + \beta_v X_{vi} + \beta_c X_{ci} + \beta_l X_{li} + \varepsilon_i , \qquad (1)$$

where β_0 is the constant term, the corresponding β_j are the coefficients associated with the explanatory variables to be estimated, and ε_i is a vector of error term, independently and identically distributed (i.i.d). In order to correct for spatial heteroskedasticity, we estimated the OLS model with the Huber-White adjusted standard errors clustered for each country where the accident took place. Previous meta-analyses have adopted a similar approach (Barrio and Loureiro, 2010; Alló and Loureiro, 2013).

In addition, we tested the presence of multicollinearity through the Variance Inflation Factor (VIF). This indicator measures the proportion of multicollinearity of the *j*th explanatory variable with the rest of explanatory variables in a regression model (O'Brien; 2007), obtaining an average value of 1.81 and 2.39, and concluding that multicollinearity is not present in our empirical specification.

In order to check the robustness of the results we estimate a Tobit model with the same specification as above. In this setting, we established a left limit equal to the smallest accident in terms of the economic damage, while the same criteria are used for modelling the economic compensation.

5.1 Research Hypotheses

As stated, our aim is to test whether the application of the strict liability regime is linked with a negative impact on the damage caused and with a positive impact on the amount of compensation paid after an accident. Previous studies, such as those of Alberini and Austin (2002), Alberini and Austin (1999) or more recently Bernard (2011) and Mondello (2011), have referred to the same idea. The logic of this argument is that under this regime, polluters are strictly liable for all the damage suffered as a consequence of their activity. Therefore, it is expected that they work with higher levels of care.

In order to assess these relationships, we test whether the coefficient representing the strict liability regime has a negative impact on the amount of damage caused, and a positive impact on the amount of compensation paid:

Impact on the amount of damage suffered:

$$\begin{aligned} H_0 &= \beta_{li} \geq 0 \\ H_1 &= \beta_{li} < 0 \end{aligned} \qquad (2)$$

Impact on the amount of compensations paid:

$$\begin{aligned} H_0 &= \beta_{li} < 0 \\ H_1 &= \beta_{li} \geq 0 \end{aligned} \qquad (3)$$

6. Empirical Results

6.1. Main Results from Damage Claimed Regression: The meta-analytical results confirm the deterrent effect of the application of strict liability, reducing the resulting damage caused by oil spills in a statistically significant way. Furthermore, and as expected from previous literature, the amount spilled also has a positive and significant effect on damage claims (in both, OLS and Tobit models). Also, if environmental claims have been accounted for, this significantly increases the damages being claimed. Environmental damage and sectorial damage in the tourism sector also seem to significantly increase the amount claimed (in the OLS model). Moreover, in the Tobit model, we find that damage claims in fisheries also increase the total amount of damages claimed from these accidents. Time effects also seem to be relevant, and even though the number of oil spills has decreased in recent years, the amount of damage caused seems to be on the rise (particularly for the decades of the 1980s and 2000s in the case of the OLS model, and during the 2010s attending to the Tobit results). This may be a consequence of the fact that although the number of accidents has decreased, the accidents that do occur these days are larger. Also, the accidents that occur in the winter season are linked with less damage. In the case of the Tobit model, we also obtain a negative coefficient for the GDP variable, which may indicate that countries with a higher GDP suffer less damage from oil spills than others. This may be a consequence of the fact that poorer countries have less resources and tools to fight against these disasters, and therefore the losses suffered are greater. Furthermore, wealthier countries are expected to have a better institutional performance that may allow them to be more efficient. Other structural ship variables, such as whether they had a single hull and were sailing under a FOC, are not statistically significant.

6.2. Regression Results on Compensations: Once again, the results show the crucial effects of the strict liability variable, which in this case increases the compensation received by the affected parties (for the OLS and Tobit models). The amount spilled is also statistically significant, increasing the compensation received, as in the case of claims related to losses suffered by the tourism and fishing sectors. Claims related to environmental damage do not increase the compensation received, but claims in the fisheries sector increase the amount of compensation finally paid. This is a logical result given that under the IMO regulation, environmental damage is not compensated. This is an important result, since the contribution of environmental damage is important when we explain the total damage caused by a large oil spill. In terms of geographical differences, and as expected, compensations for spills occurring in North America are larger in magnitude, due to the effect of strict liability in the US. Attending to other variables related to the causing factors, explosion and grounding seem to be related to higher levels of compensation, while the various error causes are related to smaller payments. The result related to the grounding cause contradicts previous results found by Agus (1999). With regard to time trends, we have observed that the decade of the 2000s is related with a higher level of compensation, which may indicate that over time the compensation tends to increase (although there are still major differences between the damages claimed and the amount paid). Finally, attending to the Tobit model, we find that the flag of convenience shows a positive coefficient, indicating that the courts or compensating bodies may consider these types of ships as substandard vessels, and therefore provide higher levels of compensation.

7. Conclusions and Implications

Oil spills result in very serious societal costs and environmental consequences. In order to provide incentives for controlling and properly managing the international bodies involved in oil transportation, the IMO has approved a series of conventions over the years on liability limits and compensation packages to victims. The objective of this chapter was to assess the evolution of compensations and damage claims, in order to obtain evidence from a meta-regression on the causing factors that may alleviate or reduce these environmental accidents. Although the empirical analysis is simple, the results obtained indicate that strict liability acts as a deterring factor on the occurrence of oil spills, while other additional explanatory factors can also reduce the impact of the damage and increase potential compensations.

Future studies should investigate whether current compensation schemes are optimally designed. In the past, the compensation of damage caused by large oil spills has been quite limited, and considerably delayed. In the case of the most recent European oil spill, caused by the 'Prestige' in 2002, the short-term economic costs have been estimated to be €743.73 million by Loureiro et al. (2006), while a comprehensive study of the mid-term effects has shown that the damage may amount to more than €4,000 million (Loureiro, 2012). However, the maximum compensation obtainable under the 1992 Fund is approximately €165.76 million, which was subsequently increased by the Supplementary Fund up to $1159 million (not applicable to the Prestige case). However, there are still many questions to be answered regarding whether the full costs associated with large oil spills can be covered by this Supplementary Fund. Judging by the Prestige oil spill, the maximum compensation obtained is well below the amount of damage caused.

In addition to the limits established by the compensation funds, the data we obtained show that economic assessments for past oil spills have only been based on partial valuations, leaving aside important amounts or categories, and not only the environmental damage that was excluded from compensation funds applicable in IMO countries.

We believe that the application of a generally acceptable valuation methodology will reduce the underestimation of damage assessments conducted after oil spills, and will help with comparability issues across international settings. Better estimates of the magnitude of the catastrophe could also be a next step in order to obtain more accurate compensation, or at least to ensure that the compensation is more in line with the damage caused.

Tables

Table 1: Damages claimed and final compensation received

Name of the ship	Claims(Damages) ($2010 million)	Compensation ($2010 million)
Aegean Sea	370.84	90.68
Agip Abruzzo	37.20	18.69
Akari	2.45	0.18
Al Jaziah 1	3.67	2.03
Amazon Venture	5.97	2.39
Amazzone	6.47	5.00
Antonio Gramsci (second time)	8.72	0.65
Apex/Galveston bay/Shinoussa	2.50	1.91
Baltic carrier	12.07	9.31
Brady Maria	3.26	2.24
Cape Mohican	6.82	4.53
Dainichi Maru n5	0.08	0.04
Daito Maru nº3	0.10	0.07
Diamond Grace	23.11	6.75
Erika	239.36	240.90
Exxon Valdez	4262.06	4484.14
Haven	1604.00	178.97
Hebei Spirit	362.55	25.45
Hinode Maru nº1	0.03	0.02
Honam Sapphire	82.04	9.31
Hosei Maru	2.73	2.05
Jan	3.67	1.80
Katja	0.22	0.22
Kazuei Maru no10	0.63	0.60
Kifuku Maru nº35	0.05	0.01
Koei Maru nº3	0.40	0.33
Koshum Maru nº1	0.35	0.31
Kriti Sea	6.42	6.42
Kyung Won	5.98	2.95
Maritza Sayalero	28.20	5.23
Mebaruzaki Maru nº5	0.12	0.10
Nakhodka	373.18	221.90
Nissos Amorgos	262.12	96.06
Ondina	18.80	7.89
Pacific Colocotronis	0.70	0.70
Patmos	125.56	6.96
Portfield	0.87	0.44
Prestige	5103.00	127.68
Rio Orinoco	32.90	19.67

Rosebay	0.07	0.07
Sea Empress	63.15	27.22
Sea Prince	257.26	18.17
Shinkai Maru nº3	0.04	0.02
Shiota Maru nº2	1.05	0.86
Showa Maru	0.59	1.24
Taiyo Maru nº13	0.11	0.08
Take Maru nº6	0.04	0.00
Tanio	218.12	54.25
Tarpenbek	6.33	1.40
Thuntak 5	6.86	3.66
Tolmiros	24.62	0.11
Tsubame Maru nº58	0.27	0.24
Volgoneft263	4.48	4.11

Sources: Cedre (2016); ITOPF (2016); DARRP (2016)

Table 2 Table 1 OPA-90 and IMO regimes

	OPA-90	**IMO**	
Type of regime	Strict liability	Common international regime	
Where is it applied?	USA	110 countries	
Since when is it applied?	1989	1967	
Type of liability	Unlimited	Limited to the tonnage of the ship	
Recognized damage	Economic and environmental damage	Economic and only regeneration damage	
History of the regimes	OPA-90	1969 CLC	1971 Fund Convention (1971)
		1992 CLC	1992 Fund Convention (1992)
			Supplementary Fund Convention (2005)
Maximum compensation	$1000 million per incident + unlimited amount	1971 Fund Convention	Since 1987 until 2002: $91.4 million
		1992 Fund Convention	Since 1996 until Nov. 1, 03: $205.6 million

	Supplementary Fund Convention (2005)	Since Nov. 1, 03 – currently: $309.1 million After March 1, 05: $1159 million

Table 3 Summary statistics for the damages and compensation regressions

		Damage		Compensation	
Variable		**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
	Dependent variable				
Log (dependent)	Logarithm of the dependent variable. It is expressed in $2010	15.322	2.637	14.541	2.912
	Characteristics of the country				
LogGDP	Logarithm of the gross domestic product (ppp)	9.931	0.461	9.926	0.328
	Characteristics of the accident				
North America	1, if the accident took place in North America; 0 otherwise	0.254	0.437	0.092	0.292
Europe	1, if the accident took place in Europe; 0 otherwise	0.342	0.477	0.425	0.499
Asia	1, if the accident took place in Asia; 0 otherwise	0.342	0.477	0.444	0.501
South America	1, if the accident took place in South America; 0 otherwise	0.053	0.224	0.037	0.190
Before80	1, if accident occurred before the 80s; otherwise 0	0.114	0.319	0.055	0.231
Decade80	1, if accident occurred in the 80s; otherwise 0	0.386	0.489	0.444	0.501
Decade90	1, if accident occurred in the 90s; otherwise 0	0.325	0.470	0.388	0.492
Decade00	1, if accident occurred in the 00s; otherwise 0	0.149	0.357	0.111	0.317
Decade10	1, if accident occurred after the 00s; otherwise 0	0.026	0.161	-	-
Log Oil Spill	Logarithm of the tons discharged	6.438	2.886	5.940	3.082
Saturday	1, if the accident occurred on a Saturday; otherwise 0	0.166	0.374	0.074	0.264
Winter	1, if the accident occurred during the winter; otherwise 0	0.193	0.396	0.203	0.406
	Characteristics of the ship				
Single Hull	1, if the ship is single hull; 0 otherwise	0.851	0.358	0.851	0.358
Flag	1, if the ship sailed with a flag of convenience; 0 otherwise	0.833	0.374	0.867	0.341
	Characteristics of the claims				
Environmental	1, if claims for environmental damage were filed; 0 otherwise	0.210	0.409	0.222	0.419

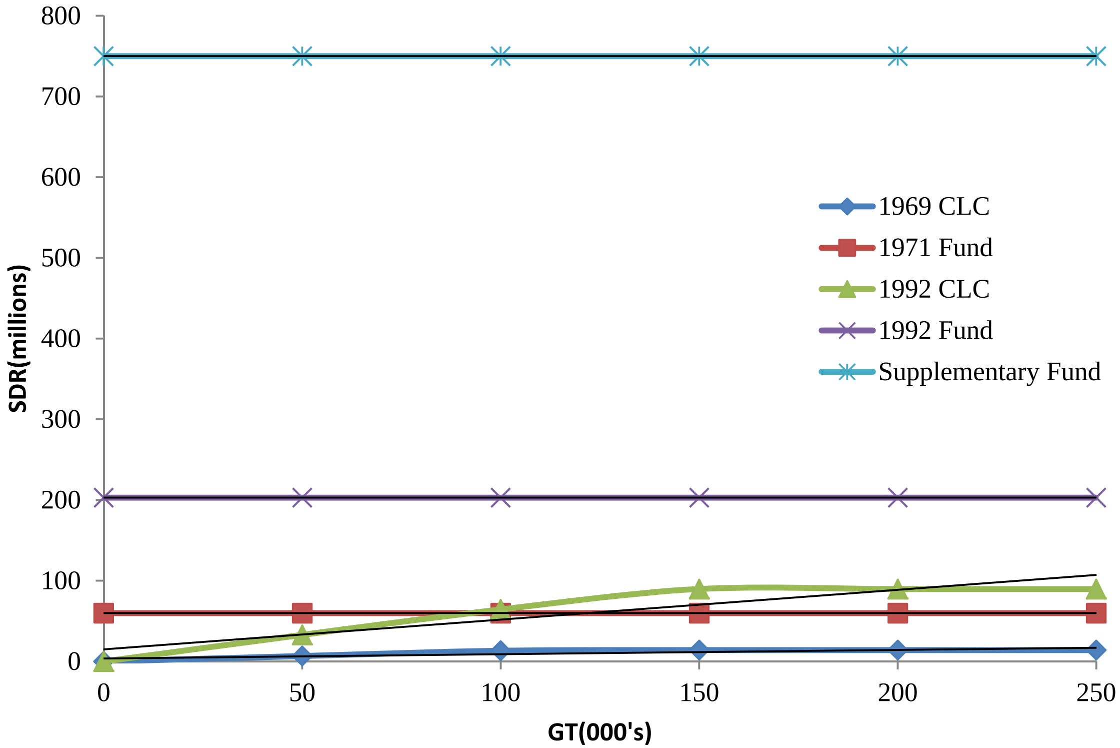
Tourism	1, if claims for tourism damages were filed; 0 otherwise	0.149	0.358	0.203	0.406
Fisheries	1, if claims for fisheries damages were filed; 0 otherwise	0.351	0.479	0.463	0.503
Other damage	1, if claims for other damages were filed; 0 otherwise	0.254	0.437	0.259	0.442
Grounding	1, if the cause of the accident was grounding; otherwise 0	0.289	0.455	0.185	0.392
Error	1, if the cause of the accident was an error; otherwise 0	0.088	0.284	0.055	0.231
Explosion	1, if the cause of the accident was explosion; otherwise 0	0.053	0.224	0.037	0.191
Collision	1, if the cause of the accident was collision; otherwise 0	0.254	0.437	0.296	0.460
Other cause	1, if the cause of the accident was not grounding, sinking, explosion, collision or an error; 0 otherwise	0.316	0.467	0.426	0.499
	Strict liability				
Strict Liability	1, for the United States of America from the year 1991; otherwise 0	0.088	0.284	0.018	0.136

Table 4 OLS and Tobit results for the damages and compensation

	Damages						Compensation					
	OLS			Tobit			OLS			Tobit		
Dependent variable	Coef.	Robust Std. Err.	P>|t|	Coef.	Robust Std. Err.	P>|t|	Coef.	Robust Std. Err.	P>|t|	Coef.	Robust Std. Err.	P>|t|
Characteristics of the country												
LogGDP	-0.850	0.500	0.101	-0.850	0.456	0.065	-0.530	0.656	0.433	-0.557	0.540	0.309
Characteristics of the accident												
North America	0.394	0.517	0.453	0.394	0.472	0.406	1.984	0.643	0.008	2.076	0.525	0.000
Europe	0.101	0.590	0.865	0.101	0.538	0.852	0.461	0.623	0.471	0.477	0.497	0.344
Decade80	1.326	0.757	0.091	1.326	0.690	0.058	0.784	0.765	0.322	0.785	0.645	0.231
Decade90	1.211	0.874	0.177	1.211	0.797	0.132	0.887	0.916	0.349	0.891	0.715	0.221
Decade00	1.861	0.855	0.038	1.861	0.780	0.019	1.151	0.781	0.163	1.162	0.625	0.071
Decade10	2.054	1.333	0.135	2.054	1.216	0.094	-	-	-	-	-	-
Log Oil Spill	0.411	0.120	0.002	0.411	0.109	0.000	0.597	0.090	0.000	0.565	0.077	0.000
Saturday	-0.021	0.662	0.974	-0.021	0.604	0.972	0.624	1.210	0.614	0.422	0.962	0.664
Winter	-0.802	0.417	0.065	-0.802	0.380	0.038	-0.140	0.344	0.690	-0.004	0.304	0.988
Grounding	0.421	0.296	0.167	0.421	0.270	0.122	1.176	0.467	0.025	1.130	0.372	0.004
Error	-0.147	0.849	0.864	-0.147	0.774	0.850	-2.029	0.976	0.056	-2.085	0.778	0.011
Explosion	0.344	0.686	0.620	0.344	0.626	0.584	1.262	0.829	0.150	1.219	0.645	0.067
Characteristics of the ship												
Single Hull	0.085	0.432	0.845	0.085	0.394	0.829	0.077	0.787	0.923	0.059	0.621	0.924
Flag	-0.035	0.876	0.969	-0.035	0.799	0.966	1.151	0.677	0.111	1.172	0.545	0.039
Characteristics of the claims												
Environmental	1.731	0.417	0.000	1.731	0.380	0.000	0.691	0.639	0.298	0.785	0.488	0.116
Tourism	1.067	0.519	0.050	1.067	0.474	0.027	0.571	0.470	0.244	0.608	0.383	0.121
Fisheries	0.788	0.464	0.101	0.788	0.423	0.066	1.342	0.485	0.015	1.284	0.401	0.003
Strict liability												

Strict Liability	-2.037	0.587	0.002	-2.037	0.536	0.000	2.955	0.794	0.002	2.677	0.681	0.000
Constant	19.111	5.032	0.001	19.111	4.589	0.000	12.886	7.203	0.095	13.358	5.872	0.029
Sigma				1.796	0.101					1.185	0.145	
N	114			114			53			53		
Root MSE	1.978						1.504					
Log-pseudolikelihood				-228.533						-81.115		
R-squared	0.532						0.829					

Graph 1: Compensation limits



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