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The Prestige catastrophe: Political decisions, scientific counsel, missing markets and the need for an international maritime protocol

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Abstract: The Prestige tankship, loaded with 77,000 tons of fuel oil, suffered an accident in a storm on November 13, 2002, about 45 miles from the Galician coast. Although the tanker came within 5 miles of Galiza, the Spanish government refused it safe harbor, instead sending it off-shore in a northwestern direction. This was the first of a series of decisions that later provoked the greatest oil spill since the Exxon-Valdez. This paper attempts to show that the political decisions first made by the Spanish government may be understood in the light of economic theory: first, because of missing financial markets, both domestic and international, for environmental accidents; and second, because the Spanish government dismissed the counsel of scientific institutions in its assessment of possible risk in the event of catastrophe, authorities misperceived the risk involved in the decisions it made, and subsequently hid from the population information concerning the possible dangers.

It is argued that the latter magnified the catastrophe -both ecological and social- and that former became the government objective closer to the individualistic coastal population interests than to the social planner, so that the observed outcome was (obviously) the well-known free-rider inefficient result found in economic theory with externalities; i.e., the Spanish Atlantic coast (and later the French) was severely polluted. This paper has two additional goals. First, at the theoretical level, it shows the need for introducing political decision analysis into economic theory. Second, as a policy recommendation, it is an appeal for an international maritime protocol that includes scientific assessment for this kind of situation, designated ports of refuge, and a suitable compensation scheme from those who benefit.

JEL Codes: D57, D62, D78, K33

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1 Introduction

On November 13, 2002, the *Prestige*, a 26-years-old single-hull tankship with 77.000 Tons of heavy fuel oil, suffered an accident in a violent storm 45 miles from Galiza, off the Spanish Atlantic coast. Although the vessel approached within 5 miles of the Galician coast, the Spanish government refused it safe harbor, instead sending it off-shore in a northwestern direction. This was the first in a series of decisions that later provoked on November 19 the sinking of the *Prestige* 150 miles off the coast and the biggest oil spill since the Exxon-Valdez accident, in terms of extension (the entire Spanish northern Atlantic coast was affected, as well as some Portuguese and French coastline); pristine ecosystems were harmed, and all fishing and seafood collection were forbidden for months along the 1.390 km. Galician coast.

Despite the tragedy of the catastrophe, some interesting economic questions arise, many of which are interdisciplinary, involving engineering, biology, law and political science. First, what is the monetary valuation of the damage caused of provoked by the *Prestige* oil spill? Second, can economic theory help us to understand why old single-hull tankships, with their high probability of accidents, are still in use and allowed to transport fuel?; and if so, what type of incentive can economic theory propose for including in the regulatory set-up to reduce the risks of accidents in the future? Third, can economic theory help identify the source of the pollution externality and, consequently, the party responsible for the clean-up expense and compensation for loss? This last question is far from a trivial. If the Spanish government's decisions magnified the catastrophe, this could contribute for determining responsibility. So, a final question emerges: can economic theory help us to understand why the Spanish government decided to refuse the *Prestige* entry to any Galician harbor? This paper hints an answer that borders on political science, as well as the penal law.

We present a very simple model. We first suppose that a tankship laden with fuel undergoes an accident along the Galician coast. There exist a number of harbors, Galician and the others (both Spanish and European), and a decision must be taken: to dock the leaking vessel at some Galician harbor, or to move the tanker off-shore further into the Atlantic.

In the case that the leaking vessel is allowed to dock at some harbor, the population of

any harbor will suffer two kinds of costs. First, an objective cost: a reduction in harbor production, and then income loss, depending on the number and volume of productive activities carried out at the polluted harbor (e.g., reduction of fishing, aquaculture, and tourism). We will assume that this objective cost for any harbor is higher if the vessel is docked there rather than another. Second, there is an environmental subjective cost due to the direct degradation observed at their harbor, as well as the degradation registered in all other harbors; this will depend on the information the population receives (mainly through the mass media). We will assume that the environmental cost will be higher for the port the vessel enters, than for others.

If the vessel does not enter any harbor this problem will become stochastic. With certain probability, nothing would happen; the tankship would be repaired off-shore, resulting in negligible environmental pollution. However, with positive probability, there would be an economic and environmental catastrophe that, with some known probability, would only affect Galician coastline and, with the remaining probability, would affect other Spanish and European coasts.

The scientific literature regarding the consequences of the *Prestige* accident have tried to shed light on some of the above questions by using different disciplinary approaches. The economic literature on the *Prestige* catastrophe has been mainly focused on the economic effects, mainly in two directions: several studies show how economic sectors and activities are affected by the accident;[1] others offer a preliminary approximation to a quantification of the negative impact on the Galician coastal economy, which includes present and future loss in economic activity, considering use and existence values, as well as destruction of the natural environment.[2]

Other issues have attracted the interest of the economic literature. With respect to why old single-hull tankships are still sailing and allowed to transport fuel under low security standards, some authors have pointed out that the present maritime transportation regulatory set-up lacks suitable international legal security, so that responsibility and financial compensation mechanisms for maritime oil spills are not fully defined: this makes "globalization and neoliberalism" ultimately responsible for the *Prestige* accident.[3] Within this view, González-Laxe et al (2003c, sec.4) present a transaction cost model in which the polluting

carrier company is fully responsible for the damage, and they show how several alternative compensation mechanisms would induce maritime carrier companies to invest in security. They conclude that regulation of the maritime transportation of potential contaminants, plus the implementation of suitable financial compensation mechanisms, would better offset social costs.

Additionally, it is interesting to ponder why, despite recent experiences, this regulation is at work in the U.S., but not in the European Union.[4] To this, González-Laxe et al. (2003a,b) have studied maritime security, the regulatory set-up in the European Union, and the problems in implementing new proposals.[5] Some authors have made several suggestions for improving maritime transportation security by public intervention,[6] most of them are included in González-Laxe et al. (2003c)'s proposals for EU regulatory change,[7] who compared it with present US regulation. Remaining, however, is the open question of how new regulations would affect national economies (e.g., the effect of the probable rise in oil price on general prices, growth, etc.).

A third economic issue, culpability in the *Prestige* catastrophe and how pay for the damage, comes close to falling under the theory of international penal law.[8] There has been a long tradition since Coase (1960) of studying inefficient allocations with externalities and the assignment of property rights, leading some authors (e.g., Labandeira et al, 2003) to support public intervention because of market failure for catastrophe- and risk-management associated with hydrocarbon maritime transportation.[9] This would require the identification of the source of the pollution externality and the property rights directly or indirectly affected, as well as determining how and who is to be paid, the cleaning expenses, and compensation for present and future loss. Indeed, the *Prestige* affair makes plain that these are not trivial issues. Economics literature customarily assigns property rights in a way that the conclusion "the polluter must pay" results. In this case, the literature treats the oil spill catastrophe a tanker in the middle of the Atlantic that undergoes an accident, sinks, and ends up polluting the sea and the coast (see, e.g., González-Laxe et al, 2003a,b,c, Labandeira et al, 2003, and the related literature). However, it was precisely the public intervention of a democratically elected government in its decision to not allow the *Prestige* to dock in any Galician harbor, and to send the punctured tanker off-shore in northwestern direction, what

magnified the catastrophe; this may have relevant consequences for identifying additional responsible parties. That is, the call for government intervention due to market failure of the first welfare theorem, in order to introduce measures and actions that will increase maritime transportation security and avert polluting accidents, does not usually take into account lobbying pressures and the efficiency, qualifications and experiences of the officials presiding over the pertinent governmental departments making political decisions. Although it seems that this issue goes beyond economic analysis and into the political science, this paper will demonstrate that economic theory can account for decision-making in the *Prestige* affair.

The scientific literature has bitterly criticized the decision of the Spanish authorities to refuse the *Prestige* safe harbor in the Galician coast, from marine biology,[10] to political science,[11] to other technical reports.[12] The Spanish government, nevertheless, stood behind all the steps taken as the right ones,[13] and both the Ministry of Transportation and the Vice-president continue to insist that the decisions made were technical and not political.[14] Insofar as economics literature is concerned, however, there has not yet been an attempt to make use of economic theory to understand this developments, so this paper aims to fill this gap. Economics analyzes decisions, and the factors that affect these decisions, made under conditions of scarcity, so this is a problem an economist can deal with. We will proceed to judge whether economic theory can shed light on the decision to send the *Prestige* off-shore, rather than have it dock in a Galician harbor.

The critiques originating in scientific literature over this decision focus on three issues: first, politicians dismissal of academic and technical counseling over the situation of the vessel and possible alternatives, resulting in the consequent incorrect perception of the situation and risks; second, refusal to allow the tankship safe harbor and sending it into an adverse Atlantic ocean without any measure to alleviate additional problems, thus magnifying the catastrophe; third, disregarding the International Maritime Organization (IMO) protocols for maritime accidents to which the Spanish government had subscribed.

A comment is in order concerning these criticisms. It is not true that the Spanish Merchant Marine Office, under the Minister of Transportation, and making the decisions, did not have a protocol to resort to in this case.[15] The Head of the Merchant Marine Office followed exactly the protocol implemented on December 31, 2000, when the *Castor*, a vessel

with inflammable load of 31,068 Tm suffered an accident just outside of Almería, on the Spanish Mediterranean coast. Permission to dock was requested, but the Spanish authorities ordered the tankship to move off the Spanish coast.[16] However, the calm Mediterranean was not the same as the stormy waters of the Atlantic. It should be noted that this procedure is characteristic of a type of political irrationality know as the "logic of indecision" in political science.[17] We share the basis of this economic theoretical studies of democracy in approaching the apparent irrationality of political decisions.

In this paper, we show that the political decision taken by Spanish government to send the *Prestige* tankship off-shore may be understood in the light of economic theory. First, there were missing financial markets for pollution disasters, both domestically and internationally, i.e., the nonexistence of a standard international maritime protocol. We illustrate that the first welfare theorem does not hold because of the existence of an externality, although this is not a sufficient condition. Second, because the Spanish government dismissed the counsel of scientific institutions in assessing risk in the event of catastrophe, authorities misperceived the risks involved in the decisions made and then hid information from the population concerning the possible dangers. We contend that the latter magnified the catastrophe -both ecologically and socially-, while the former became the government objective closer to each of the individual coastal population interests than to efficiency.

We suggest that this decision depends on two crucial issues: first, on who has the *property rights* in deciding whether the punctured vessel is prohibited or not from entering a harbor, and which are the existing institutions, i.e. maritime protocols; and second, on what the risks are viewed by decision-makers of sending the vessel out to sea, i.e., the politician's *apriorism* risk probability.

The latter is relevant following our assumption that there exists a true probability for the economic and environmental catastrophe, known for certain by the social planner although perhaps not readily known at the decentralized equilibria by the decision-makers. Political authorities have, initially, some *apriorism* probabilities based on intuition, past experiences, etc., and we will suppose that an approximation to the true probability cannot be known unless a scientific and technical report is carried out.

With regard to the role of these *property rights*, we will study three possible cases: the

myopic decentralized equilibrium, the *social planner problem*, and the *political equilibrium* under three scenarios. First, we will suppose that each harbor's political authority controls rights, and we suppose that the risk probability if no harbor admits the tankship was considered very low by this local authority. We arrive at the *myopic decentralized equilibrium*, in which all Galician harbor political authorities optimally do not allow the vessel to dock, and force the vessel to remain off-shore. However, there does exist a probability that a catastrophe will occur in which all Galician harbors are polluted, reproducing the well-known free-rider outcome.

Next, we determine the Pareto efficient allocation using the *social planner problem*, which concerns all harbors (Galician, Spanish and European), where we assume that the planner knows with certainty the true probability of the risks involved. There exists a probability threshold at which the costs involved in the decisions of admitting and not admitting the ship offset each other. If the true probability is higher than this bound the efficient allocation will be to allow the vessel to enter some harbor and redirect resource compensation from the other harbors to the polluted one. Otherwise, if the risk probability is low, the efficient allocation results in sending the vessel off-shore and, if the catastrophe contingent occurs, transferring resources from the non-affected harbors to the polluted one.

Finally, we come to the *political equilibrium*, in which the corresponding Spanish office opts for or denies the ship's entry. We examine three scenarios. In the first scenario, the government holds onto its an *a priori* risk probability, there exists only one pollution compensation scheme of up to 180 million euros provided by the International Tanker Owners Pollution Federation (ITOPF),[18] and there is no compensation scheme between harbors. This describes the actual situation, and we find that if the politicians misperceived the risk probability, judging it to be lower than the true probability in the *Prestige* affair, the political equilibrium would mandate sending the vessel off-shore, and with positive probability polluting all the Atlantic coast. That is, the observed outcome is the well-known free-rider theoretical inefficient result found in economic theory with externalities; in other words, the Spanish, and later the French, Atlantic coasts were severely polluted. The second scenario considers the existence of that complete financial markets between harbors for pollution. However, despite the economic theory supports that efficient allocation would then

be achieved, the fact that politicians made relevant decisions based on a low *a priori* probability the previous inefficient result is reproduced again. Finally, we consider a third scenario in which complete financial markets for pollution exist between harbors, and scientific and technical assessment is furnished to assist in government decision-making. Here, efficiency is restored.

There exists two additional contributions of this paper. First, at the theoretical level, we illustrate the need for introducing political decision analysis into economic theory. Second, as a policy recommendation, this is an appeal, analogous to those of other authors and institutions,[19] for the development of an international maritime protocol that includes scientific assessment in this kind of situation, designated ports of refuge, and a suitable compensation scheme from those who benefit, all as a way to improve social welfare.

This work develops along the following sections. Section 2 is a brief description of events. In Section 3 we first present the model, next we find the myopic decentralized equilibrium, then the optimal Pareto allocations, and finally the political equilibrium for three scenarios: with incomplete markets of pollution, with complete markets of pollution, and with complete markets of pollution and scientific assessment integrated into the government decision. Finally, Section 4 summarizes conclusions and indicates further research.

2 The events

On the afternoon of Wednesday, November 13, 2002,[20] the tanker *Prestige*, carrying a cargo of some 77,000 tons of heavy fuel oil, en route from Ventspils in Latvia to Singapore, experienced hull damage in heavy seas some 30 miles off Cape Finisterre, in northern Spain. The problem started with a failure of the ship's side platin in one of the starboard ballast tanks, which was empty at the time. The tank rapidly filled with seawater, causing the ship to list to about 25 degrees. The main engine stopped at about this time. The master reacted immediately and tried to reduce the list, but it was several hours before the list was reduced to 5 degrees. Heavy rolling on the sea led to small amounts of cargo oil being forced through screwdown plates in the deck. This stage continued for several hours with no damage to any of the cargo tanks, yet. However, because of the ship's lay in such a position relative to the prevailing

winds, heavy waves continued to pound the damaged area. Eventually, a further piece of side plating was torn away, damaging, in the process, the plating of one of the cargo tanks, which began to spill oil, causing serious pollution.

The exact cause of the initial damage, giving rise to the precarious list, is not known but the *Prestige* drifted to within five miles of the coast before salvage vessels were able to attach lines. The tanker was denied access to a sheltered, safe haven decision was made by the shore authorities to order the ship out to sea, without any provisions for preventing further damage, the ship was likely to sink eventually unless the weather abated very quickly.

She was towed out into the Atlantic to face further tempest and severe conditions. Tug boats tried to minimize stress on the vessel by their direction of tow, and because of its residual strength, the ship managed to stay afloat for six days after the initial damage. However, on November 19 the weakened ship finally broke in two about 170 miles off the Spanish coast, with both parts sinking to the sea bed about 3,500 meters below. (See satellite picture 1 for the tankship path.)

Oil began to reach Galician shores on November 17. The heaviest contamination was between A Coruña and the Toriñan Cape, although varying degrees of contamination eventually extended from the border area of Spain and Portugal to Bordeaux in France. Although oil entered Portuguese waters, it did not wash ashore there.

The contaminated coasts of Spain and France are popular tourist destinations, but are also sites of international importance for birds. In addition, the Galician region of Spain supports a rich fishing and aquaculture industry. Mussels, oysters, turbot and several other species are cultivated along the coast, while various natural stocks of fish and shellfish are harvested by traditional methods. The local regulatory authority imposed a ban on fishing and shellfish harvesting over an extensive area of the Galician coast. In France the oyster fishery in the region of Arcachon was subject to a short ban on harvesting while there was floating oil in the area.

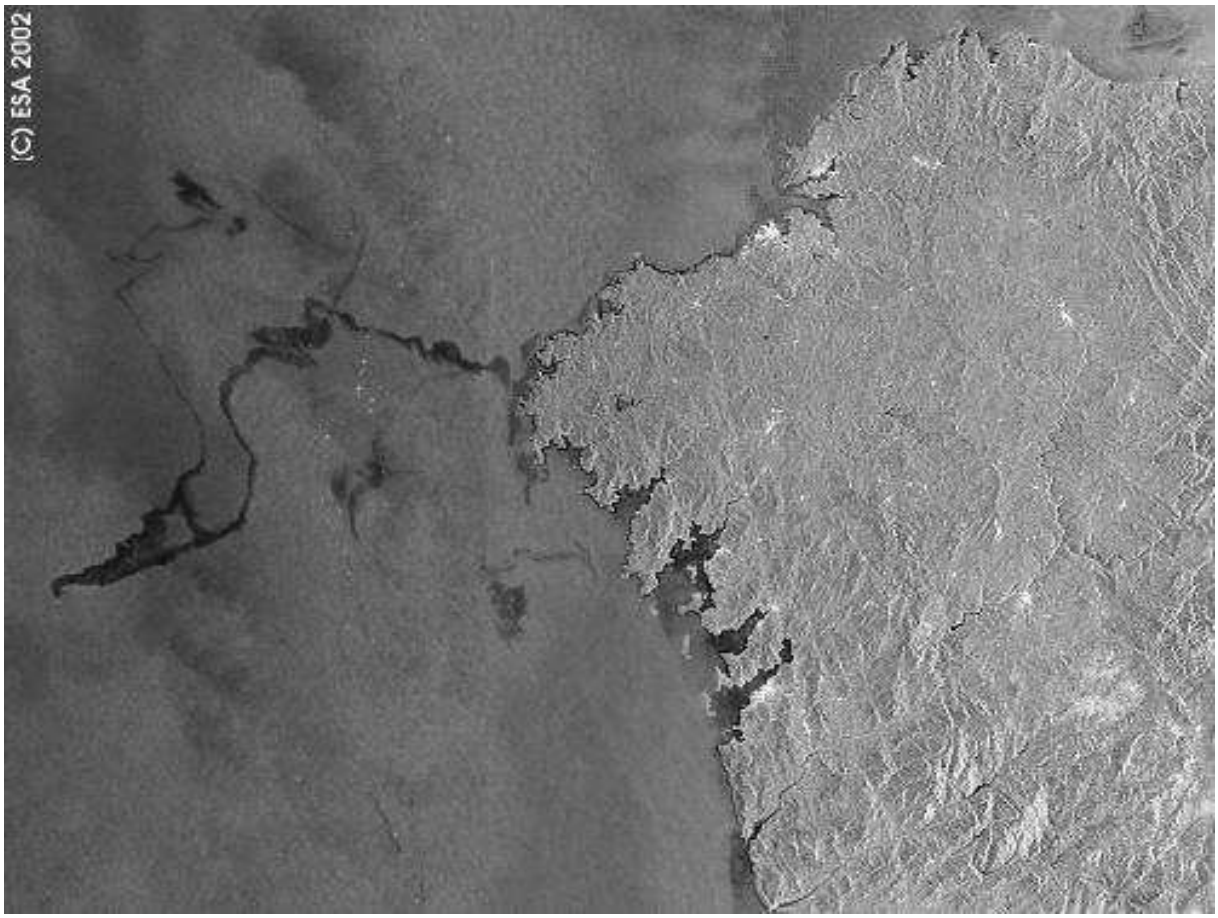

Figure 1: Satellite Picture on 17 November 2002, ESA

3 The model

Let us suppose H Atlantic harbors, with H_G as the Galician ones, and the rest along the Spanish northern coast or in other European countries on the Atlantic (Portugal, France, Great Britain, Ireland, etc.).

Then, let us suppose that a tankship with 77.000 Tons of heavy fuel oil undergoes an accident in a violent storm 45 miles from the Galician coast. A decision must be taken: whether to escort the leaking vessel into some Galician harbor $h \in H_G$, or to move the ship farther off-shore into the Atlantic. Since economics study decision-making, this is a problem economists may deal with. Crucial to the outcome is who has the *right* to decide whether the vessel is allowed to enter some harbor. We will present three equilibria depending

on the entity holding this right, and given the prevailing institutions and protocols. In the first case, the political authorities have this right of each harbor control, and then we develop the decentralized individual harbor equilibrium. Then, we consider the Pareto-efficient allocations from the social planner problem, and stipulate a supranational office that confronts problem.[21] Finally, we study the political problem, in which the maritime decisions regarding the Spanish coast are taken at the corresponding government office.[22]

3.1 The scenarios

Denotes I_h as the decision of whether to allow the punctured vessel to enter harbor h, which is consequently polluted. The decision to permit entry will be denoted by $I_h = 1$; otherwise, $I_h = 0$. Given the existence of H_G harbors, the available decisions are represented by the H_G-dimensional canonical base, $\mathcal{B} = \{e_1, ..., e_{H_G}\}$, plus the zero H_G-dimensional vector, e_0, such that the set of feasible decisions is arrived at by $\mathcal{B}' = \mathcal{B} \bigcup \{e_0\}$, yielding $e_j = (I_1, I_2, ..., I_{H_G})$ as one of the feasible decisions, with $I_j = 1$ and $I_k = 0$ if $k \neq j$, or $I_j = 0$ for all $j \in H_G$.

Admitting the leaking tankship into harbor j will result in two kinds of costs for any harbor $h \in H$: an impact on its productive activities $\nabla M_h(e_j)$ (both direct, such as decreased fishing, and indirect, such as reduced tourism.), and a subjective psychological pain $v_h(e_j)$ for the population of harbor h as it assimilates the destruction of its natural environment.

The former indicates that, if the punctured tankship enters some harbor j, i.e. $e_j \in \mathcal{B}$, harbor h will suffer the costs of decreased activity (as a negative productivity shock); this we will denote by $\theta_h(e_j) = \theta_h(I_1, I_2, ..., I_{H_G})$ as the fraction of productive activities affected at harbor h for some decision e_j. For example, if the vessel is allowed to dock at harbor $j = 1$, harbor h productive activity will decrease $\nabla M_h(e_1) = \theta_h(1, 0, ..., 0)Y_h$. For simplicity, we will assume that harbor h's productivity cost for refusing the vessel entry is the same as for any decision taken by the other harbors, i.e. $\theta_h(e_j) = \theta_h(I_1, ..., I_{h-1}, 0, I_{h+1}, ..., I_{H_G})$ for any I_j and $j \neq h$.[23] It is reasonable to assume that if the vessel enters its harbor it is reasonable to assume that a harbor will experience greater damage, so $\nabla M_h(e_h) = \theta_h(e_h)Y_h >> \theta_h(e_k)Y_h = \nabla M_h(e_k)$ with $k \neq h$, for each harbor h.

The latter means that the population of harbor h suffers because of the degradation of its natural environment, as well as that of all other harbors. This subjective cost is represented

by a continuously increasing function $v_h(e_j) = v_h(I_1, I_2, ..., I_{H_G})$ for each $h \in H$, and will depend on information harbor h citizens receive. It is also reasonable to assume that a harbor will experience greater damage if the vessel enters its harbor, so $v_h(0, ...1, ..., 0) > v_h(I_1, ..., I_{h-1}, 0, I_{h+1}, ..., I_{H_G})$.

There are two possible outcomes. First, if the vessel is allowed to dock at some harbor j, this harbor will suffer devastating productive and environmental costs; the other harbors will undergo both productive and environmental costs, but much lower than if they had admitted the vessel. Second, if the vessel enters no harbor, the problem turns out to be stochastic. Under probability $1 - \pi$ nothing happens, the tankship is repaired off-shore and there is negligible environmental pollution, i.e., $\theta_h(e_0, 1 - \pi) = 0$ and $v_h(e_0, 1 - \pi) = 0$ for all $h \in H$. However, with probability π, an economic and environmental catastrophe could result that, with probability $1 - \psi$ only affects the Galician coast, and with probability ψ, affects the rest of the Spanish and European coasts. We will make the following assumptions for both probabilities: first, it seems reasonable to assume that the probability of catastrophe affecting only the Galician coast or all neighboring coasts can be known approximately, so that ψ is given; second, the evaluation of the risks of sending the leaking tankship off-shore probably differs among decision-makers because of their despaired views of the situation, their experience, available information, etc. At any rate, it is paramount to realize that a precise estimation of probability π depends on technical assessment. The costs involved in each case will be denoted by $\nabla M_h(e_0, \pi(1 - \psi)) = \theta_h(e_0, \pi(1 - \psi))Y_h$ and $v_h(e_0, \pi(1 - \psi))$, and $\nabla M_h(e_0, \pi\psi) = \theta_h(e_0, \pi\psi)Y_h$ and $v_h(e_0, \pi\psi)$, respectively, for all $h \in H$. Finally, it also seems reasonable to assume that the productivity shock caused by oil reaching any Galician harbor will approximate that experienced if the vessel were admitted into harbor will be much higher if the leaking vessel enters another harbor, and will be highest if no catastrophe happens; that is, $\theta_h(e_h) \geq \theta_h(e_0, \pi) > \theta_h(e_j) >> \theta_h(e_0, (1 - \pi))$ for any Galician harbor $h \in H_G$, where $j \in H_G \setminus \{h\}$.

3.2 Myopic decentralized equilibrium

The harbor h problem. Let us suppose the political authority of each harbor $h \in H_G$ has the property rights to allow a vessel to enter its harbor. This enables us to simplify the

notation by substituting the outcome vector e_j with the individual harbor decision variable I_h. In addition, we will assume that each harbor h's political authority has insufficient information about the risks involved if the ship's being admitted to no harbor, thus assigning this probability the value $\tilde{\pi}_h = 0$ for all $h \in H_G$.[24] The harbor h's political authority faces the decision, I_h, whether to permit the leaking tankship inside its harbor, $I_h = 1$, or not, $I_h = 0$, given the other harbors' decisions; that is,

$$\begin{aligned} \min_{I_h \in \{0,1\}} \quad & \nabla M_h(I_h) + v_h(I_h) \\ & \text{subject to } \nabla M_h(I_h) = [I_h \theta_h(1) + (1 - I_h)\theta_h(0)]\, Y_h \end{aligned}$$

This means that harbor h's problem is

$$\min \left\{ \theta_h(1) Y_h + v_h(1); \;\; \theta_h(I_1, ..., I_{h-1}, 0, I_{h+1}, ..., I_{H_G}) Y_h + v_h(I_1, ..., I_{h-1}, 0, I_{h+1}, ..., I_{H_G}) \right\}$$

given other harbors decision I_k, with $k \neq h$. The optimal decision is to refuse the tanker safe haven, i.e., $\theta_h(0)Y_h + v_h(0)$ for any harbor's political authority $h \in H_G$.

The remaining non-Galician harbors take no option. If the vessel is allowed into some Galician harbor, they will suffer no productive cost but a subjective cost, i.e., $\nabla M_h(e_j) = 0$ and $v_h(e_j) > 0$ for $j \neq 0$ for all $h \in H/H_G$. If none admits it, the cost will be $\theta_h(e_0)Y_h + v_h(e_0)$, the same for all $h \in H/H_G$.

The myopic decentralized equilibrium. Let us represent each harbor output as $\{Y_h\}_{h \in H}$; the productivity cost as $\{\theta_h(e_j)\}_{h \in H}$ and the subjective environmental cost function as $\{v_h(e_j)\}_{h \in H}$ for each $e_j \in \mathcal{B}'$; and the known probability that the pollution will reach every harbor after an off-shore catastrophe occurs as ψ. And we will make all harbor h perceived probability of risk $\{\tilde{\pi}_h^M = 0\}_{h \in H_G}$. Then, $e_0 \in \mathcal{B}'$ is an equilibrium, such that $I_h = 0$ will be the solution for each harbor problem $h \in H_G$.

This equilibrium means that no Galician harbor will allow the vessel entry. Consequently, the tankship is sent off-shore. Nothing may happen, or, with some true probability $\bar{\pi}$, a catastrophe will occur. To sum up, due to the fact that any Galician harbor cannot lay claim to any other harbor's benefits (either Galician or foreign), none admits the vessel, most likely

ending up in damage to all H harbors. This inefficiency resulting from incomplete markets for the pollution bad is the standard free-rider outcome in the literature of externalities.

3.3 The Pareto efficient allocation

The Social Planner problem. We would address the Pareto efficient decision in the Social Planner problem following the accident: whoever makes the decision to offer safe haven to the punctured tankship at some harbor has to choose a Galician harbor $j \in H_G$ to introduce the vessel $I_j = 1$ and $I_k = 0$ with $k \neq j$, or, alternatively, send the vessel off-shore, $I_h = 0$ for $h \in H_G$.

If the Social Planner decides to allow the vessel into a particular harbor, this one will be sacrificed in benefit of the others. Therefore the Planner will transfer some resources from the other harbors to the affected harbor so that all harbors mitigate the impact at the affected harbor. If the decision consists of closing all Galician harbors to the vessel, the Social Planner must know the true probability $1-\bar{\pi}$ that nothing adverse will happen, as well as the true probabilities $\bar{\pi}(1-\bar{\psi})$ and $\bar{\pi}\bar{\psi}$ of an economic and environmental catastrophe affecting all Galician harbors H_G only, or also other Spanish and European coastline, respectively.

Let us make $\{\alpha_h\}_{h\in H}$ the Social Planner set of weights for each of the H Galician and other Spanish and European harbors, and g a continuous increasing function the Social Planner assigns to the cost for each harbor.[25] The Social Planner's problem consists of a suitable transfer of the productive costs, denoted by μ_h, after deciding whether to allow the tankship to dock at one of the H_G ports, $I_h = 1$ for one $h \in H_G$, or to send the vessel off-shore, i.e., $I_h = 0$ for all H_G; that is,

$$\begin{aligned}\min\Big\{ \quad & \textstyle\sum_{h\in H} \alpha_h g\Big(\nabla M_h(e_1) + \mu_h(e_1) + v_h(e_1)\Big); ...; \sum_{h\in H} \alpha_h g\Big(\nabla \mu_h(e_{H_G}) + \mu_h(e_{H_G}) + v_h(e_{H_G})\Big); \\ & \beta\bar{\pi}(1-\bar{\psi}) \textstyle\sum_{h\in H} \alpha_h g\Big(\nabla M_h(e_0, \bar{\pi}(1-\bar{\psi})) + \mu_h(e_0, \bar{\pi}(1-\bar{\psi})) + v_h(e_0, \bar{\pi}(1-\bar{\psi}))\Big) + \\ & + \beta\bar{\pi}\bar{\psi} \textstyle\sum_{h\in H} \alpha_h g\Big(\nabla M_h(e_0, \bar{\pi}\bar{\psi}) + \mu_h(e_0, \bar{\pi}\bar{\psi}) + v_h(e_0, \bar{\pi}\bar{\psi})\Big) \quad \Big\},\end{aligned}$$

subject to the resource cost constraint $\sum_{h\in H} (\nabla M_h(e_j) + \mu_h(e_j)) = \sum_{h\in H} \theta_h(e_j) Y_h$ for $e_j \in \mathcal{B}$, and $\sum_{h\in H} (\nabla M_h(e_0, \rho) + \mu_h(e_0, \rho)) = \sum_{h\in H} \theta_h(e_0, \rho) Y_h$ for $\rho \in \{\bar{\pi}(1-\bar{\psi}); \bar{\pi}\bar{\psi}\}$; β is the discounted factor; and $\bar{\psi}$ is given. Consequently, the summation of the net compensations

among harbors will be zero for any contingency, so that μ_h may be negative or positive, i.e., $\sum_{h\in H}\mu_h(e_j)=0$ for $e_j\in\mathcal{B}$, and $\sum_{h\in H}\mu_h(e_0,\rho)=0$ for $\rho\in\{\bar{\pi}(1-\bar{\psi});\bar{\pi}\bar{\psi}\}$, respectively.

The Pareto efficient allocations. An outcome of this problem, which depends on the Planner weights and the probabilities, would be an allocation of productive resource costs and a spatial allocation for the vessel based on the decision taken, i.e., $\left\{\{\hat{\mu}_h(\hat{e}_j;\alpha_1,...\alpha_H,\bar{\pi},\bar{\psi})\}_{h\in H},\hat{e}_j\in\mathcal{B}'\right\}$. Given these weights and probabilities, this allocation is Pareto efficient due to the fact that there is no other allocation of productive resource costs or other spatial allocation for the tankship making some harbor better off and no other harbor worse off.

Proposition 1 *Let us work with the coastal harbor output set as* $\{Y_h\}_{h\in H}$*, and the subjective environment valuation function as* $\{v_h(e)\}_{h\in H}$ *. Suppose that the probability of the pollution reaching every harbor following the off-shore disaster* $\bar{\psi}$ *is known. Then, for sufficiently high negative productivity shocks* $\{\theta_h(e_j),\theta_h(e_0,\rho)\}_{h\in H;\ \rho\in\{(1-\bar{\pi});\bar{\pi}(1-\bar{\psi});\bar{\pi}\bar{\psi}\}}$*, there exists a threshold* $\breve{\pi}$ *of probability for the off-shore catastrophe, such that*
i) If the true probability of an off-shore catastrophe is lower than this threshold $\bar{\pi}<\breve{\pi}$*, then the efficient allocation consists of sending the leaking vessel off-shore, i.e.,*
$\left\{\{\hat{\mu}_h(\hat{e}_0;\alpha_1,...\alpha_H,\bar{\pi},\bar{\psi})\}_{h\in H},\hat{e}_0\right\}$*;*
ii) If the true probability of an off-shore catastrophe is higher than the threshold, i.e., $\bar{\pi}>\breve{\pi}$*, then there will be a Galician harbor* $h'\in H_G$ *that receives the leaking tankship, and a compensation transfer from the other harbors, i.e.,* $\hat{\mu}_{h'}(\hat{e}_{h'})<0$*. That is, the efficient allocation is* $\left\{\{\hat{\mu}_h(\hat{e}_{h'};\alpha_1,...\alpha_H,\bar{\pi},\bar{\psi})\}_{h\in H},\hat{e}_{h'}\right\}$ *for some* $h'\in H_G$*.*

It is noteworthy that the μ_j transfers made in case ii) for $j\neq h'$ and $j\in H$, are lower bounded by the opportunity cost of refusing the vessel entry into harbor j, that is, $0>\mu_j(e_{h'})>-\theta_j(eh')Y_j$ for each harbor $j\neq h'$. It must also be pointed out that this is a discrete choice problem, so that, given Planner weights and probabilities, there will be a correspondence of Pareto efficient allocations for each decision $e_j\in\mathcal{B}'$, instead of unique ones given the planner weights.

Proof: The proof is simple. First, if the tankship is allowed to enter some harbor, only this harbor will suffer productive costs and all other harbors will suffer a subjective environmental

cost because of the pollution to that harbor. Both values are independent of the probability π. Second, if it is not allowed to enter, e_0, with some likelihood all Galician harbors will suffer a productive cost and a subjective environmental cost because of the pollution to all H_G harbors. The summation of these costs, higher than in the first case where only one harbor suffers negative productivity shock, increase in π. Thus the higher the probability of the leaking tankship sinking off-shore and creating an environmental disaster, the higher cost of not allowing the vessel to enter some Galician harbor.[26] Therefore, the planner should look for a harbor h' that would minimize the aggregate harbor costs.□

The inefficiency of the myopic decentralized equilibrium. Next, we show under what circumstances the myopic equilibrium allocation found in this section would be inefficient. We present the following corollary.

Corollary 1 *Under the conditions of Proposition 1, if the true probability of an off-shore catastrophe is higher than the threshold, i.e., $\bar{\pi} > \breve{\pi}$, and, consequently, higher than the myopic harbor h probability evaluation $\bar{\pi} > \tilde{\pi}_h^M = 0$ for all $h \in H_G$, then the leaking vessel will be sent off-shore and the myopic decentralized equilibrium becomes inefficient.*

In the case that true probabilities condition the social Pareto efficient solution is to be admittance of the oil-spilling vessel to some harbor and compensation for this harbor by all the other harbors, the decentralized equilibrium will be inefficient because of missing financial markets from which to appropriate benefits.

3.4 The political equilibrium.

Let us suppose now that decisions relating to the Spanish coast are taken by the Ministry of Transportation, which may delegate responsibilities to the Merchant Marine Office.[27] After the accident of the tankship, the Minister and the Head of the Merchant Marine Office, jointly with collaborators gathered in a Crisis Coordination Commission,[28] confronted the decision of whether to let the leaking tankship enter some H_G harbor.

We assume that the Commission for Crises Coordination has an *a priori* evaluation of the stochastic risks involved for each decision. If the puncture vessel is not admitted any

Galician harbor, the Commission for Crises Coordination will have considered that with some probability of $1-\tilde{\pi}^P$ no disaster will occur, the tankship will be repaired off-shore, and there will be little environmental pollution. However, with a probability of $\tilde{\pi}^P$ the Commission for Crises Coordination will consider that an economic and environmental catastrophe could take place, which with a known probability of $1-\bar{\psi}$ will only affect the Galician coast, and with a probability of $\bar{\psi}$ will affect additional Spanish and European coasts.

Let us make $\{\lambda_h\}_{h\in H}$ the weight the Spanish government assigns to each H harbors. Since democratic governments care mainly about their national voters, it is reasonable to think that foreign harbors weighted few or none for the Spanish government;[29] i.e, $\lambda_h \approx 0$, for $h \in H \setminus H_S$.

The political problem. In addition to determining whether to dock the tanker at some H_G harbor, the Commission for Crises Coordination has to distribute financial resources among the affected in the case that there is an existing a financial scheme of compensation and for pollution finally reaching Spanish coasts. The Commission for Crises Coordination cost function for each of the menu options is the following:

$$\Big\{ \ \sum_{h\in H_S}\lambda_h\Big[\nabla M_h(e_1)+\mu_h(e_1)+v_h(e_1)\Big];...;\sum_{h\in H_S}\lambda_h\Big[\nabla \mu_h(e_{H_G})+\mu_h(e_{H_G})+v_h(e_{H_G})\Big];$$
$$\beta\tilde{\pi}^P(1-\bar{\psi})\sum_{h\in H_S}\lambda_h\Big[\nabla M_h(e_0,\tilde{\pi}^P(1-\bar{\psi}))+\mu_h(e_0,\tilde{\pi}^P(1-\bar{\psi}))+v_h(e_0,\tilde{\pi}^P(1-\bar{\psi}))\Big]+$$
$$+\beta\tilde{\pi}^P\bar{\psi}\sum_{h\in H_S}\lambda_h\Big[\nabla M_h(e_0,\tilde{\pi}^P\bar{\psi})+\mu_h(e_0,\tilde{\pi}^P\bar{\psi})+v_h(e_0,\tilde{\pi}^P\bar{\psi})\Big] \ \Big\},$$

where β is the discounted factor, and $\{\mu_h\}_{h\in H_S}$ are the set of financial compensation transfers, positive or negative, that enhance or drain resources from each harbor.

The solution for the political problem depends on the monetary constraint established by the existing financial compensation scheme. Next, we will examine three possible equilibria, depending on the existence or not of domestic financial markets and on whether the government requires scientific and technical assessment. The first equilibrium may well represent the present situation, resulting in an inefficient allocation. The second indicates that, despite the existence of complete markets, an efficient allocation may not necessarily be found. Finally, an equilibrium providing a financial scheme and scientific and technical assessment for government decision-making that restores efficiency is proposed.

3.4.1 The politician problem without domestic financial markets

We will first suppose that in the case of the vessel entering some harbor h, the Spanish government will have no financial scheme whereby this harbor will be compensated by the others, i.e., $\mu_j(e_h) = 0$ for $j \neq h$. This seems to fit best with real past events, where no catastrophe on the Galician coast (Polycomander, 1970; Erkowit, 1970; Urquiola, 1976; Andros Patria, 1978; Cason, 1987; Aegean Sea, 1992, ...) ever met with compensation from other harbors. The only compensation would come from an exogenous financial fund provided by the ITOPF in the case that pollution reaches the coast, although the affected harbor must wait a number of T years to be paid.[30] Here, the political problem is to minimize the $H_G + 1$ cost functions subject to the following financial restrictions

$$\mu_h(e_h) = \beta^T ITOPF_h, \text{ and } \mu_j(e_h) = 0 \text{ for } j \neq h$$

for each $e_h \in \mathcal{B}'$ and $h \in H_G$; and $\mu_h(e_0, \rho) = \beta^T ITOPF_h$, for $h \in H_G$ if $\rho = \pi(1 - \bar{\psi})$ and $h \in H$ if $\rho = \pi\bar{\psi}$.

The political equilibrium without financial markets. Let us make each harbor output $\{Y_h\}_{h\in H}$; the productivity cost $\{\theta_h(e_j)\}_{h\in H}$ and the subjective environmental cost function $\{v_h(e_j)\}_{h\in H}$ for each $e_j \in \mathcal{B}'$, and the known probability of the pollution reaching all harbors following an off-shore catastrophe ψ. We will make the Commission for Crises Coordination's probability of risk $\tilde{\pi}^P$. Then $e_j^*(\tilde{\pi}^P) \in \mathcal{B}'$ constitutes an equilibrium, such that, given the stochastic *apriorism* $\tilde{\pi}^P$, it becomes the a solution for the political problem.

The inefficiency of the political equilibrium. The equilibrium allocation just described depends crucially on the Commission for Crises Coordination's evaluation of risk probability for sending the vessel off-shore, $\tilde{\pi}^P$. Given that, in fact, this probability was not necessarily the fruit of any academic study, but the product of politicians intuition, experience or interests, or simply of the desire to gain time because of inadequate existing resources for confronting the pollution on shore, etc.,[31] the stochastic political *apriorism* might be overvalued or undervaluated. Both academic work and some maritime organization reports

suggest that the risks of the actual decision taken where very high and argue for the alternative of accepting the vessel into a harbor.[32] For our terminology, these works indicate that the value assigned to the off-shore catastrophe contingency by the Commission for Crises Coordination was greatly undervaluated, i.e., $\tilde{\pi}^P << \pi$. Other literature[33] suggests that the estimation of this probability relied too heavily on the previous experience of the Head of the Merchant Marine Office with the calm Mediterranean, rather than on any scientific assessment.[34] Further evidence is that the hypothesis of the ships sinking is disregarded perfunctorily by the Commission for Crises Coordination, in the blind hope that nothing would happen, despite no scientific basis for such thinking.[35]

The next proposition helps to understand the events taking place between November 13-15, 2002, where the political equilibrium may reproduce the myopic decentralized equilibrium.[36]

Proposition 2 *Let us make the coastal harbor output set* $\{Y_h\}_{h\in H}$*, and the subjective environmental valuation function* $\{v_h(e)\}_{h\in H_S;\, e\in\mathcal{B}'}$*. Let us suppose that the probability of the pollution reaching every harbor following the off-shore disaster* $\bar{\psi}$ *is given, and that, for sufficiently high negative productivity shock* $\{\theta_h(e_j), \theta_h(e_0,\rho)\}_{h\in H_S;\, \rho\in\{(1-\pi);\pi(1-\bar{\psi});\pi\bar{\psi}\}}$*, the true probability of an off-shore catastrophe is higher than the threshold found in Proposition 1, i.e.,* $\bar{\pi} > \breve{\pi}$*. Then, if the a Commission for Crises Coordination apriorism for on the probability of an off-shore catastrophe is lower than the threshold found in Proposition 1, i.e.,* $\tilde{\pi}^P < \breve{\pi}$*, the political equilibrium without financial markets results in an inefficient allocation* $e_0^*(\tilde{\pi}^P)$*; i.e., the Prestige is sent off-shore.*

The proof is similar to that of Proposition 1, but uses the opposite argument for a low π. That is, if this were true, the case the political equilibrium allocation $e_0^*(\tilde{\pi}^P)$ would not have been Pareto efficient.

Two political comments on this result are in order. First, as an immediate political recommendation for the Spanish maritime authorities, this proposition concords with Labandeira el al (2003) in urgently suggesting the formation of a contingent scientific and technical committee for accurete rist evaluation in assessing political decisions. Second, this result argues against the idea that Galiza holds little political weight in the Spanish central

government decisions, i.e., in our notation $\lambda_h = 0$ for all $h \in H_G$, since the vessel would otherwise have been allowed to enter to any harbor.

3.4.2 The politician problem with domestic financial markets

In the second case under study we will assume the existence of financial markets for oil spills, such that each harbor's political authority may trade with other harbor authorities to minimize the impact on its own harbor. It is well known that if financial markets are complete, the resulting equilibrium allocation will be efficient (see Mass-Collel et al, 1995, Chap.19C). However, we will find that this situation does not prevail here because the decision-makers' *a priori* risk probability differs greatly from the true probability; besides, the traders in financial markets may not be the decision-makers. That is, we enter the realm of the political science politicians' behavior.

Let us suppose that financial markets exist in the sense that, if the government decides to sacrifice one harbor in benefit of the others and dock the tanker, some productive resources from the other harbors will be devoted to the affected harbor. The political restriction for the ship's entering harbor h are

$$\sum_{h \in H_S} (\nabla M_h(e_j) + \mu_h(e_j)) = \sum_{h \in H_S} \theta_h(e_j) Y_h$$

for $e_j \in \mathcal{B}$, and

$$\sum_{h \in H_S} (\nabla M_h(e_0, \rho) + \mu_h(e_0, \rho)) = \sum_{h \in H_S} \theta_h(e_0, \rho) Y_h$$

in the case of catastrophe off-shore, i.e., $\rho \in \{\pi(1-\bar{\psi}); \pi\bar{\psi}\}$. Consequently, the summation of net compensations among harbors will be zero for any contingency, so that μ_h may be negative or positive; i.e., $\sum_{h \in H_S} \mu_h(e_j) = 0$ for $e_j \in \mathcal{B}$, and $\sum_{h \in H_S} \mu_h(e_0, \rho) = 0$ for $\rho \in \{\bar{\pi}(1-\bar{\psi}); \bar{\pi}\bar{\psi}\}$, respectively. Additionally, any harbor j affected by the pollution will also be paid an exogenous compensation from the ITOPF if pollution reaches the coast, although the affected harbor must wait a number of T years to be paid; i.e., $\mu_j(e_j) + \beta^T ITOPF_j$ or $\mu_j(e_0, \rho) + \beta^T ITOPF_j$ for $\rho \in \{\bar{\pi}(1-\bar{\psi}); \bar{\pi}\bar{\psi}\}$. We must remember that the summation of transfers from the ITOPF to all harbors are upper bounded, i.e., $\sum_{j \in H_S} ITOPF_j \leq 180m$.

The following proposition casts doubt as to whether the political decisions made with

complete markets will yield an efficient allocation.

Proposition 3 *Let us maintain the same assumptions of Proposition 2. We will asume that, for sufficiently high negative productivity shock* $\{\theta_h(e_j), \theta_h(e_0, \rho)\}_{h \in H_S;\, \rho \in \{(1-\pi);\pi(1-\bar{\psi});\pi\bar{\psi}\}}$*, the true probability of an off-shore catastrophe is higher than the threshold found in Proposition 1, i.e.,* $\bar{\pi} > \breve{\pi}$*. Then, if the Commission for Crises Coordination apriorism for the probability of an off-shore catastrophe is lower than the threshold found in Proposition 1, i.e.,* $\tilde{\pi}^P < \breve{\pi}$*, the political equilibrium with financial markets will result in an inefficient allocation* e_0^{**}*.*

In addition, if the apriorism of each harbor for the probability of off-shore disaster is lower than the threshold found in Proposition 1, i.e., $\tilde{\pi}^M < \breve{\pi}$*, the myopic equilibrium with financial markets results in the same inefficient allocation* e_0^{**}*.*

On a theoretical level, this proposition casts doubt on whether the result found in Proposition 2 (that is, the political equilibrium reproduces at the aggregate decision making the free-rider problem) is strictly a problem of missing financial markets; that is, because no Galician harbor can appropriate from benefits of other harbor (both Galician and foreign), none will offer the tanker safe haven and, then, all H harbors could eventually see damaged. It might be maintained that this is an inefficient allocation because some redistribution of the resources saved in the case of admittance to a particular harbor could ensure the state of all harbors. However, despite the existence of complete financial markets, an inefficient allocation inevitably results, owing to the inappropriately low valuation of risk in refusing the vessel safe haven set by the stochastic *apriorism* of politicians. This takes the problem beyond economic theory and into the realm of political science, specifically the study of how politicians make decisions.[37]

3.4.3 The politician problem with financial markets and scientific assessment: a proposal.

For the politician problem, then, to achieve an efficient allocation, complete markets are required, but so is suitable scientific and technical assessment for evaluating the risks properly, allowing $\tilde{\pi}^{PS}$ to be estimated closer to $\bar{\pi}$. At present, there is no such scheme. Now that the danger has passed and public outrage with politicians has somewhat subsided, there is polit-

ical intertemporal inconsistency on the part of the Spanish government to devote resources to preventing or preparing contingency plans for the next accident. This seems a repetition of as, e.g., previous A Coruña harbor accidents.

Lemma 1 *Under the conditions of Proposition 3, we will further suppose that scientific and technical assessment produce an evaluation closer to the true probability of an off-shore catastrophe, i.e.,* $\tilde{\pi}_h^{PS} \simeq \bar{\pi}$.

Then, for sufficiently high negative productivity shocks $\{\theta_h(e_j), \theta_h(e_0, \rho)\}_{h\in H;\ \rho\in\{(1-\bar{\pi});\bar{\pi}(1-\bar{\psi});\bar{\pi}\bar{\psi}\}}$, *there is a threshold* $\breve{\pi}$ *of the probability of an off-shore catastrophe, such that:*
i) If the estimated probability of an off-shore catastrophe is lower than this threshold $\tilde{\pi}_h^{PS} < \breve{\pi}$, *the efficient allocation consists of a decision to send the leaking vessel off-shore, i.e.,* $\left\{\{\tilde{\mu}_h(\tilde{e}_0; \lambda_1, ...\lambda_H, \tilde{\pi}_h^{PS}, \bar{\psi})\}_{h\in H}, \tilde{e}_0\right\}$;
ii) If the estimated probability of an off-shore catastrophe is higher than the threshold, i.e., $\tilde{\pi}_h^{PS} > \breve{\pi}$, *there will be a Galician harbor* $h' \in H_G$ *where the leaking tankship docked, and which receives a compensation transfer from the other harbors, i.e.,* $\tilde{\mu}_{h'}(\tilde{e}_{h'}) < 0$. *That is, the efficient allocation is* $\left\{\{\tilde{\mu}_h(\tilde{e}_{h'}; \lambda_1, ...\lambda_H, \tilde{\pi}_h^{PS}, \bar{\psi})\}_{h\in H}, \tilde{e}_{h'}\right\}$ *for some* $h' \in H_G$.

In the event of a future tankship accident scientific and technical assessment may recommend that politicians offer the vessel safe haven, case ii), enabling this harbor to receive financial compensation from the ITOPF, as well as from the other harbors. This idea approximates that of the "port of refuge," or "shelter haven," as proposed by the IMO (2001) and the European Commission (see González-Laxe et al, 2003a,b,c and Labandeira et al, 2003).

By way of a final comment, we should observe that due to discrete decision-making (entry allowed/entry denied), the efficient allocations resulting from the decentralized equilibrium are a correspondence. That is, several compensation schemes exists by which the decision can be made. The only requirement is that resource transfers made by some harbor must be lower than if the tanker entered its harbor. This might be an advantage from the political implementation point of view, since several distributions of resources provide the conditions for efficient allocation. The following example illustrates this.

Example. Let us suppose that there are only three Galician harbors, $1, 2, 3 \in H_G$ with $H = H_G$. Their cost function is given in Table 1.

			Harbor		
Choice	Allocation	Probability	1	2	3
1	e_1	1	100	50	50
2	e_2	1	50	300	50
3	e_3	1	50	50	300
4	e_0	$(1-\tilde{\pi}^P)$	0	0	0
		$\tilde{\pi}^P$	100	300	300

Table 1: The monetary valuation cost for each of the politician choices and stochastic realizations.

Proposition 2 may be applied straight forwardly. For example, for the equalitarian social planner weights, the threshold $\breve{\pi} = 2/7$ can be found. It is important to note that if a true probability $\bar{\pi} > \breve{\pi} = 2/7$, the efficient allocation with complete markets will be Choice 1, with the vessel placed at $\hat{e}_1$ and monetary transfer inflow for the harbor $j = 1$; i.e., $\hat{\mu}_1 < 0$ and monetary transfer outflow for the harbors $j = 2, 3$. We must observe that, due to the discrete feature of the decision problem, any allocation with $\hat{\mu}_j \in (-min\{250; \theta_j(e_1)Y_j\}, 0]$ with $j = 1$, 2 and $\hat{\mu}_1 = -(\hat{\mu}_2 + \hat{\mu}_1)$ is an efficient allocation.

However, Proposition 2 and 3 show that where the politicians hold a very low stochastic *apriorism* with respect to the true probability, $\tilde{\pi}^P << \bar{\pi}$, the Commission of Crisis Coordination will opt for Choice 4, and then inefficient allocation e_0 will be obtained, despite the possible existence of financial markets.

On the other hand, where politicians receive scientific and technical assessment, Lemma 1 shows that their decisions as to vessel placement and transfers will restore efficiency. This is interesting because, due the discrete feature of the decision problem, politicians posses a menu of optimal allocations. □

4 Conclusion

In this paper we have shown that the Spanish government's decision to refuse the leaking tankship *Prestige* safe harbor in Galiza on November, 13-14 2002, may be understood in the light of economic theory: first due to both domestic and international missing financial markets for pollution accidents, i.e. the nonexistence of any international maritime protocol;

and second, because the Spanish government neglected to consult of scientific institutions to assess possible risk in the event of a catastrophe, and because it misperceived the risks involved in its decisions, consequently hiding from the population information about the possible dangers.

We have studied this using a simple model, where two elements play a crucial role: the ownership of the *property rights* for offering or denying a vessel safe haven, and the politicians *a priori* probabilities of the risks involved in sending the vessel out of sea. If the right to admit the ship belongs to the harbor's political authority, whose *a priori* probability is considered to be zero, we found that sending the vessel off-shore amounts to the equilibrium of the myopic decentralized problem. We were able to determined the Pareto-efficient allocations where, depending on the value of the true probability with respect to a particular threshold, the vessel may or may not be allowed to enter and a suitable compensation scheme for resources Is developed in the case of catastrophe. Finally, the property rights belong to the Spanish government. We arrive at a result for which the vessel will be sent off-shore, if the politicians' *a priori* risk probability is very low, as seems to have been the case in the *Prestige* affair; this result demonstrates that this political equilibrium is inefficient. To support our statement that this was the case, we understood that the Spanish political *a priori* probability originated with the past experience of the Castor accident in December 2000. The maritime protocol implemented at that time was repeated in the *Prestige* case: rescue the crew and send the vessel as far away as possible. Besides, this concurs with politicians' "logic of irrationality," a behavior described in the literature of political science.

Several comments are in order here. First, on theoretical grounds, this paper serves as a warning to integrate politician decision-making into economic theory. There is a long tradition in economic theory that identifies market failures and supports some government intervention to achieve first best or even second best allocations. However, the study carried out in this paper shows that even in the case of no market failure, like missing financial markets, for which economic theory would predict an efficient allocation outcome, the allocations achieved might end up being inefficient because of the way political decisions are made. Moreover, we have been assuming that scientific assessment is solicited and provided from the outset at zero cost. On the contrary, a costly acquisition of information by the au-

thorities, i.e., devoting some public resources to pay for information, gives rise some doubts about the possibility of achieving first best solutions in a decentralized political equilibrium, with respect to the perfect knowledge of the social planner problem.

Second, as a policy recommendation, this is an appeal for an international maritime protocol, which would feature scientific assessment in this kind of situation, ports of refuge,[38] and suitable compensation scheme from those who benefit, all as a way to improve social welfare. In fact, because of heavy maritime traffic close to the Galician coast, the seasonally stormy seas of the North Atlantic, and the experiences of the last decades, it is reasonable to conclude that more accidents, many of them inevitable, will occur in the near future. This warning underscores the need for adopting the necessary measures to be prepared for the next accident. The constitution of a scientific and technical committee for such a contingency seems to be the most logical and easily-attained first step.

Finally, this paper leaves some issues unaddressed. First, there the question of which Galician harbor would have been the most suitable for accepting the leaking *Prestige*; this was the dilemma that the Spanish President, the Vice-President and the Ministry of Transportation put in the Parliament to those crizitising the decision. This issue is left for an empirical study.[39] Second, is the question of whether the Spanish government decisions magnified the catastrophe due to the protocol followed.[40] It could be the case that Spanish government (and then the Spanish harbors) will have to compensate other European harbors, e.g., Portuguese and mainly French, for polluting them in accordance with International Penal Law

Finally, at the theoretical level, further research must be devoted to formalizing some elements that play a role in political decision-making (e.g., voters' lack of confidence, etc.). The *Prestige* affair comprises an extreme case of a democratically-elected government to attend to its citizen's needs, so those elements and policy implementation are easily and sharply identified. An example would be the case of the Spanish government hiding information from citizens in order to minimize the problem and reduce subjective psychological pain, in our notation $v_h(e)$, thus improving social welfare. Such a tactic could be optimal for citizens, who are then are less psychologically stressed with the bad news of a leaking tankship,[41] as well as for the politicians who, if disaster is averted, would maintain credi-

bility with voters.[42] However, this procedure is full of pitfalls, for if things go wrong as in the *Prestige* accident, the more the government tries to conceal information, the less happy citizens are, and they feel deceived by their government,[43] orphaned by their elected political representatives,[44] unsheltered by the State against catastrophe,[45] and social movements and individual initiatives arise aside spontaneously, without the organization of political parties (so that politicians and institutions lose credibility) both to face the catastrophe, and to protest.[46] Analyzing this would require further modelization on the subjective psychological function v_h, and the consequences for efficiency and the political decentralized equilibrium remain open to explore.

As a final comment, it must be said that introducing the vessel into some harbor would have inevitably led to social protest of those affected. Distribution of voters undoubtedly plays some role in t political decision-making. The population wants its politicians to defend its local interests, disregarding whether the decision is socially optimal, unless they is suitable compensation.[47]

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Notes

[1] General economic effects on the Galician economy (De la Dehesa, 2002, and Arias-Veira, 2003), the negative effects on the Galician fishery sector (Doldán-García et al., 2003, Domínguez-Torreiro et al, 2003, García-Negro, 2003, Garza-Gil et al, 2003, Puñal, 2003, or Queipo, 2003), and on other economic activities, like tourism (Pardellas-de-Blas et al, 2003).

[2]For example, Doldán-García (2003a,b), Grandío-Dopico (2003), García-Negro et al (2002), Prada et al. (2003), Prada et al. (2002), Santamaria-Conde (2002), Varela-Lafuente et al (2003), or Vázquez et al. (2003b). It should be observed that the valuation of the damage of pollution has to take into account present and future losses in economic activities (e.g., sea extracting activities and tourism), and use and existence value, as well as the destruction, of the natural environment. This means that a monetary valuation requires some methodology for non-market goods, see Nogueira-Moure et al (2003), and it also rely on Marine Biology studies. (See Barja-Pérez et al, 2003; Bermejo-Barrera et al, 2003; Carballeira Ocaña, 2003; Domínguez-Conde, 2003; Duarte, 2003; Fernández-Pulpeiro et al, 2003; Freire et al, 2003; Mora-Bermúdez et al, 2003; Murado, 2003a,b; Pérez-Cirera et al, 2003; Urgorri-Carrasco et al, 2003; or Vilas, 2003.)

[3]See González-Laxe et al (2003a), García-Pérez (2003) and Vence (2003). However, some institutions consider that, despite the *Prestige* accident, there have been enormous improvements through the decades thanks to successful safety and prevention programs implemented by the industry, sometimes voluntarily and sometimes because of new regulations promulgated by governments through the International Maritime Organization (see ITOPF, 2003, p.1). The results of a study by the US National Research Council (2002) show that the incidence of major tanker spills has decreased dramatically since the 1970s and the amount of oil that reaches the worlds oceans from this source is now relatively low compared with natural and other man-made inputs, particularly via rivers and urban run-off.

[4]After the 1989 Exxon Valdez accident in Alaska, several important accidents happened in Europe (Haven, 1991; Aegean Sea, 1992; Braer, 1993; Sea Empress, 1996; and Erika, 1999).

The U.S. authorities were prompt to harden their regulations, issuing the Oil Pollution Act of 1990 and determining the responsibility of the maritime oil carrier and with no upper limit of compensation. A similar law was proposed by France after the Erika accident in 1999, but slow EU bureaucracy led the European Parliament to approve instead a transition period up to 2015.

[5]See also Glen et al (2002) for a description of the features of the transportation market of fuel and derivatives.

[6] See, Labandeira et. al (2003), Moro (2002), Navaza-Blanco (2002), Nunca-Máis (2003), Parga-López (2002), Rodríguez-Sierra (2002), Santamaria-Conde (2003), Vallejo (2003) or Vázquez, et al. (2003a). In addition, some of these authors suggest complementary economic policies.

[7]Observe that, given that the reduction of the risk on transportation to zero is not realistic, the regulatory requirements to be set in order to reduce the risks of accidents in the future requires a joint effort by engineering, economics and law: it would include technical requirements of the vessels, a clear compensation responsibilities in the case of accident, a penalty scheme and some supervision measures.

[8]A perspective from the law literature can be seen in García-Rubio (2003), García-Rubio et al. (2003), or Martínez-Buján (2003).

[9]This government intervention would include prevention and risk reduction, an emergency plan for limiting damage and reducing loss, and treatment and regeneration toward recovering pre-catastrophe conditions (see Walker et al, 1979).

[10]See the letter published in *Science* by Serret, Álvarez-Salgado, Bode and 419 scientists (2003) (and see also Bohannon et al, 2003, and Fernández-Suárez, 2003). Mr. Serret'scould not be presented to the Spanish Parliament because of the majority veto of the Popular Party (see Comisiones, 2003, pp.22874-81). See, however, Méndez-Martínez et al. (2003, pp.187-193)

[11]See Barreiro-Rivas (2003).

[12]The reports by the American Bureau of Shipping (ABS) (2003a), the Bahamas Maritime Authority (2003) and the French Office for the Research of Maritime Accidents (BEA-Mer) (2003), all criticize the decision. See, also, a strong institutional critique issued by the Committee on the Environment, Public Health and Consumer Policy (2003).

[13] The decision to send the vessel off-shore was defended in the Spanish Parliament by Mr. Aznar, the Spanish President, Mr.Rajoy-Brey, the Spanish Vice-president, and Mr. Álvarez-Cascos, the Ministry of Transportation. They even challenged the opposition parties to designate a Galician harbor in which the vessel should have been docked (see Pleno y Diputación Permanente, 2002b, p.10763; Comisiones Mixtas, 2002, P.2848; and Pleno y Diputación Permanente, 2002c, p.10960, respectively). Moreover, the same decision would be made in a repeat scenario, as reported by the Spanish government (see Senado, 2003, p.48).

[14]See several statements by Mr.Rajoy-Brey to the Parliament (Comisiones Mixtas, 2002, p.2810, 2831; or Pleno y Diputación Permanente, 2002b, p.10787). Notwithstanding, before the vessel sank, there was no technical or scientific report evaluating the status of the punctured vessel, and the set of available alternatives in conjunction with contigency outcomes (including freezing the oil "like a brick," requested by the Delegate of Spanish government in Galiza, November 19, 2002) have never been publicly reported by any Government office.

[15]The economic literature decries the lack of a protocol for accidents (see González-Laxe et al, 2003c, or Labandeira et al, 2003). Despite the lack of resources for preventing or fighting pollution in Spain (see Acinas, 2003, and Acinas et al, 1991), a protocol was designed and tested in June, 2001, following a mock exercise in A Coruña, at the Spanish Atlantic coast. The exercise consisted of an imagined collision 45 miles north, in which a tankship spills oil. However, this protocol was not followed at the time of the *Prestige* accident.

[16] After wandering through calm Mediterranean waters for 35 days without find a sheltered place to effect cargo transfer and repair, the ship was towed to a relatively sheltered spot off the coast of Tunisia where her cargo was safely unloaded. Mr. López-Sors, a maritime engineer, was already Head of the Merchant Marine Office at that time, and he was self-

congratulatory in pronouncing that this was the protocol to be implemented when a vessel is in trouble: first, attend the crew, and then send the ship as far away as possible from the coast (see Cacho, 2002). However, Mr. O'Neil, the IMO Secretary-General, showed his concerns over this incident, which brought to light the question of ports of refuge, and suggested that the IMO should consider the problem globally, adopting any measures to ensure that coastal States review their contingency arrangements to provide disabled ships with assistance (see IMO, 2001)

[17] The "logic of indecision," first used by Barreiro-Rivas (2003), is a somewhat particular reformulation of Buchanan and Tullock (1962)'s "calculus of consent." The latter renders understandable some political decisions whenever the benefits are higher than the costs, as a straightforward use of the rational decision rule (see Frank, 2001, Chap.1); e.g., important concessions by the majority parties to active minorities in order to integrate them into the final democratic consensus. The former focuses on understanding the decision/no decision behavior: whenever active decision-making, as opposed to the alternative no-decision option, yields higher costs than benefits, including the respective benefits and expected costs of the no-decision option, the "logic of indecision" arises. Consequently, we can see why, in some particular circumstances, all political decisions are aimed toward two implicit ends: furthering the problem, and transferring the problem from one government office to another in order to avoid responsibility (see Barreiro-Rivas, 2003).

[18]This fund was created in 1992 by 74 countries within the International Maritime Organization. Its main goal is to supplement compensation paid by the vessel's insurance in the case that this is insufficient.

[19]González-Laxe et al (2003c), Labandeira et al (2003), ABS (2003a), IMO (2001), European Commission, etc.

[20]This section that describes the accident is mainly taken from Bahamas Maritime Authority (2003) and ITOPF (2003). For more technical details see ABS (2003a) and International Association of Classification Societies (IACS) (2003). For a detailed exposition of the events in the Spanish Parliament see the official Spanish government version in Comisiones

(2002a, pp.20927-31), Comisiones Mixtas (2002, pp.2809-10), Pleno y Diputación Permanente (2002a, pp.10503-4), and for critical version of the opposition parties, see Pleno y Diputación Permanente (2002b, p.10782-4). For a more journalistic and less technical depiction of the events see De Toro (2003), Díaz et al (2003), and Gómez et al (2003).

[21]Currently, there does exist a supranational office of the European Union that issues maritime law within the EU, but with no capacity to take decisions concerning European maritime coasts.

[22] For example, the Merchant Marine Office, under the Ministry of Transportation, in Spain, or the Delegate of the Ministry of Environment, Transport and Regions of the United Kingdom (see Acinas, 2003).

[23]In fact we are assuming a discrete distribution of the negative productivity cost θ_{ke_j}. Some other assumption as to the distribution function may be considered more realistic, such as a distance basis for harbor h or the location of harbor h's fishing activities.

[24] A strictly positive value could be considered. However, as far as we undertake the assumption that if the vessel enters its harbor it is reasonable to assume that a harbor will experience the greatest damage, i.e. $\theta_h(e_h) > \theta_h(e_0, \pi)$, the results presented below will not be affected.

[25] The literature usually considers g linear, but convexity may be assumed, as well.

[26]Notice that the opposite means that for a low enough level of the probability π, the optimal decision is to send the vessel off-shore. This is the case, for example, when the probability that no accident will occur is quite high, i.e., $\bar{\pi}$ close to zero.

[27]According to the Spanish Law "Puertos del Estado y de la Marina Mercante" 27/1992, article 87.

[28]One month after the accident, it was still not clear who made the decision (see Mr.Rajoy-Brey statement in Pleno y Diputación Permanente, 2002b, p.10792). Later it was learned that the decisions in the case of the *Prestige* were made by the Commission for Crises

Coordination, created on November 14 at 5:00AM (see Comisiones Mixtas, 2002, p. 2811), and constituted by the Delegate of the Spanish government in Galiza (Mr. Fernández-De-Mesa), the Head of the Merchant Marine Office (Mr. López-Sors), and its delegate in A Coruña, the Capitán of A Coruña Harbor Headquarters (Mr. Del-Real). These decided, with the acquiescence of the Minister of Transportation, Mr. Álvarez-Cascos, to send the vessel as far away as possible. See Comisiones (2002b, p.21246).

[29]Two facts reinforce this argument. First, there exists no international financial markets by which a Galician harbor can appropriate benefits from, say, French Atlantic harbors. Second, although *Prestige*'s path after being forced off Galician coast would seem erratic, see Picture 1, the Spanish officials at the Commission for Crises Coordination in fact tried to transfer the problem to the Portuguese maritime zone, as announced by Mr. Fernández-De-Mesa on November 15. This is further indication of the "logic of the indecision" pointed out by political science authors (Barreiro-Rivas, 2003).

[30]This fund was created after the Erika accident off the Brittany coast in 1998, and it has a cap of 180 million euros. The ITOPF took 5 to 8 years to pay victims off the previous accident in A Coruña, the Aegean Sea on 1995.

[31]Some of these arguments for justifying the decision to send the vessel off-shore were presented by Spanish Vice-president Mr. Rajoy-Brey to the Spanish Parliament (see Comisiones Mixtas, 2002, p.2810 and Pleno y Diputación Permanente, 2002b, p.10787).

[32]Maritime biologists strongly criticized this decision (see Serret et al, 2003) as did technical reports by ABS, Bahamas Maritime Authority, BEA-Mer and ITOPF. In addition, there was a strong institutional critique issued by the Committee on the Environment, Public Health and Consumer Policy. By way of example: "There is little doubt that the ultimate failure of the hull structure and subsequent sinking of the *Prestige* can be attributed to six days of additional dynamic sloshing inside the structure and external wave impact on the damaged structure while the vessel was adrift or under tow in the open ocean," ABS (2003a, p.i); "Eventually, the determining factors of the disaster could be as follows: [among others,] keeping the ship at sea in extreme conditions for another six days following the initial

damage," BEA-Mer (2003); "It is arguable that if it had been possible to allow the *Prestige* access to a safe haven for lightering, the total spill volume would have been restricted to the initial loss, thereby limiting the extent of the coastline affected," ITOPF (2003, p.2); "[I]f decisive action had been taken at an early stage to move the ship to a more sheltered location, the ship and its cargo would almost certainly have been saved and any pollution would have been minimal," Bahamas Maritime Authority (2003); or, the Committee on the Environment, Public Health and Consumer Policy (2003) "[d]eplores Spain's decision to tow the Prestige out to sea, whereas a decision to bring it into calm waters (and even into a safe haven) would have made it possible to contain and limit the extent of a disaster which was clearly going to happen."

[33]See Cacho (2002) and Barreiro-Rivas (2003).

[34] On December 31, 2000, the *Castor*, a vessel filled with inflammable cargo, underwent an accident just off of Almería, on the Spanish Mediterranean coast. After the crew was rescued, the vessel was forced to move off-shore. It wandered the calm Mediterranean waters for 35 days without finding a shelter to effect cargo transfer and repair, before it was towedTunisia, where her cargo was safely unloaded. Mr. López Sors was already Head of the Merchant Marine Office at that time.

[35]The Delegate of the Spanish government in Galiza, Mr. Fernández-De-Mesa, periodically offered several bogus scientific arguments from November 14-20, 2003. These made apparent the lack of academic assessment, but were made with the strong assurance that nothing would happen. For example: "The heavy fuel of the sunken Prestige will solidify due to the low temperatures and will remain there forever" November 19, 2003; or "The fuel will become frozen as a brick."

[36] Interestingly, an argument displayed by those who support the no-entry decision is that all Head of Semen Guild at each of the Galician harbors agreed with the decision, and by no means they would accept the ship's being admitted their harbor (see Díaz et al, 2003, p.140). On the contrary, this reinforces our thesis that the political equilibrium is closer to the free-rider solution of the myopic decentralized equilibrium, besides showing up the lack

of knowledge on economic theory of those proposers.

[37] The Government should designate funds for preventative and mitigating resources (to build a refuge harbor, to maintain assistance vessels, etc.). This would improve the economy of the harbor where these preventative measures are taken... which might also be a hard political sell.

[38] The location of the selected port would not be a trivial one, again because of political pressure. The problem of redistribution between harbors would have to be faced. (For example, a headline could read in the Faro de Vigo newspaper: "The Port of Vigo will lose business if a port of refuge is built close to A Coruña.")

[39]However, see Comisiones (2002b, p.21246) for some technical opinions and arguments for docking the Prestige in the harbor of A Coruña.

[40] It is not clear whether responsibility for this way of decision-making process is to be restricted to politics (and, in the end, how citizens vote), or if it has some additional implications. Indeed, members of the Committee of Crises Coordination may be sued for not requiring scientific and technical assessment in making their decision, if ABS (2003b) is right. In a tough response to the Government of Spain's suit against ABS, and seeking recovery of any claims made against the classification society for damages arising from the *Prestige* casualty, ABS "alleges that the Governments decision to deny the vessel access to a place of refuge was a clear violation of its legal duty and that the Government acted recklessly, negligently and grossly negligently in its response to the casualty. [...] Spain should reasonably have foreseen that its actions, including assuming control of the vessel, refusing the request for a place of refuge or to move the vessel to a location where the cargo could have been off-loaded, and ordering the vessel away from the coast in deteriorating weather, could cause pollution in the sovereign territories of the Republic of France, the Kingdom of Spain itself, and other potentially affected areas which may include Portugal and the United Kingdom. ABS contends such wrongful acts of the Kingdom of Spain were the sole cause of any damage alleged in the complaint, as well as injuries which may have occurred elsewhere. These actions [...] were in direct violation of the Governments duties

under applicable law, including the UN Convention of the Law of the Sea (UNCLOS). [T]he actions taken by the Spanish Government directly contravened its obligations under the 1989 Salvage Convention, to which Spain is a signatory." ABS (2003b)

[41] Again, past experience led the political way for the Government in the case of the *Prestige*. In November, 2000, the first case of Mad Cow disease sprung up in Galiza, but the Government minimized information so that the expected sharp drop in consumer confidence in meat products would not occur.

[42]Many examples can be given. "It is most likely that the fuel will not reach the coast," Mr. Fernández-De-Mesa, Delegate of the Spanish government in Galiza, 14 November; "The most severe danger has passed," Mr. Fraga-Iribarne, President of Galiza, 15 November; "Thanks to the rapid intervention of the Spanish authorities to move the vessel away from the shore, we do not fear an ecological catastrophe," Mr. Arias-Cañete, Minister of Agriculture, 16 November; or, "I think that some of these warnings are less than justified," Mr. Aznar, Spanish President, 27 November.

[43] The difference between the *Prestige* affair and the Mad Cow outbreak was that citizens could not monitor what was happening on private farms, while it was very easy to visit the coast and witness the effects of the disaster. The fact that what citizens saw contrasted with what the Government reported increased their irritation. For example, Government politicians were afraid for weeks to call the spill a "black tide," trying to minimize the catastrophe, while citizens themselves experienced the massive pollution covering the shores. "We cannot call [the spill] a 'black tide'; there are disperse black spots," said Mr. Lpez-Sors on November 17; or, "It '[the spill] affects an extensive part of A Coruña, but it is not a black tide," and "It is not a black tide, but isolated spots," Mr. Rajoy-Brey affirmed on November 23. This continued up to December 5 when Mr. Rajoy-Brey spoke to Parliament, see Comisiones Mixtas, 2002.

[44]For example, the Spanish Ministers involved, as well as the Galician President, last for long to visit the area, and the Spanish President waited for one month. In addition, on the weekend after the accident, 16-17 November, several Ministers involved (included of

Transportation and Environment), as well as the Galician President, went hunting. Although first they denied this, finally they had to recognize it.

[45] Due to government hide information to citizens, they kept informed by other foreign sources of information (mainly the French CEDRE, and the Portuguese Instituto Hidrográfico) to collect news about the evolution of the catastrophe. Even more, the Spanish official information (e.g., "The tide will not reach the Rías Baixas," Rajoy-Brey, 21 November), delayed the preparative to defend against the black tide, so that without government aid seamen and women from Rías Baixas (firstly Ría de Arousa and later in Ría de Vigo) shipped towards the entrance of the harbors to collect oil with own-invented stuff and even with their own hands on 3-4 November.

[46]The social movement Nunca Máis, created on 1992 after the Aegean Sea catastrophe, took its importance this time to fill the gap left by the official and political institutions. Nunca Máis gathered all the protests, call for demonstrations, sue government politicians, etc. Even the Center Intelligence Agency (CIA) (2003) considered that this was a "political group of pressure" in Spain. The Spanish government politician tried to reduce its popularity, and Nunca Máis was sued although nothing was proved. (This can be understood since in democratic societies, politicians have the monopoly of the citizens' representation of needs, as they are elected democratically by them. No one choose Nunca Máis leaders instead.) Wrongly estimation of the true probabilities should include this kind of social feelings and events.

[47]The idea of the Plan Galicia seems to go in this line, to restore confidence on the Spanish government in exchange of public monetary transfers (See Álvarez-Cobelas, 2003, and Faíña, 2003).