Economía Agraria y Recursos Naturales. ISSN: 1578-0732. e-ISSN: 2174-7350. Vol. 13, 2. (2013). pp. 103-126

Environmental accidents and stigmatized fish prices: Evidence from the Prestige oil spill in Galicia

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ABSTRACT: Assessing the economic damages and their temporal dimension caused by oil spills is very important. In the present paper, we analyze the stigma effect caused in fish markets, in the North West coast of Spain (Galicia) after the Prestige oil spill. Specifically, we focus on pelagic fish species which represent a relevant market share in Galicia. The results show that printed media surrounding the accident had a statistically significant role in the evolution of fish prices. Two types of stigma were found: temporal and geographical stigma. Our results conclude that there is persistence of environmental effects after the spill.

KEYWORDS: Economic damages, fisheries, Galicia, hedonic prices, Prestige oil spill.

JEL classification: Q51, C23.

DOI: 10.7201/earn.2013.02.05.

Accidentes ambientales y precios de pescado estigmatizados: Evidencia del vertido de petróleo del Prestige en Galicia

RESUMEN: La evaluación y dimensión temporal de los daños económicos provocados por vertidos de petróleo es muy importante. En este trabajo, se analiza el efecto del estigma en los mercados de pescado en la costa Noroeste de España (Galicia) tras el vertido del buque Prestige. Este trabajo se centra en las especies de peces pelágicos, que representan una importante cuota de mercado. Los resultados muestran que las noticias publicadas han tenido un papel estadísticamente significativo en la evolución de los precios. Hemos encontrado dos tipos de estigma: temporal y geográfico. Esto evidencia la persistencia de los efectos medioambientales después del vertido.

PALABRAS CLAVE: Daños económicos, pesquerías, Galicia, precios hedónicos, vertido de petróleo del buque Prestige.

Clasificación JEL: Q51, C23.

DOI: 10.7201/earn.2013.02.05.

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Recibido en julio de 2012. Aceptado en octubre de 2013.

1. Introduction

Assessing the economic damages (and their corresponding temporal length) caused by oil spills is important for multiple reasons. First, it may provide ex-post answers related to the adequate amount of compensation when liability issues are at stake. Further, it may also be used as an important decision-making tool when assessing the optimal level of protection that should be employed in marine safety to avoid future similar disasters. In this context, the impact, evolution, and duration of stigma posterior to a spill have significant economic implications (see McCluskey and Rausser, 2003).

Stigma has become a popular concept of study in social sciences. It is associated with risk perceptions towards technologies, places, or foods. These negative perceptions are mainly reflected by lower prices or lower demand levels, which are usually connected with the discovery or perception of a hazardous episode. An important amount of literature deals with stigma episodes linked to real estate markets (see Dale *et al.,* 1999; Kiel and McClain, 1996), although literature related to the study of stigma in other fields is also growing (including labor markets, physical appearance, divorce, crime, etc.).

Currently, in order to compensate economic losses caused by oil spills occurring in international waters, it is necessary that there is a "reasonable degree of geographical and economic proximity between the contamination and the loss or damage sustained by the claimant" (see IPIECA/ITOPF, 2000). In the present paper, we investigate the presence of the stigma effect caused in fish markets in the North West coast of Spain (Galicia) after the Prestige oil spill. Our results show clear evidence of the presence of stigmatized prices after the spill. Furthermore, the obtained results also show that printed media surrounding the accident have played a statistically significant role determining fish prices, and thus, amplifying the social risk. On the light of these findings, we claim that in addition to direct market losses (caused by fishing bans imposed after the spill), stigma effects should be analyzed through historical data to have a complete assessment of the total damages caused by large oil spills to fisheries.

The current paper is divided into the following sections. First, we present a brief description of the Prestige oil spill and its effects over the local multi-species fisheries in Galicia. Then, it follows a literature review of stigma effects linked to food contamination episodes, continuing with the data description and analysis. Finally, the results and policy implications are presented.

1.1. The Prestige oil spill: Magnitude of the accident

The Prestige oil spill has been the most serious environmental catastrophe experienced in Spain. It began in November 2002 and it affected the Atlantic coasts of Portugal, Spain and France; although most of the oil impacted the continental shelf and coastal areas of Northwest Spain, mainly Galicia (see Map 1). On November 13, 2002, the single-hull 26 year-old oil tanker, Prestige, suffered a serious accident just 46 kilometers away from the Fisterra Cape in Galicia. Six days after the accident, and after traveling without a clear direction in front of the Atlantic coast of Galicia, the Prestige sank 222 kilometers away from mainland after splitting in two during a storm. On its way to the bottom of the sea, it spilled more than 60,000 MT of oil, polluting more than 1,500 kilometers of coastline (see Loureiro *et al.,* 2006). During the next four months after its sinking, oil was still leaking from its tanks and kept arriving to the local coasts. The most affected area was *The Death Coast* (Costa da Morte) in Galicia. This area was heavily exposed to the oil spill, and it is considered as the ground zero area. Putting these magnitudes into historical perspective, the highly publicized Exxon Valdez lasted about two months and polluted about 1,000 kilometers of coastline.

Many studies have been published showing that oil spills affect directly and negatively the resources of the area in which they occur. The Exxon Valdez spilled on the coast of Alaska in 1989 around 42,000 MT of oil. This spill affected especially commercial fishing areas and its consequences have led to significant ecological damages. Economic damages in fish markets were also very important, suffering larger losses during the two years following the spill in an amount around $155 million (see Cohen, 1995). The most recent and largest spill is the *Deepwater Horizon*, spilling around 1.7 to 3 million barrels of crude in the Gulf of Mexico from April 20 to June 2010 (see Brown, 2010). Taking into account the scale per gallon used to estimate the damages of Exxon Valdez, the Deepwater Horizon oil spill damages could reach an estimate between $105 billion to $239 billion, including natural resource damages and economic damages to private parties (see Krupnick *et al*., 2011).

Some studies had been conducted to estimate the direct economic damage caused by the Prestige oil spill in Galicia. Short-term estimates of direct economic damages caused by the Prestige oil spill were estimated around 774€ million (in prices 2006), (see Loureiro *et al.,* 2006). However, when adding environmental damages to this short-term estimate, total damages duplicate (see Loureiro *et al.,* 2009). At the moment, no studies related to the Prestige oil spill have been conducted which have taken into account the effects caused by possible stigma on fresh fish markets. Therefore, at the present time, the total economic damages caused by the Prestige oil spill still remain unknown, although there is a clear evidence of short-term economic and environmental effects, as well as other mid-term lasting consequences. In this paper, we assess just one of the multiple aspects of the impacts caused by this spill linked to its length and ex-posts effects on fish prices.

1.2. Previous studies

The stigmatization of places and products often results in losses of assets´ value due to growing consumers concerns about hazards of the products and the impact of its consumption on human health. Relationship between stigma and the decline in consumption of products has been shown previously in different studies. Rosen (1990) studied the effect of the Alar scare on apple demand. Mitchell (1989) studied the case of Tylenol poisoning in Johnson & Johnson Company, causing a $1.24 billion wealth decline (14 percent of the forecasted value of the company) due to the depreciation of the company brand name. In addition, there is evidence that markets react to news regarding environmental quality information (see Gupta and Goldar, 2005; Hamilton, 1995). As is well known, market reactions to risk-related information can have serious economic consequences for private business involved in the production process or for the entire productive sector. In this sense, it is necessary to pay special attention to the importance of the risk amplification process through mass media, for example newspapers (see Chung, 2011).

A large number of previous studies have assessed the impact of news surrounding pollution or contamination episodes (see Flynn *et al.,* 1998; Henson and Mazzocchi, 2002; McKenzie and Thomsen, 2001; Powell, 2001; Salin and Hooker, 2001; Wessells *et al.*, 1995). Specifically the role of negative TV coverage and advertising expenditures on meat consumption was studied in Belgium during 1995-1998 (see Verbeke and Ward, 2001), a period in which mad cow disease became very relevant on the media. This study showed that the impact of TV positive advertising had a perverse effect on beef/veal expenditures, shifting consumers toward other kinds of meats, such as pork.

In the case of large environmental accidents, such as oil spills, the first attempt made to estimate the impact of the accident on the market of biological resources was conducted by Cohen (1995), who analyzed the effects of the Exxon Valdez oil spill on Alaskan salmon and shellfish, concluding that the accident caused large losses. The current study adds to the above literature, analyzing the effects of the Prestige oil spill in a traditional multi-species fishery. From the multiple commercialized species, we analyze the markets of the most important pelagic fish species (open sea species). We employ a hedonic spline regression to model fish prices, including as explanatory factors other variables linked to the theory of social amplification of risk (see Kasperson *et al*., 2000), and the impact of news surrounding the oil spill. The information channels may amplify risk events in two ways: “Intensifying or weakening signals that are part of the information that individuals and social groups receive about the risk; or filtering the multitude of signals with respect to the attributes of the risk and their importance” (see Kasperson *et al*., 2000; pg. 237).

2. The Galician fishery sector: Data description

2.1. The Galician fishery sector

The Galician fishery sector, -which includes activities related to extractive fishing, shell fishing, aquaculture, canning and freezing industries- still is one of the most important economy sectors of this region. The social dependence of fishing is especially important in several municipalities of the Galician coast as Ribeira or Illa de Arousa where this sector generates between 30% to 60% of the local jobs, respectively. According to data from the Government of Galicia, the extractive, aquaculture and transformer sectors together generate about 38,000 jobs approximately, representing 52% of total employment in this sector in Spain and 10% of the EU fisheries employment. Moreover, in 2008, the turnover of Galician fisheries and aquaculture reached about 1,000€ million, being 44% of this value generated by high seas fishing, 19% by coastal and artisan fisheries, 6% by shell fishing and 31% by aquaculture. Extractive annual production of this region represents in terms of value, 15% of the EU leadings, which is well above the joint production of Germany, Belgium, Finland, Greece and Sweden (see Xunta de Galicia, Consellería do Medio Rural e do Mar, 2013a).

Specifically, looking at the statistics of the Autonomous Community of Galicia, we find that extractive fishing is the most important practice regarding the quantity of kilos sold in the fishery sector; even more important than shellfish. This occurs because in the years analyzed more than 75% the quantity traded comes from extractive fishing. However, when turning our attention to trading values in economic terms, this figure declines to 53%. Despite of the economic importance of the shellfish sector, our study focuses on the evolution of the price of commercial fishes, in particular pelagic species. One of the main reasons for selecting fish rather than shellfish is to avoid the effects of shellfish closures throughout the year caused by many different reasons[1]. In the case of fish, we encounter the high and low fishing seasons. The main difference between both is that the optimal harvest period is during the high season, or period in which the fish achieves an optimal size.

2.2. Data description

The data used in this study are original, and come from various sources. In order to assess the relationship between media coverage and price fluctuations, an original dataset has been constructed containing all printed news about the Prestige oil spill between November 2002 (accident time) to 31st December 2006. This daily media dataset has been linked with the fish prices and quantities datasets obtained from daily fish sales at the Galician ports.

2.2.1. Media coverage database

This database has been created collecting all news from four major newspapers; three of these are the most national widely read newspapers in Spain: *"El País"*, *"El Mundo"* and *"ABC"*, while the forth is the most read in Galicia *"La Voz de Galicia"* according to data published by the annual media study or EGM (Estudio General

[1] These reasons can be related to the occurrence of "red tides" caused by toxin concentration or other periods to preserve and grow shellfish stocks, among others.

de Medios). Moreover, and in addition to their importance, the selected newspapers cover also the entire political spectrum from left to right ideologies. In this way, the printed media reflect the various points of view about the event. The sample period selected for the news coverage ranges from 11th November 2002 (day when the news about the spill began) to 31st December 2006. Graph 1 presents the average daily readers per year from each of these newspapers, taking into account the information provided by AGM (2002-2006).

According to Graph 1, *"El País"* is the most read non-sport newspaper in Spain. During the period of analysis, it has a daily average circulation of 391,816 copies and, *"El Mundo"* is the second most important newspaper with a daily average circulation of 300,174 copies. It follows *"ABC"* with a daily average circulation of 256,650 copies, and the regional newspaper "*La Voz de Galicia*", with a daily average circulation of 102,859.

Each of the articles has been recorded individually, taking into account that on the same page several articles could be reported about the spill. In the following analysis, we are going to consider the total number of news published every day[2] in the group of the selected newspapers. To compute the total news we have used data from the AGM´s study in order to enhance the impact of those newspapers that have a greater number of readers nationwide.

The total number of lagged news has been computed as follows:

$$Total\ news_t = \sum_{x=1}^{4} Number\ of\ news\ published\ on\ each\ newspaper\ X_{t-1} * Weight \qquad [1]$$

where X indicates the code number of each newspaper[3].

2.2.2. Fish prices and quantities database

The fishing fleet with port in Galicia is the most important of all regions of Spain and Europe, so that Galicia is classified as a region being highly dependent on the fish sector. In fact, in 2010, Galicia owned about 40% of the Spanish ships (see Xunta de Galicia, Consellería do Medio Rural e do Mar, 2013a). The relative importance of the Galician fishery sector in both Spain and EU, justifies the need for evaluation of the effects caused by the Prestige oil spill on some species.

The data used in this study come from the electronic platform of the Galician Ministry of Rural Affairs and the Sea (Pesca Galicia Database, 2000-2006). It contains the official fish statistics and daily records published by the regional government of Galicia. The sample period extends from the very first day in which data were collected (1st January 2000) until 31st December 2006.

[2] This variable was lagged to take into account the news published the day earlier may have an impact on the day after.

[3] Weight X = % distribution of newspapers, which was calculated based on the number of readers of these newspapers. This information was gathered from AGM.

We use the fish market classification provided by the Galician government that aggregates the 80 local fish markets in the following geographical areas: Vigo, Pontevedra, Arousa, Muros, Fisterra, Costa da Morte, Cedeira, Mariña and Coruña-Ferrol (see Map 1). This classification by geographical area allows us to assess the potential impact linked to stigma, differentiating between the ground zero area (Costa da Morte) and other surrounding areas. Due to the large number of species and daily observations of each fish market, we decide to focus the study on the most important species in Galicia in terms of trade volumes. Specifically, in this study we focused on the evolution of the prices of the following pelagic fish species: *Sardine, Atlantic mackerel, Horse mackerel, Hake, Whiting and Swordfish.* We select these species because they are always among the top 20 of quantity and trade values in the Galician fishing yearbooks between 2000-2006. Moreover, these species represent nearly 60% of total commercial value of fish trade and about 73% of quantity in kilograms of our sample period.

The explanatory variables are related to the media effect, earlier described, and additional seasonal variables which include the seasons of the year in order to catch the high and low fishing periods for each fish species. The high seasons vary across the species and these can be described as follows. The *Sardine*´s high season is from May to October; the *Atlantic Mackerel*´s is from February to May and also December; the *Horse Mackerel*´s is from April to October; the *Hake*´s from April to July; the *Whiting*´s from March to June and also November-December and finally the *Swordfish*´s is from April to November (see Xunta de Galicia, Consellería do Medio Rural e do Mar 2013b)[4]. As we can observe, most fish species analyzed have a common high season, which in most cases covers to a greater or lesser extent, *Spring*, *Summer* and *Autumn*. And the low season for practically all of them is *Winter*. As such, we may expect to find seasonal effects in our regression. Additional variables such as the different fishing arts were also considered. Following McConnell and Strand (2000), we took into account the different fishing arts in order to assess if one art may be more punished in terms of price reductions than others due to the techniques employed when fishing, but the effects were not statistically significant for any of the arts; and as such these were dropped from the final specification.

We may expect that our data suffer some structural breaks, potentially due to the Prestige oil spill. These phenomena appear as unexpected shifts in the time series, which in our case may be produced by the pollution episode and its respective media coverage. In general, when a priori we face unknown breaks in our data, it is common to use the cumulative sum of errors to the square test (CUSUM-sq) to examine the constancy of the coefficients of the model over the entire period. This technique was developed by Page (1954) and is commonly used for monitoring change detection. Using a graph of cumulative sum of errors to the square, we discover the structural breakpoints of our sample. The basic idea of this graph is to represent for each observation, x_i , its mean deviation objective $(x_i - \mu)$, and to accumulate these deviations from the beginning to the current instant:

[4] Available at: http://deondesenon.xunta.es/es/. Accessed October 13, 2013.

$$S_t = \sum_{i=1}^{t} (X_i - \mu) \quad [2]$$

If the process is under control, the differences around the mean $(x_i - \mu)$ are small positive or negative values around 0. For this reason its sum must be a value close to 0. However, if the process is out of control, the cumulative sum must be a large value different from 0, showing a structural break due to a change on the slope.

Samples from a process are assigned weights, w_t and summed as follows to detect the upper and lower limits of control:

$$\begin{cases} S_o = 0 \\ S_{t+1} = \max(0, S_t + x_t - w_t) \\ S_{t+1} = \min(0, S_t + x_t + w_t) \end{cases} \quad [3]$$

An important aspect of this study is that our data contain several important periods with respect to the history of the Prestige oil spill. For this reason, we investigate the existence of structural breaks using the CUSUM-test. In order to analyze the duration of stigma and its evolution over the years, the CUSUM test reveals that the data cover 4 important periods, which can be denoted as event-driven time periods, which according to the results provided by the structural break test can be described as follows (see Graph 2). Period 1 counts from the first day of our database until 13th June, 2003. This period contains observations before and after the Prestige. Due to the fishing bands, fish markets were not fully reopened until June 2003, and it was at that moment when a change on the price trajectory became very relevant. Period 2 covers the dates ranging from the 14th June 2003 until 19th February 2004, being these the periods in which there were more news about the event. Period 3 covers from 20th February 2004 to 16th June 2004, a period of additional cleaning operations. And finally, period 4 covers the dates after 17th June 2004 until 31st December 2006. In 2004 and 2005 there were some small cleaning operations, especially in the rocks and cliffs, while the cleaning was completed in 2006.

Tables 1 and 2 show the complete definition and summary statistics of each of the variables included in our regression. After the removal of extreme values or outliers[5], we have a total of 164,524 observations. About 24.12% are from period 1; 13.37% from period 2; 6.70% from period 3 and the remaining 55.81% observations correspond with period 4. The average sale price[6] for the selected pelagic fish species for the entire period is 2.61€/kg and the mean of total weighted published news on the

[5] Grubbs test for outliers is a statistical test to detect abnormal values in a data set that are supposed to come from a normal distribution.

$G = \frac{max_{i=1,\dots,N}|Y_i - \bar{Y}|}{s}$, where $\bar{Y} = mean \;\; s = Standard\ desviation$.

[6] Prices were deflected to 2001 using the Consumer Price Index (CPI) from the National Statistics Institute of Spain.

day before is 0.8059. Regarding the price transactions 13.32% of our observations are from the area of *Vigo*, 14.94% from *Pontevedra*, 16.42% from *Arousa*, 7.55% from *Muros*, 4.21% from *Fisterra*, 10.99% from *Costa da Morte* (ground zero), 4.67% from *Cedeira*, 13.36% from *Mariña* and the remaining 14.54% from *Coruña-Ferrol*. Regarding the seasons, 20.98% of our observations are from *Winter*, 29.17% from *Summer*, 25.15% from *Spring* and 24.70% from *Autumn*. As we expected, *Winter* (which coincides which the low season of fishing in most of our analyzed species) has less observations than the rest of the seasons. Regarding the species distribution and its fishing arts, Table 2 contains this information. As we can see, 13.22% of our observations are form *Sardine*, 17.34% from *Atlantic Mackerel*, 23.39% from *Horse Mackerel*, 31.42% from *Hake*, 12.46% from *Whiting* and the remaining 2.17% from *Swordfish*. Finally, the fishing art more used is *Trawling fishing* (66.94%) followed by *Seining fishing* (30.40%), and finally *Longline fishing* (2.16%).

Price differences between mean prices per species before and after the Prestige oil spill are shown in Tables 3 and 4. These both tables show that prices are statistically different and higher for the series of period 1 which covers dates before the accident until the end of most fishing bans. In addition, this difference is statistically significant in most cases at the 99% significance level. Thus, it is observable that this decline on prices was not temporary, remaining over time and for most of the analyzed species the average price does not recover during the time of study to levels prior to the accident. Table 5 presents the variation rate of prices, focusing on those which decreased in a statistically significant way. We present this analysis in order to check differences between lower end and high end-price species. It is interesting to note that some of the most popular and sold species in Galicia, such as *Sardine, Horse mackerel* or *Atlantic mackerel,* which are fairly cheap, suffer the biggest reductions in prices, reaching price drops over 40% of their initial values. These species are quite important, representing about 15% of the total trade value of the sample period, and usually are in the top 6 in terms of both; number of kilos discharged and total fish trade value in this area. Graph 3 presents the evolution of the average price of analyzed pelagic species. In this Graph 3 we can observe that the mean price of all pelagic species decreased from 2.84€/kg in period 1 to 2.44 in period 2 (first of post-spills periods). This decreasing trajectory remains in period 3 when the mean price is 2.39€/kg, while in period 4 there is a slow recovery of prices, achieving 2.58€/kg. In this graph we appreciate that in the first months after the Prestige oil spill (between November 2002 and June 2003), mean price suffers little variations due to fishing bans above all. The same evolution is presented just only for the *Horse mackerel* in Graph 4, given that this is one of the most representative fish species of Galicia. The effect of the Prestige oil spill on these species is very significant, observing a very drastic reduction on its price, from an initial value of 1.33€/kg in period 1 to 0.80€/kg in period 2, which represents a reduction of 0.53€/kg (or 40.17%). We observe that in periods 3 and 4, the mean prices experience a recovering but do not get to reach their initial levels.

3. The model

One of the techniques used for the monetary valuation of environmental goods and services is the Hedonic Price Model (HPM). This model relates the price of a good or product to each of its attributes. Each attribute can affect the price of the good positively or negatively, depending on consumers´ preferences.

The general form of the model is:

$$P_i = f(x_{1i}, x_{2i}, \dots, x_{mi}) \quad [4]$$

Empirically, we can write the expression [4] as follows:

$$P_i = d_0 + d_1 x_{1i} + d_2 x_{2i} + \cdots + d_m x_{mi} + \varepsilon_i \quad [5]$$

Where P_i is the price of fish, x_{1i} are the arguments of the function *f* in expression [4] and ε_i is a random error.

As in the estimation of traditional hedonic models, the selection of a proper functional form, linear or semi-log (natural logarithm of the dependent variable), is crucial (see Rosen, 1974). A linear specification has the obvious interpretation that a unit increase in an explanatory variable causes the price to raise by an amount equal to the coefficient; while with a semi-log specification, the coefficients can be interpreted as percentages of the average price. The following Box-Cox transformation of the dependent variables was used on the full data set to choose between the linear or natural logarithmic forms for the dependent variable only.

$$p(\lambda) = \begin{cases} \dfrac{P^{\lambda} - 1}{\lambda}, \lambda \neq 0 \\ ln\lambda, \quad \lambda = 0 \end{cases} \quad [6]$$

Using Box-Cox maximum likelihood analysis, λ was estimated. A value of λ=0 implies that a semi-log specification should be chosen, and λ=1 indicates a linear form is best. Confidence intervals for λ were also estimated. The hypothesis that λ =0 could not be rejected at the 95% confidence level for any of the structural models. Therefore, based on this analysis of functional form, the log-linear specification of the hedonic price equation is used in our analysis.

Because the accident took place in 2002, it makes sense to think that during the period of analysis, the slope of the regression could suffer some variations to respond to the earlier described changes. Therefore, and with the objective to reflect the effect of the oil spill on prices, we use in our estimation a linear regression via *spline*. *Spline* models are also called *"piecewise regressions"*. These spline models can be viewed as models of dummy or binary variables with one or more constraints, which are used to model the jump on a particular variable. Using a CUSUM test, we found statistical evidence that there exist structural breaks on prices, which divide the sample in the 4 periods earlier described. These models contain several explanatory variables defined for all the segments and a dependent variable, which is a function of the explanatory variables, defined in all segments but with different slopes (see Marsh and Cormier, 2001).

The spline regression is represented as follows:

$$P_i = a + bT_i + cD_i(T_i - T_1) + df(x_{1i}, x_{2i}, \dots, x_{mi}) + \varepsilon_i \qquad [7]$$

Where P_i is the dependent variable, T is the variable that accounts for the time through the years of the series, D is a dummy variable that takes the value 0 in the pre-spill period for the regression and 1 in the post; T_1 is the number corresponding to the period when the change occurs, so that $D\ (T_i - T_1)$ is a count of time since the change occurs; a is the constant term; b, c and d are the corresponding coefficients of the regression slopes. In addition, $f\,(x_1, x_2, \dots, x_m)$ is the function of explanatory variables to model the price attribute and ε_i is the error term of regression.

3.1 Empirical estimation and relevant hypotheses

In order to assess the evolution of prices and analyze whether a stigma effect may be present, we model equation [7] with the following empirical functional form:

$$\begin{aligned} logprice_i = {} & \beta_1 period\ 1_i + \beta_2 period\ 2_i + \beta_3 period\ 3_i + \beta_4 period\ 4_i + \beta_5 Lagged\ News \\ & + \beta_6 Vigo_i + \beta_7 Pontevedra_i + \beta_8 Muros_i + \beta_9 Fisterra_i \\ & + \beta_{10} Costa\ da\ Morte_i + \beta_{11} Cedeira_i + \beta_{12} Mariña_i + \beta_{13} Coruña\ Ferrol_i \\ & + \beta_{14} Sardine_i + \beta_{15} Horse\ Mackerel_i + \beta_{16} Atlantic\ Mackerel_i \\ & + \beta_{17} Withing_i + \beta_{18} Hake_i + \beta_{19} Spring_i + \beta_{20} Summer_i + \beta_{21} Autumn_i + \varepsilon_i \end{aligned} \qquad [8]$$

We should note that prices of other substitutes (such as non-pelagic species or shellfish products) could also be considered, given that provide information about relevant market conditions. However, based on the large amount of fish species already considered in this analysis, part of the substitution effects (or at least the most direct ones) may already be embedded into the estimated fish specific effects. The complete definition and summary statistics of each of the included variables are presented in Tables 1 and 2.

The main hypothesis states that *the news related to the spill have a significant effect on prices, that is:*

$$\left.\begin{aligned} H_0&: \beta_5 = 0 \\ H_1&: \beta_5 \neq 0 \end{aligned}\right\} \qquad [9]$$

Taking into account that the lagged news can have an influence on the consumer perception of a product, it is interesting to study whether they have an influence on the average price of fish. Thus, we will assess whether the published news contributed negatively and helped to spread the stigma effect even after concluding the cleanup operations.

4. Results

Table 6 presents the empirical results provided by the estimation of equation [8]. The estimated coefficients carry the expected signs and most are statistically significant at conventional critical levels. In addition, the R-square of the regression is fairly high, with an $R^2 = 0.6837$, this means that our estimation explains the 68.37% of our data variability. In this Table 6 we also see that coefficient β_1 (denoting the period prior to the spill) is larger than β_2, β_3 and β_4 (coefficients corresponding with post-spill periods). This result is highlighted on Table 7 where the slopes are reported. In this table, negative and significant differences between period 1 and the rest of the periods are presented. We also find that although the slope has been recovering, it does not reach previous levels prior to the spill.

Returning to Table 6, we find that, as expected, the published news have a negative and statistically significant impact on prices with $P > |1| = 0.006$. The coefficient of this variable indicates that an additional number of news published in the previous day contributes to a reduction of the average price by 0.29%. Therefore, this implies that Galician fish markets suffered the consequences of image loss. Our results also show that fish prices experienced large seasonal variations. In this regard, prices corresponding with the *Spring*, *Summer* and *Autumn* seasons carry lower average prices than with respect to the omitted season *Winter*, which corresponds with the Christmas holiday, and the off-season for most of the species in this analysis, fact that limits their supply.

With respect to the geographical variations, results show that prices are more affected in markets closer to the ground zero area (with respect to the omitted variable *Arousa*), even when these markets may represent a smaller percentage over the total sales. This is the case of *Costa da Morte* (the ground zero area), carrying a large negative and significant coefficient (-0.2091), even larger than those carried by more economically important areas, such as *Vigo* (-0.1282) or *Pontevedra* (-0.1486). Moreover, we observe that the North of Galicia suffers worst consequences than the South. This is the case of *Coruña-Ferrol* which is one of the most important areas in the sale of fresh fish, carrying the variable that represents this area a coefficient that presents a greater impact, even larger than those associated with the South of the Galician coast (*Vigo* and *Pontevedra*). Moreover, all coefficients are statistically significant, reflecting that the stigma is expanded to all coastal areas of Galicia[7]. In

[7] Cedeira, Muros and Fisterra also present a negative impact. However the coefficient of Fisterra is smaller than those of the other areas, we think that this is due to its small percentage over the total sales.

this sense, it is observable that the coefficient associated with the least affected area (*Mariña*) carries also a negative and significant coefficient, reflecting the existence of geographical stigma. We may explain this finding by taking into account that the spill affected the whole Galician coast, and even polluted other regions of the North part of Spain, including also parts of France and Portugal. Because of the larger incidence of the spill in the North than to the South it makes sense that the *Mariña* area was also affected. Furthermore, and in terms of image loss, this area is a very relevant selling point for pelagic species.

The remaining variables correspond to the coefficients of the dummy variables related to the analyzed species. In this regard, we find that all species carry negative and significant coefficients, with respect to the omitted variable *Swordfish.* This is consistent with the baseline analysis performed in the data section. Considering the equation results (displayed in Tables 6 and 7), we predict the estimated *logprice* using the estimated coefficients evaluated at the mean values of the explanatory variables per period. Transforming the *logprice* into the linear estimated price and computing the losses in prices times the number of kilos sold[8] per period, we are able to predict that the total damage for the analyzed species is about 70.2€ millions (evaluated at real prices 2011) (Table 8).We acknowledge that several factors linked to the spill and posterior market dynamics are responsible for this damage. Direct factors account for those explicitly modeled in the regressions based on the social amplification of risk in local fish markets. Further, we should note that these Galician fish markets are also suppliers for the local canning industry, which suffered serious impacts derived from the saturation of demand, consequence of the spill, as well as the growth of new international competitors. Thus, the price dynamics based on the primary demand reflects already other circumstances emerging in the secondary or derived demand. Future studies should look into more detail about the dynamics of price transmissions in fish markets and their alterations after large food scares.

5. Conclusions and discussion

In this paper, we analyze the evolution of prices of the most important pelagic fish species in the local markets of Galicia before and after the Prestige oil spill. The selected species represent around the 60% of total value of fish trade in Galicia in our period of study. Additional fish species and shellfish markets have not been included into this analysis. It should be then remarked that the present results do not provide estimates about the total economic fish losses in the Galician fisheries sector, and are only related to the loss of image occurring in the pelagic species.

Our results for the pelagic fisheries conclude that there exists clear evidence of the persistence of stigma effects on these fish markets. Two types of stigma have

[8] The number of kilos sold is: 488,149,350.9 kg in period 1; 96,886,578.81 kg in period 2; 47,010,832.26 kg in period 3 and 409,875,689.5 kg in period 4.

been found: temporal and geographical stigma. The temporal stigma reflects that prices after the Prestige oil spill are lower than those prior to the accident. The geographical stigma shows that prices are lower in the nearby markets of the most affected area and in the North of Galicia (the most affected part). We have also examined the effect that the news published in the four of the most representative newspapers have played on this decline, finding that the printed news had a negative impact on prices that remain over time. Thus, we find that the effects of stigma can be extended even after the cleaning operations, which concluded in 2004. Further, the stigma is spread by geographical areas and it has remained over time. This effect has created mistrust among consumers of Galician fish. This reputational effect has created important losses in the fisheries sector of the community of Galicia. It is important to note that much economic activity of this area is related to the fishing sector.

Based on these current results, we consider that new protocols of compensation of damages should also be investigated when dealing with oil spills. Thus, research of stigma effects may help to properly measure the total economic damages caused by oil spills, so that affected parties (fishermen and related industries) can be adequacy compensated. In order to come up with a proper compensation scheme, we recommend that in addition to the payments received by the affected parties during the period of fishing inactivity, additional compensation should be also warranted if stigma is present.

Nowadays compensation caused by stigma is rather limited and awarded in very few oil spills. However, our empirical results show that stigma effects may increase the total costs suffered by the affected parties. In order to control and reduce the magnitude and duration of stigma and to recover the previous reputation, well-designed promotion campaigns may be put in place after food safety authorities demonstrate that there are no known risks associated with fish consumption in the affected area. Nevertheless, we should not forget that previous literature has shown that maybe the best way to deal with stigma is just to prevent its appearance (see Kunreuther and Slovic, 1999).

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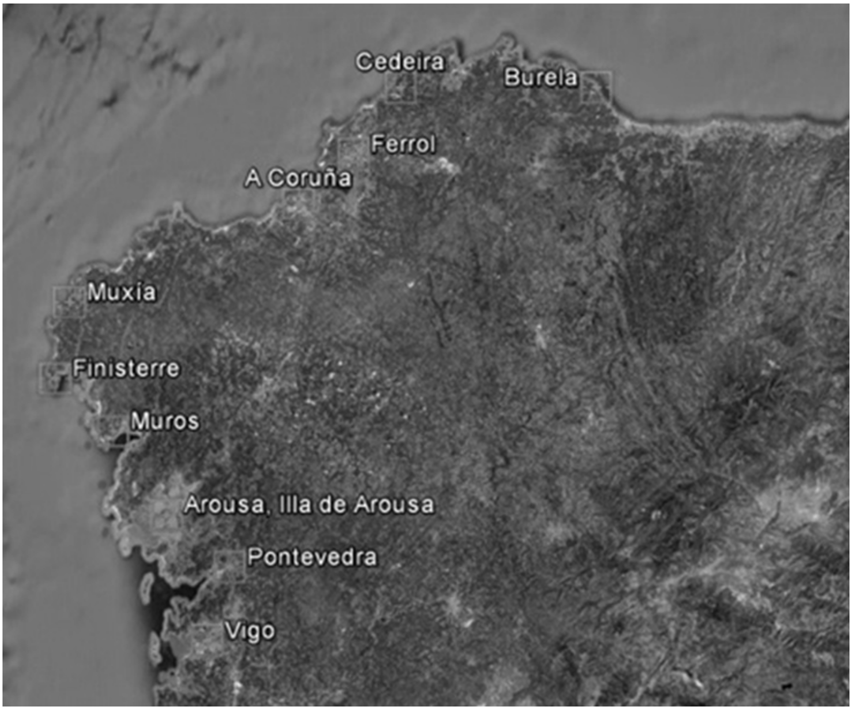
ANNEX

MAP 1

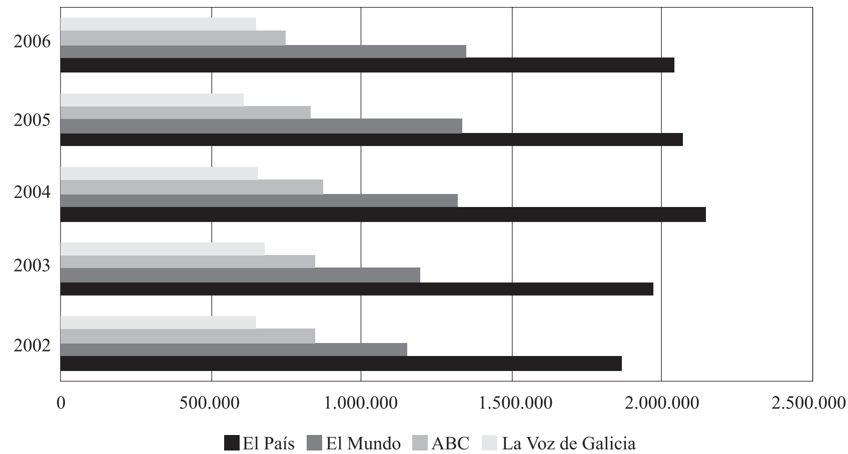
Map of Galician coast



Source: Googlemaps, with adaptations by authors.

GRAPH 1

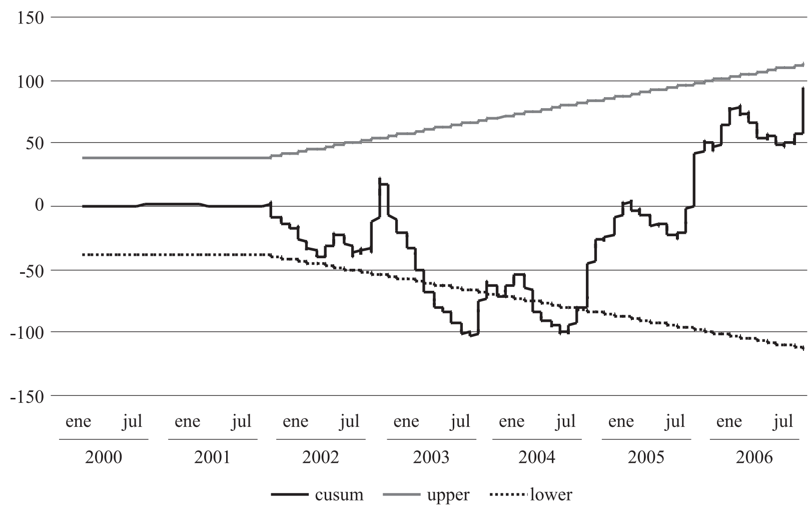
Average daily readers per newspaper



Source: Own elaboration.

GRAPH 2

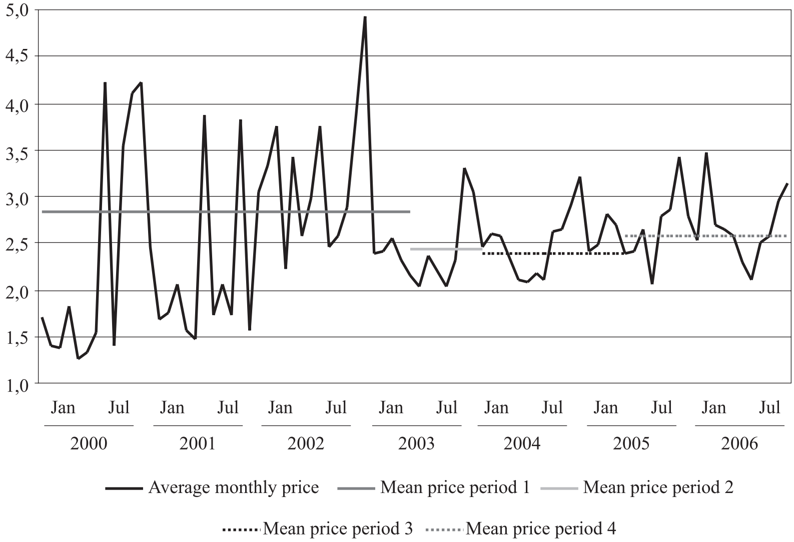
CUSUM test: Detection of structural point breaks



Source: Own elaboration.

GRAPH 3

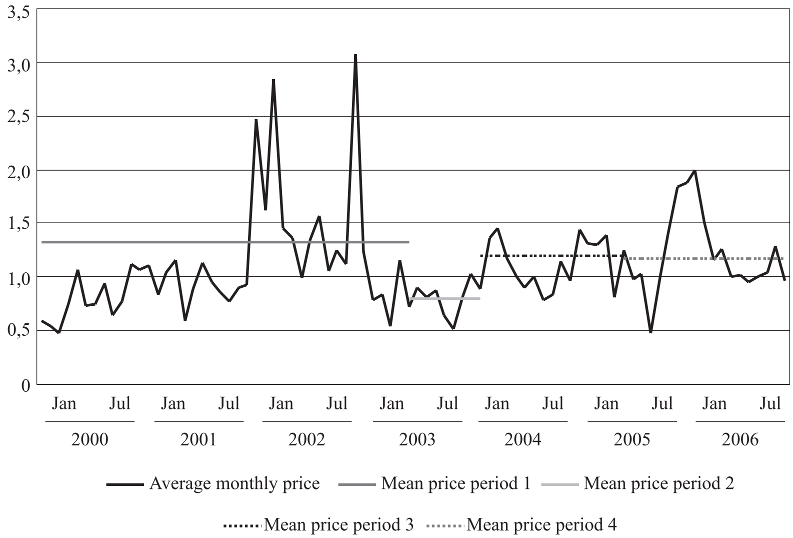
Prices of pelagic species per kg



Source: Own elaboration.

GRAPH 4

***Horse mackerel* prices per kg**



Source: Own elaboration.

TABLE 1

Variable definition and summary statistics

Variable	Definition	Mean	Std. Dev.
Period 1	Dummy that takes value 1 if date is <= 12/06/2003 and 0 otherwise	0.2412	0.4278
Period 2	Dummy that takes value 1 if date is >= 13/06/2003 & date <= 18-02-2004, and 0 otherwise	0.1337	0.3403
Period 3	Dummy that takes value 1 if date is >= 19/02/2004 & date <= 15/06/2004, and 0 otherwise	0.0670	0.2501
Period 4	Dummy that takes value 1 if date is >= 16/06/2004 , and 0 otherwise	0.5581	0.4966
Lagged News	Total weighted news published in the day before	0.8059	1.5659
Vigo	Dummy variable (Vigo=1, rest of areas=0)	0.1332	0.3399
Pontevedra	Dummy variable (Pontevedra=1, rest of areas=0)	0.1494	0.3565
Arousa	Dummy variable (Arousa=1, rest of areas=0)	0.1642	0.3704
Muros	Dummy variable (Muros=1, rest of areas=0)	0.0755	0.2642
Fisterra	Dummy variable (Fisterra=1, rest of areas=0)	0.0421	0.2008
Costa da Morte	Dummy variable (Costa da Morte=1, rest of areas=0)	0.1099	0.3127
Cedeira	Dummy variable (Cedeira=1, rest of areas=0)	0.0467	0.2110
Mariña	Dummy variable (Mariña=1, rest of areas=0)	0.1336	0.3402
Coruña-Ferrol	Dummy variable (Coruña-Ferrol=1, rest of areas=0)	0.1454	0.3525
Winter	Dummy variable (Winter=1, rest of seasons=0)	0.2098	0.4072
Summer	Dummy variable (Summer=1, rest of seasons=0)	0.2917	0.4546
Spring	Dummy variable (Spring=1, rest of seasons=0)	0.2515	0.4339
Autumn	Dummy variable (Autumn=1, rest of seasons=0)	0.2470	0.4312
Price	Daily real fish price per kg	2.6136	2.6629
Logprice	Natural logarithm of real price	0.3938	1.1281

Source: Own elaboration.

TABLE 2

Variable definition and Summary statistics of pelagic species and fishing arts

Variable	Definition	Mean	Std. Dev.
Sardine	Dummy variable (Sardine=1, rest of species=0)	0.1322	0.3387
Atlantic mackerel	Dummy variable (Atlantic mackerel=1, rest of species=0)	0.1734	0.3786
Horse mackerel	Dummy variable (Horse mackerel=1, rest of species=0)	0.2339	0.4233
Hake	Dummy variable (Hake=1, rest of species=0)	0.3142	0.4642
Whiting	Dummy variable (Whiting=1, rest of species=0)	0.1246	0.3303
Swordfish	Dummy variable (Swordfish=1, rest of species=0)	0.0217	0.1458
Trawling fishing	Dummy variable (Trawling fishing=1, rest of fishing arts=0)	0.6694	0.4704
Longline fishing	Dummy variable (Longline fishing=1, rest of fishing arts=0)	0.0216	0.1454
Seining fishing	Dummy variable (Seiling fishing=1, rest of fishing arts=0)	0.3040	0.4600

Source: Own elaboration.

TABLE 3

Price trends by species in Euros/kg

	Mean price by periods estimated by CSUM test			
Pelagic fish	**Period 1**	**Period 2**	**Period 3**	**Period 4**
Sardine	1.34	1.28	1.03	1.15
Horse Mackerel	1.33	0.80	1.19	1.17
Atlantic Mackerel	1.10	0.60	0.53	0.74
Whiting	1.22	0.98	1.13	1.02
Swordfish	6.33	5.64	7.49	7.93
Hake	5.75	5.52	5.33	5.59

Note: Period 1 goes from 1st January 2000 until 13th June, 2003; Period 2 covers the dates ranging from the 14th June 2003 to 19th February 2004. Period 3 covers between 20th February 2004 to 16th June 2004. Finally, Period 4 covers dates after 17th June 2004.

Source: Own elaboration.

TABLE 4

T-test: Price differences by species in euros/kg

	Differences in prices		
Pelagicfish	**H_0: Price period 1 = period 2 (p-value)**	**H_0: Price period 1 = period 3 (p-value)**	**H_0: Price period 1 = period 4 (p-value)**
Sardine	-0.06** (0.040)	-0.31*** (0.000)	-0.19*** (0.000)
Horse Mackerel	-0.53*** (0.000)	-0.14*** (0.000)	-0.16*** (0.001)
Atlantic Mackerel	-0.50*** (0.000)	-0.57*** (0.000)	-0.37*** (0.000)
Whiting	-0.24*** (0.004)	-0.09** (0.025)	-0.20*** (0.000)
Swordfish	-0.69*** (0.000)	1.16*** (0.000)	1.60*** (0.000)
Hake	-0.22*** (0.000)	-0.42*** (0.000)	-0.16*** (0.000)

P-values in parenthesis ** and *** denotes statistically significant differences at 95% and 99% significance level, respectively.

Source: Own elaboration.

TABLE 5

Variation rate of prices

	Variation rate of prices (%)		
Pelagic fish	**Period 2 - Period 1**	**Period 3 - Period 1**	**Period 4 - Period 1**
Sardine	-4.70	-23.11	-14.43
Horse Mackerel	-40.17	-10.25	-11.79
Atlantic Mackerel	-45.34	-51.90	-33.19
Whiting	-19.48	-7.69	-16.24
Swordfish	-10.86	-	-
Hake	-3.91	-7.31	-2.74

Source: Own elaboration.

TABLE 6

Logarithm price regression model

	Variable	β	Std. Err.	*t*	P>|*t*|
	Period 1	2.1738	0.0121	178.85	0.000
	Period 2	1.9883	0.01279	155.37	0.000
	Period 3	2.0227	0.0135	149.65	0.000
	Period 4	2.1458	0.0121	177.28	0.000
	Lagged News	-0.0029	0.0011	-2.77	0.006
Location dummys	Vigo	-0.1282	0.0058	-21.92	0.000
	Pontevedra	-0.1486	0.0056	-26.49	0.000
	Muros	-0.1691	0.0069	-24.51	0.000
	Fisterra	-0.0689	0.0086	-8.04	0.000
	Costa da Morte	-0.2091	0.0061	-34.18	0.000
	Cedeira	-0.2691	0.0082	-32.68	0.000
	Mariña	-0.2886	0.0058	-49.61	0.000
	Coruña-Ferrol	-0.3608	0.0056	-63.82	0.000
Species dummys	Sardine	-1.9887	0.1176	-169.06	0.000
	Horse Mackerel	-2.0318	0.0114	-178.85	0.000
	Atlantic Mackerel	-2.4154	0.0116	-208.47	0.000
	Whiting	-2.0526	0.0117	-174.59	0.000
	Hake	-0.2038	0.0112	-18.17	0.000
Season dummys	Spring	-0.0781	0.0048	-16.39	0.000
	Summer	-0.0496	0.0045	-10.87	0.000
	Autumn	-0.1408	0.0047	-29.84	0.000
	R-Square	0.6837	N	164,524	

Source: Own elaboration.

TABLE 7

Slope changes

	Log price			
	Coef.	**Std. Err.**	**T**	**P>|t|**
Period 2 – Period 1	-0.1856	0.0055	-33.50	0.000
Period 3 – Period 1	-0.1512	0.0071	-21.43	0.000
Period 4 – Period 1	-0.0280	0.0039	-7.09	0.000

Source: Own elaboration.

TABLE 8

Estimated damages at real prices 2011

	Estimated total losses (€)
Period 2	- 33,560,367.04
Period 3	- 13,487,827.62
Period 4	- 23,153,771.37
TOTAL	**- 70,201,966.03**

Source: Own elaboration.