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The determinants of fishing vessel accident severity

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ABSTRACT

The study examines the determinants of fishing vessel accident severity in the Northeastern United States using vessel accident data from the U.S. Coast Guard for 2001–2008. Vessel damage and crew injury severity equations were estimated separately utilizing the ordered probit model. The results suggest that fishing vessel accident severity is significantly affected by several types of accidents. Vessel damage severity is positively associated with loss of stability, sinking, daytime wind speed, vessel age, and distance to shore. Vessel damage severity is negatively associated with vessel size and daytime sea level pressure. Crew injury severity is also positively related to the loss of vessel stability and sinking.

1. Introduction

Commercial fishing is a dangerous occupation, and accidents are bound to happen given the operational environment within which fishing is conducted. In the United States, during 1992–2008, an annual average of 58 reported deaths occurred (128 deaths per 100,000 workers) in the fishing industry, compared with an average of 5,894 deaths (four per 100,000 workers) among all U.S. workers. Among the 504 U.S. commercial fishing deaths during 2000–2009, the majority occurred after a vessel accident (52%) or a fall overboard (31%). A quarter of the deaths occurred in the Northeast region. The fisheries with the highest fatality rates include Northeast multispecies groundfish fishery (600 per 100,000 full-time equivalent employees) and Atlantic scallop (425 per 100,000 full-time equivalent employees) (Lincoln and Lucas, 2010).

The risk associated with commercial fishing may be defined as the product of the probability of an adverse outcome (event probability) and the severity of that outcome (Windle et al., 2008). The adverse outcome typically involves vessel damage and crew injury. The severity of vessel damage may vary from no damage to the loss of the vessel. The severity of crew injury may also vary from no injury to death. This study investigates the determinants of fishing vessel accident severity. Specifically, we examine fishing vessel accidents in the waters off the coast of Northeastern United States using the U.S. Coast Guard data from 2001 to 2008. Is the accident severity of a fishing vessel more likely to be greater for a certain type of vessel accident, vessel characteristic, weather condition, and season? The results of the investigation will be useful for policymakers that regulate the safety of fishing vessels, insurance companies that insure fishing vessels, and fisheries managers.

The paper extends our earlier studies of fishing vessel accidents in U.S. waters from 1981 to 2001. Jin et al. (2001) found that the probability of a total loss of the vessel was the greatest for a capsizing, followed by a sinking accident. Fire/explosions and capsizings were expected to incur the greatest number of crew fatalities: 3.5 and 3.8 for every 100 such accidents. For every 100 collisions, 2.1 nonfatal crew injuries were expected. The probability of a total loss and the expected number of crew fatalities varied inversely with the price of fish catches.

In another study, Jin and Thunberg (2005) investigated fishing vessel accident probability and vessel trip probability in North Atlantic U.S. EEZ fisheries using logit regression and daily data from 1981 to 2000. The study showed that fishing vessel accident probability declined over the study period. Higher wind speeds were associated with greater accident probability. Medium size vessels had the highest accident probability before 1994. Within the study region, accident probability was lower in southern New England and Mid-Atlantic waters than on Georges Bank and in the Gulf of Maine. Accidents were more likely to occur closer to shore than offshore. Accident probability was lower in spring and fall. Changes in fishery management in 1994 did not lead to a general increase in either accident or vessel trip probability. Although higher economic payoff (i.e., revenue of landings) induced more vessels to go fishing, this was not associated with an increase in accidents.

A comprehensive, multi-national review of fishing vessel safety studies can be found in Windle et al. (2008). Results of their study highlight the need for an improvement in assessment and for access to accurate and standardized statistics regarding fishing-related injuries and illnesses.

The paper is structured as follows. In Section 2, a model of the fishing vessel accident severity is presented. Data are discussed in

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Section 3. Sections 4 and 5 describe estimation procedures and results, respectively. Estimated marginal effects are presented in Section 6. Conclusions are set forth in Section 7.

2. The model

According to vessel accident literature (Talley et al., 2006, 2008), the fishing vessel accident damage severity (D) is expected to vary with the type of vessel accident (a), vessel characteristics (c), type of vessel propulsion (p), type of vessel hull construction (h), weather condition (w), spatial location (s), and time of vessel accident (t), i.e.,

$$D = f(a, c, p, h, w, s, t) \quad (1)$$

Each vector on the right hand side of Eq. (1) consists of a number of measurement variables. The type of accident (a) includes many traditional variables found in Coast Guard statistics (i.e., allision, capsize, collision, explosion, fire, flooding, grounding, material failure, and sinking),[1] several new variables describing post-ship-accident activities (i.e., vessel abandonment, vessel set adrift, loss of electrical power, and losses of vessel stability and maneuverability), and other new variables (i.e., vessel caused environmental damage and vessel requested emergency response). The vessel damage severity is expected to be greater if the vessel sank resulting from an accident. Otherwise, the *a priori* relationship between type of accident and D is indeterminate.

Vessel characteristics (c) include vessel size (gross ton) and vessel age. The *a priori* sign of the relationship between accident vessel damage severity and vessel size is negative, as larger vessels are expected to be more seaworthy (e.g., less susceptible to adverse weather). The *a priori* sign of the relationship between damage severity and vessel age is positive, since vessel structural failure is expected to increase with age.

Propulsion for a fishing vessel (p) includes diesel and gasoline engines. It is unclear, however, which of these propulsion sources are expected to result in greater vessel damage. A vessel's hull (h) may be constructed with aluminum, fiberglass, steel, or wood. Since steel is the strongest of these materials, it is expected that a vessel constructed with steel will incur less damage, all else held constant.

Weather condition (w) is represented by the daily maximum wind speed (m/s) and daily maximum sea level pressure (hPa). The spatial variable (s) measures the distance to shore (km). Time of vessel accident (t) includes time of day (nighttime versus daytime) and time of year (seasons). These variables capture the effects of changes in visibility as well as general weather conditions. Adverse weather and visibility are expected to increase the risk of a vessel accident, in turn, the vessel's damage severity. Replacing the vectors in Eq. (1) with the above described measurement variables (x), one obtains the fishing vessel accident damage severity reduced-form equation:

$$D = F(x) \quad (2)$$

Crew injury severity (J) in a fishing vessel accident is expressed as a function of vessel damage severity (D) and other factors in Eq. (1), such as accident type, i.e.,

$$J = g(D, a, c, p, h, w, s, t) \quad (3)$$

Vessel damage severity should have a non-negative effect on the crew injury severity given that a damaged vessel does not necessarily result in injured crew members. Also, more injuries are expected to occur under bad weather conditions. The *a priori* relationships between J and vessel characteristics and other variables are unclear. Replacing the vectors in Eq. (3) by the variables used to measure them and rewriting, one obtains the crew injury severity reduced-form equation:

$$J = G(x) \quad (4)$$

In the study, we develop two sets of regression models for accident severity, one for vessel damage (D) and the other for crew injury (J).

3. Data

Eqs. (2) and (4) are estimated utilizing detailed data of individual fishing vessel accidents that were investigated by the U.S. Coast Guard during the 8-year time period 2001–2008 and extracted from the Coast Guard's Marine Information for Safety and Law Enforcement (MISLE) database. The U.S. Coast Guard compiles vessel casualty and pollution statistics and maintains a computer database of detailed records on vessel accident and pollution events in U.S. waters. For the vessel accident data, each observation is a vessel involved in an accident. A long list of variables describes the vessel, time and location of the accident, and other related information (e.g., vessel type and flag). The name and format of the database have changed over the years. Between 1981 and 1991, the vessel casualty database was called CASMAIN. From 1992 to 2001, vessel casualty and pollution records were incorporated into a larger database called Marine Safety Information System (MSIS). Since December 2001, the database has transitioned to the MISLE information system. Three MISLE data tables were used to compile the two data sets (vessel damage and crew injury) for this study. The three data tables include: the Vessel Event Table (MisleVslEvents), the Vessel Table (MisleVessel), and Personal Injury Table (MisleInjury). Only US flagged fishing vessels in the Northeast region were included in the data sets.

Hourly wind speed and sea level pressure recorded from offshore buoys and nearshore weather stations were obtained from NOAA's National Data Buoy Center. Daily maximum wind speeds and daily maximum pressure from each recording station were mapped to different fishing areas by assigning each area to the nearest weather recording station. The spatial feature of accident probability (distance from shore) is the distance from the center of each fishing area to the nearest coast. This was calculated using GIS software and the NMFS digital map of fishing areas.

Variables used in the vessel damage equation estimation, their specific measurements, and descriptive statistics (mean and standard deviation) appear in Table 1. The mean for the dependent variable, damage severity (D), is 1.03. Among the accident cases in the data set, 28.5% are classified as vessel "undamaged" ($D = 0$), 40.3% as vessel "damaged" ($D = 1$), and 31.2% as vessel "total constructive loss" or "actual total loss" ($D = 2$). The definition of dependent variable will be discussed further in the next section. The mean statistics for the explanatory variables reveal that the average size and age of a fishing vessel involved in an accident are 74 gross tons and 26.2 years, respectively. 66.2% and 30.7% of the accidents occurred at daytime and in winter, respectively. Most frequent accident types include environmental damage (19.4%), material failure (14.9%), sinking (11.4%), and flooding (11.3%). The average daily maximum wind speed and sea level pressure are 10.6 m/s and 1,018.9 hPa.

Variables used in the crew injury equation estimation, their specific measurements, and descriptive statistics (mean and standard

[1] An allision accident occurs when a vessel strikes a stationary object (not another vessel) on the water surface. A collision accident occurs when a vessel strikes or was struck by another vessel on the water surface. A grounding accident occurs when the vessel is in contact with the sea bottom or a bottom obstacle. A material-failure accident typically involves equipment failure on board the vessel.