Transport Policy 63 (2018) 141–156

Contents lists available at ScienceDirect

Transport Policy

journal homepage: www.elsevier.com/locate/tranpol

Survival analysis of the world ship demolition market

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ARTICLE INFO

Keywords:
Ship demolition
Survival analysis
Cox proportional hazards regression
Survival distribution

ABSTRACT

Ship demolition is an important strategy for balancing the fleet capacity of the shipping industry. In addition to the effects of ship obsolescence, technical developments and environmental regulations on ship demolition, the state of the shipping market and operational costs are also significant influences. Using a dataset compiled from various data sources, this study analyzes individual shipowners' ship demolition decisions using survival analysis models. The empirical estimation of the Cox proportional hazards regression suggests the different demolition decision behavior under different shipping market cycles. The results also indicate the active ship demolition activities of the owners from developing countries after the financial crisis. Meanwhile, more aged and less efficient ships have been demolished after 2008 because of the high bunker consumption and the big owners cannot escape from this. Finally, the survival distribution function illustrates the impact of different factors on demolition behavior in different market situations.

1. Introduction

Among the four sub-markets in the shipping industry, the freight market, the newbuilding market, the sales and purchase market and the demolition market, only operations in the newbuilding and demolition markets can affect the actual fleet supply in shipping transportation. In a rising market, shipping companies can place new orders to increase capacity, while in a depressed situation, old and obsolete vessels can be sent to scrap dealers for demolition (Stopford, 2009), where end-of-life ships are broken into pieces for recycling. Because 98% of a ship by weight can be recycled into reusable materials (Jain et al., 2013), ship demolition can provide an important source of cash flow to shipowners when freight rates are low (Stopford, 2009). Very importantly, this ship recycling activity is closely related to the recessionary phase in the market cycle for shipping. The analysis of Stopford (2009) showed from the perspective of psychology that the recessionary phase in the shipping market cycle tends not to relent until some shipowners resort to successive ship scrapping for cash. In general, ship demolition is a primary element in balancing the supply of and demand for ships (Buxton, 1991).

In general, the average life span of a ship is about 30 years because of economic, technical and regulatory limitations affecting ships. This period may be shortened by economic or financial crisis (Jain et al., 2013). Fig. 1 illustrates the number of ships scrapped in each year from 2000 to mid-2016, together with the average age of the ships at demolition. It is clear that before the market began to boom in 2004, the number of demolished ships was relatively stable each year, while in the rising market from 2004 to 2007, fewer ships were scrapped and the age of the scrapped ships increased from previous years. Fig. 1 shows that after the financial crisis and the downturn in the market, shipowners begin to scrap more ships, and that in recent years ships are being sent for demolition at relatively young ages. Fig. 1 provides support for the notion that demolition behavior changes in different phases of the market cycle for shipping. Therefore, it is important to analyze shipping demolition behavior in light of the current gloomy post-financial crisis situation.

In addition to the influence of economics and particularly the financial crisis, demolition behavior can be impacted by other factors, including technical improvements in ships and environmental regulations. An example of the latter is the regulation-induced phasing out of most single-hulled tankers susceptible to oil spills in favor of double-hulled tankers by 2020 (Yujuico, 2014). A search of the literature turns up many studies discussing ship recycling, marine pollution and environmental conventions, but few researchers have investigated ship demolition behavior from the perspective of the individual ship and shipowner, except some aggregate analysis by Buxton (1991), Knapp et al. (2008) and Kagkarakis et al. (2016). Therefore, this study aims to investigate individual shipowners' demolition behavior, especially their

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https://doi.org/10.1016/j.tranpol.2017.12.019
Received 14 April 2017; Received in revised form 29 November 2017; Accepted 15 December 2017

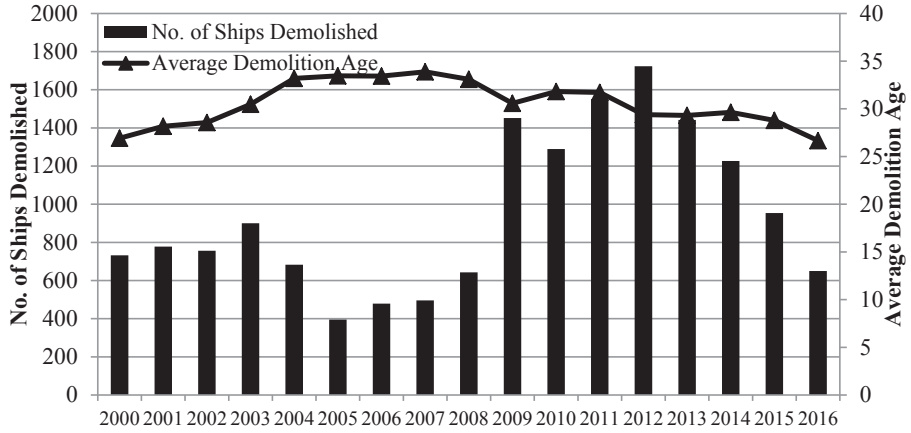

Fig. 1. Ship demoliton activity from 2000 through July, 2016.
Note: the data for 2016 is up to July.
Data source: Clarksons, August, 2016.

changes in behavior after the financial crisis. Another innovation of this study is the survival analysis or duration modeling method employed. This is a branch of statistics used to analyze the expected duration of time until one or more events happen, in this case the demolition of a ship. Compared to binary logit or probit models, survival analysis can assess the impacts of various time-variant factors on demolition behavior. Moreover, it can estimate the proportion of a population (here of ships) that will survive past a certain point in time, and the subsequent rate at which this survivor population will expire (here be demolished). These results may provide valuable information for future decision-making, especially under the current depressed market.

The remainder of this study is structured as follows. Section 2 reviews related studies on ship demolition. Section 3 introduces the data sources and provides an overview of the ship demolition market in order to gain some insight into the psychology of a shipping company's demolition behavior. Section 4 presents the methodology of survival analysis modeling used in the study. Section 5 reports the empirical results and discussion. The concluding section, section 6, summarizes the main findings and the study's potential contributions to the shipping industry.

2. Literature review

Ship demolition did not become an established industry until the nineteenth century when there were a sufficient number of vessels which had reached the end of their lives (Sinha, 1998). It initially flourished in the highly industrialized nations of Europe, the United States and Japan. Later, in the 1970s, the center of the ship demolition industry moved to Taiwan, China and South Korea. Since the 1980s, the industry has gradually moved to the region of the Indian subcontinent including Bangladesh, India and Pakistan (Kagkarakis et al., 2016). Along with its development, issues of unacceptable worker conditions, pollution and environmental degradation have raised much attention (Sinha, 1998). Therefore, international conventions and guidelines have attempted to address such concerns, including the Basel Convention, the International Maritime Organization (IMO) guidelines on ship recycling, the International Labor Organization (ILO) guidelines and the Hong Kong International Convention for Safe and Environmentally Sound Recycling of Ships (HKIC) (IMO, 2009; Jain et al., 2013). Currently, important improvements have been implemented in the majority of ship recycling centers to comply with these conventions and guidelines.

In addition to discussing environmental, safety and social aspects of the ship recycling market, some researchers have investigated the factors influencing demolition decisions. Evans (1989) discussed the cost factors impacting the age at which ships should be replaced and concluded that capital and operating costs are the most important influences on the decision. Buxton (1991) explored the fundamental characteristics of the ship demolition market and argued that the disposal decision is determined by technical and economic factors influencing the anticipated profitability of a particular ship. Mikelis (2007) provided a statistical overview of the ship demolition market as background information for a discussion of HKIC. The study pointed out the positive correlation between freight rates and demolition prices and discussed the impact of local labor costs and the demand for steel on demolition price.

Knapp et al. (2008) applied econometric modeling to test the relationships hypothesized by Mikelis (2007). Using a binary logistic regression, the study analyzed the probability that a ship would be scrapped in five major demolition locations (India, Bangladesh, Pakistan, China and Turkey). The results suggest a negative relationship between a ship's earning and the probability of demolition for all locations and a positive relationship between scrap prices and the probability of demolition for all locations. It also discussed the impact of various factors, including vessel characteristics, economic conditions of the shipping market and safety inspections on the probability of demolition for all five demolition locations. To the authors' knowledge, this is the first econometric analysis conducted on the demolition market, and it has made a useful contribution in explaining the effects of various factors on the probability of scrapping. However, we think the logistic regression is not the best option for modeling the demolition market, although it provides valuable results for discussion. In this binary model, the value of the dependent variable is 1 if a ship has been scrapped and 0 if not. This will create an unbalanced dataset as the 0s are unchangeable, while the 1s change according to the change in the time period. Actually, this kind of data is a censored variable where the variable of interest (whether a ship is demolished) is only observable under certain conditions (the ship is in fact demolished). In addition, the independent variables used in the binary model cannot be time-variant because the demolitions and non-demolitions happened at different times. Hence, the present study innovatively adopts the Cox proportional hazards regression method to analyze the survival probability and, importantly, the impact of various time-variant factors on demolition behavior.

In addition to the above studies, there are some empirical studies investigating the macro-level impacts of the demolition market using aggregate data. Mikelis (2013) examined the importance of the ship demolition market to global steel production and to the five leading ship demolition countries (India, China, Bangladesh, Pakistan and Turkey). The study confirmed the contribution of the demolition market to the