Does energy efficiency affect ship values in the second-hand market?\*☆

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\section*{ABSTRACT}

This paper investigates whether the energy efficiency of vessels is reflected in sales prices in the second-hand market. Using unique data of nearly 1600 sales transactions over a 21-year period, we consider a hedonic pricing framework in which we control for market conditions, vessel specifications and buyers' country of origin to identify the specific impact from energy efficiency. Using two indicators for energy efficiency, we find a negative relationship between energy efficiency and sale price with an elasticity around 0.4. Furthermore, our results show a reduction in the influence of energy efficiency on asset values during the drybulk market boom in 2003–2008 compared to the remainder of the sample.

\section*{1. Introduction}

There are several mechanisms by which the energy efficiency of a ship should influence its asset value in the second-hand market. First, improving energy efficiency can be a way to restore profit margins, particularly when freight rates are low and fossil energy price are expected to increase in the future. Second, because users (final customers and vessel owners or charterers) are increasingly aware of the negative environmental impact from transport, energy efficiency may be a competitive factor when buying or hiring new or second-hand assets (Raucci \textit{et al.}, 2017). Third, differences in operating costs and the environmental profile of an asset may translate into differences in utilization (Prakash \textit{et al.}, 2016). For instance, an energy efficient ship may have less idle time between contracts or a lower probability of being mothballed. Therefore, energy efficient assets could potentially obtain a premium in contracted revenue, reflecting higher demand from increasingly environmentally conscious users in a two-tier market.

Given that the present asset values should reflect earnings from future employment and resale values, and not just current market conditions and policies, these incentives for private operators to invest in energy efficient assets are not straightforward to estimate separately. For instance, the present value of the cost savings due to lower fuel consumption depends on the uncertain lifespan of the asset, the conditions under which the asset is operated and, perhaps most importantly, expectations on fuel price. This issue is further complicated by the fact that ships can be employed on a variety of short and long-term contracts, in any region of the world, and on different types of freight contracts with varying allocation of fuel costs between the buyers and sellers of the transportation service.

Because asset values should reflect expectations about the future, they are also subject to uncertainty in environmental policies that could affect the cost of fuel, the lifespan of the asset, or limit the geographical regions in which they can be operated. Regulatory

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uncertainty manifests itself in different ways, for instance, the timeline of implementation, the speed and scope of ratification of international law, financial penalties of non-conformance and the impact on market prices. In the shipping industry, an example is the phasing out of single-hull tankers (Tamvakis, 1995), where the IMO set deadlines after which such tonnage could only trade among a limited number of non-signatory countries and otherwise faced premature demolition or conversion. In the general energy efficiency literature, these sources of risk are generally classified as external risks (Sorrel et al., 2000) and complements general business risks (access to financing) and technical risk (asset performance) or as supply-side and demand-side risks (Raucci et al., 2017).

While the impact of energy efficiency and, indirectly, environmental policy risk is clearly of interest to the owners and financiers of real assets and policy makers alike, there has been little empirical research in this area. One notable exception is Fuerst and McAllister (2011) who investigate the impact of energy performance certificates on commercial real estate values using a hedonic pricing model. Opinion concerning shipping assets are mixed and not based on thorough empirical analysis. Faber et al. (2009, p. 255) simply state that “environmental performance is generally not reflected in the asset price”. However, drawing on interviews with shipbrokers and ship financiers, Mitchell and Rehmatulla (2015) find the general opinion to be that efficiency is priced by the market, even though energy efficiency may not always be explicitly assessed in lending decisions.

This paper represents, to our knowledge, the first empirical analysis of the relationship between energy efficiency and the value of ships. Specifically, we consider the second-hand values of small oceangoing bulk carriers, so-called Handysize bulkers with a deadweight (DWT) carrying capacity of 10,000–40,000 tonnes. This market segment is an ideal candidate to test the relationship between energy efficiency and asset values. First, as ships are mobile assets and relatively fungible within a segment (i.e. a size range of a particular ship type), the second-hand market can be considered as a global single market. Second, while cashflow shocks influence the investment decisions of shipping firms (Drobertz et al., 2016), the trading flexibility and modest investment size of small bulkers means that the second-hand market for Handysize bulkers remains sufficiently liquid throughout the shipping market cycle. Third, shipping assets have seen a gradual tightening of environmental policy in the past decade with the introduction of stricter sulphur limits in marine fuels – leading to higher fuel costs - first in regional Emission Control Areas (Adland et al., 2017a) and globally from 2020. Fourth, the assets are known to be subject to policy risks, with both the EU and the International Maritime Organization (IMO) trying to reach an agreement on some form of carbon taxation (Lee et al., 2013; Hermeling et al. (2015); Wang et al., 2015) which would increase the future fuel costs.

The remainder of our paper is structured as follows. Section 2 reviews the relevant literature on the impact of energy efficiency in shipping. Section 3 provides a description of the data. Section 4 presents our econometric results along with many robustness checks. Finally, Section 5 contains our concluding remarks and suggestions for future research.

2. Literature review

Until now, empirical analyses of the pricing of energy efficiency in shipping have mainly examined the impact on the freight rate agreed for individual contracts (fixtures). This follows a long tradition of microeconomic analysis of freight market fixtures based broadly on the hedonic pricing framework of Rosen (1974) as undertaken by Bates (1969), Tamvakis (1995), Dick et al. (1998), Tamvakis and Thanopoulou (2000) and Alizadeh and Talley (2011a, 2011b). In these studies, the price (freight rate) of each individual fixture is regressed on vessel characteristics (such as age and DWT) and contract characteristics (such as route and duration) to control for variations due to observable differences. Adland et al. (2016a) expand on this methodology by accounting for unobservable charterer, owner and owner-charterer match effects in fixed-effects regression models and find that the influence of charterers is greater than that of owners for large tankers and bulkers.

Only a small subset of this literature on the microeconomic modelling of freight rates explicitly considers the impact of energy efficiency on the pricing of contracts. We note here that vessels can be chartered on two main types of contracts in the freight market: voyage charters and timecharters (TC). Under a voyage charter, the shipowner is paid on a dollar per tonne cargo basis and pays all costs including fuel expenses. Under a TC, the shipowner gets paid on a dollar per day basis for the duration of the hire period, but fuel expenses and other voyage costs are borne by the charterer (Stopford, 2009). The differentiation between these two main types of contracts is closely related to the split incentives problem. Split incentives occur when the costs and benefits of energy efficiency accrue to different agents (Blumstein et al., 1980; Fisher and Rothkopf, 1989; Howarth and Winslow, 1994). In the context of a TC, the cost of building or upgrading an energy-efficient vessel is borne by the shipowner, while the benefits in terms of fuel cost savings accrue to the charterer.

The literature has focused on how the savings in fuel costs are shared between owners and charterers through higher TC rates, thus reducing the split incentives problem. Agnolucci et al. (2014) estimate a microeconomic model for TC rates in the Panamax drybulk market and find that approximately 40% of the energy efficiency savings are shared with the shipowner for the period 2008–2012. Adland et al. (2017b) expand the analysis to several drybulk vessel sizes over a 15-year time period and find that only 14–27% of the fuel cost savings are shared with shipowners by way of higher TC rates, and only during normal market conditions. Importantly, they find that energy inefficient tonnage is rewarded in strong markets, suggesting that revenue-enhancing attributes such as speed and capacity trump the value of fuel savings during such market conditions. This is an important finding, as it suggests the pricing of energy efficiency in TC contracts is market dependent and that owners of energy efficient tonnage could even be penalized in very strong markets.

Though not explicitly concerned with the pricing of energy efficiency, Köhn and Thanopoulou (2011) investigate the presence of a quality premium in the Panamax drybulk TC market using Generalized Additive models and a non-linear relationship. They find that only vessels with very high fuel consumption have to accept a discount in rates. Prakash et al. (2016) suggest that there is little or no...
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