VESSELS' OPERATING EXPENSES: A KEY VARIABLE ON COMPANIES' STRATEGIC DECISIONS

Nicholas D. Belesis *, Christos G. Kampouris **, Andreas E. Fousteris ***

* *Corresponding author*, Department of Business Administration, University of Piraeus, Piraeus, Greece
Contact details: Department of Business Administration, University of Piraeus, 80 M. Karaoli & A. Dimitriou St., 18534 Piraeus, Greece
** Department of Tourism Studies, University of Piraeus, Piraeus, Greece
*** Department of Business Administration, University of Piraeus, Piraeus, Greece

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Abstract

This study examines the operating expenses (OPEX) incurred by tankers and bulk carriers (bulkers), which are widely utilized vessels within the maritime sector, over the period from 2018 to 2021. The study specifically examines the movement of OPEX during the specified period and assesses the impact of the COVID-19 pandemic, vessel age, and size on OPEX. The study and comprehension of the behaviour of operating expenses hold significant importance for managerial purposes in shipping companies, as it is one of the two most critical expenses. The OPEX data is obtained from the Moore Maritime Index (MMI) database. The vessels are categorized into clusters based on age and size to facilitate a more focused and comprehensive analysis of OPEX. Data are examined through statistical analysis. The study's findings suggest a positive correlation between OPEX and the age of vessels, with a stronger correlation observed in larger vessels. Furthermore, OPEX experienced a consistent increase throughout the entire study period, with the rate of increase directly linked to the vessel's size. Ultimately, OPEX remained unaffected by the pandemic. This study is distinctive in that it examines not only the OPEX behaviour of different types of vessels but also considers vessel size subcategories and the impact of COVID-19.

Keywords: Operating Expenses, OPEX, Tankers, Bulk Carriers, COVID-19, Moore Maritime Index, MMI

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1. INTRODUCTION

Maritime transportation plays a crucial role in the global economy, representing approximately 80% of global trade (Psaraftis, 2021), and significantly influencing economic growth. Maritime transport and its associated activities exert a significant influence on the economy, affecting numerous industries, both directly and indirectly. Maritime transport is widely regarded as a crucial element of global trade (Bai, 2021). Additionally, numerous industries heavily depend on it for the transportation of various resources to manufacturing hubs.

In general, a well-established transportation infrastructure leads to increased productivity through various macroeconomic factors, including the expansion of business activity, innovation, investment, labour market dynamics, competition, domestic and international trade, global mobility, regional economic development, population well-being, environmental safety, and health (Skorobogatova & Kuzmina-Merlino, 2017). Maritime transport plays a crucial role in the transportation system and is responsible for a significant portion of global trade. Furthermore, engaging in international maritime trade is widely regarded as a crucial element in attracting global capital (Lane & Pretes, 2020).

Maritime transport is a subject of significant importance and has been extensively studied in the literature. Over the past few decades, numerous papers have been published on various aspects of maritime transport. The primary academic focus in maritime transport has traditionally been on the detailed management of ports and liner shipping. However, in recent decades, there has been a shift in research towards enhancing the efficiency and sustainability of maritime transport as a whole. This shift encompasses areas such as regulations and policy management, which were previously of significant interest (Bai et al., 2021).

Consequently, numerous research papers examine the influence of maritime transport on economic growth and development, underscoring the significance of maritime transport for international trade, economic prosperity, and global development trends.

Akbulaev and Bayramli (2020) demonstrate that enhancing the administration of maritime transport fosters sustainable economic growth. In their study, Gherghina et al. (2018) established a positive correlation between maritime transport and associated investments, and economic growth. Additionally, they found a negative correlation between air pollutants and economic growth. Khan et al. (2018) discovered a positive correlation between container port traffic and income per capita in a panel of 40 diverse countries. Similarly, Saidi et al. (2018) determined that transport infrastructure has a positive impact on economic growth. Niavis et al. (2017) discovered that maritime transport is the second most influential factor contributing to change in the Adriatic-Ionian region, following coastal tourism. Also, Özer et al. (2021) discovered that there is no noteworthy correlation between rail transport and economic growth. However, they did observe a positive and statistically significant correlation between maritime container transport and economic growth, both in the short term and long term.

In addition, Park and Seo (2016) discovered that container port activities have a positive impact on regional economic growth, using an augmented Solow model. In their study, Lane and Pretes (2020) investigate the influence of five key factors on economic development in relation to maritime dependency. They discover a noteworthy correlation between maritime dependency and gross domestic product per capita. Park et al. (2019) conducted a study where they compared the effects of maritime, air, and land transport on economic growth in both Organisation for Economic Co-operation and Development (OECD) and non-OECD countries. They used a hybrid production approach that combined economic growth with the supply and demand of transportation. The researchers found that maritime transport exerts a more potent influence on economic growth compared to air and land transport, which occasionally exhibit no impact or even have a detrimental effect on economic growth, particularly in developing nations.

The efficient management of vessel OPEX is a crucial factor in determining the profitability and long-term viability of this particular industry. The objective of this study is to conduct a comprehensive comparative examination of the operational expenditures associated with two prominent categories of maritime vessels, namely tankers and bulkers, spanning the timeframe from 2018 to 2022.

Operating expenses, often denoted as OPEX, encompass the regular expenditures linked to the routine functioning and upkeep of a vessel. OPEX include crew wages, victualling, general crew costs, lubricating oils, stores, spares, repairs and maintenance, P&I insurance, marine insurance, registration costs, management fees, and sundries. Operational expenditure does not encompass capital expenses such as the acquisition cost of vessels or the costs associated with financing. Additionally, it does not account for expenses specific to individual voyages, such as fuel costs (referred to as bunker expenses) or charges incurred at ports.

The significance of OPEX within the maritime industry is of utmost importance. Expenses have a direct influence on the financial performance of shipping enterprises, and their efficient administration plays a crucial role in determining a company’s ability to compete and generate profits. The presence of high OPEX has the potential to diminish profit margins, especially within a competitive market characterized by volatile freight rates. On the other hand, the effective administration of OPEX has the potential to enhance profitability, even when faced with difficult market circumstances. Moreover, possessing a comprehensive comprehension of OPEX is imperative for the purpose of budgeting and financial planning. This knowledge empowers ship owners and operators to anticipate forthcoming expenditures, strategize for essential maintenance and repairs, and establish freight rates that guarantee profitability.

One prominent development has been the growing digitization of the maritime sector. The utilization of data analytics and digital technologies is facilitating ship owners and operators in the monitoring and optimization of diverse facets of vessel operations, encompassing fuel consumption and maintenance requirements. The utilization of predictive maintenance technologies has the potential to detect and address potential problems in advance, thereby mitigating the need for expensive repairs or operational downtime. Additionally, the implementation of route optimization software can effectively minimize fuel consumption, which is a significant contributor to OPEX for the majority of vessels.

The COVID-19 pandemic has had a substantial influence on vessel OPEX. The global health crisis has resulted in escalated expenses associated with crew rotations as a consequence of travel limitations and mandatory isolation protocols. Moreover, the implementation of the International Maritime Organization's (IMO) sulfur cap regulation in January 2020 has resulted in heightened bunker costs, as shipowners have borne the burden of the elevated expenses associated with the pricier IMO sulfur-compliant fuel (Sigalas, 2022).

OPEX fluctuated from 2018 to 2021. OPEX for bulk carriers rose steadily from 2018 to 2021, reaching $6,107 in 2021, averaging $5,736. Tanker OPEX dropped in 2020 but rose in 2021 as the market rebounded, averaging $6,941. In 2019, LNG-LPG carriers experienced the biggest rise, peaking at $7,163, probably due to increased demand for liquefied natural gas (LNG) and liquefied petroleum gas (LPG) as cleaner energy transition fuels. Although the average dropped in 2021, it remained high at $6,634, indicating significant operational expenditures for this specialist segment. Container ship OPEX fell in 2019 and 2020, potentially due to trade tensions and COVID-19's first impact on global trade. After lockdowns, consumer demand rose, boosting 2021's OPEX to $5,799, averaging $5,508. The maritime transport industry's response to global economic developments, environmental laws, and shipping demand cyclicity shaped OPEX trends throughout this time.

This paper aims to conduct a comparative analysis of the OPEX associated with tankers and bulk carriers (bulkers), which are widely recognized as two prominent vessel types within the maritime industry. Tankers and bulkers are distinct types of vessels that serve different purposes in the transportation industry. Tankers are primarily used for transporting liquid cargoes, such as crude oil or oil products, while bulkers are designed to carry dry bulk cargoes, including grain and coal. These two types of vessels exhibit varying operational characteristics and cost structures. The objective of this study is to analyze and compare the OPEX of two distinct vessel types from 2018 to 2022. Through this analysis, we seek to enhance comprehension of the financial dynamics associated with these vessels and make a valuable contribution to the field of cost management within the maritime industry.

This study will additionally examine the influence of different vessel characteristics on OPEX, encompassing vessel age, size, and type, alongside the ramifications of the COVID-19 pandemic.

The objective of this paper is the understand OPEX behavior and its relation with vessel type, vessel age and also vessel size. The paper aims to present a thorough examination of vessel operating expenses, elucidating the financial intricacies of the maritime sector and providing valuable insights to assist ship owners and operators in effectively managing the complexities and prospects of the present-day maritime environment.

The paper presents OPEX changes based on these variables. It hypothesizes a positive correlation between OPEX and vessel size and a negative correlation with Vessel age.

One notable limitation of the study pertains to the temporal scope, as we have restricted our investigation to the period commencing from 2018. This constraint arises from the utilization of the Moore Maritime Index (MMI) database, which exclusively contains data from 2018 onwards.

The rest of this paper is structured as follows. Section 2 provides a comprehensive literature review on the financial performance of the shipping industry. The studies presented in this section examine the variables that appear to influence the financial performance of maritime companies. Section 3 presents the data utilized in this study and its respective sources. Furthermore, this section provides a comprehensive explanation of the methodology employed in this study to analyze the data. Section 4 presents and discussed the data analysis and findings. Finally, Section 5 concludes the study by discussing the overall findings of the study, which are based on the results obtained from data analysis. Additionally, in this section, the study suggests potential areas for future research in this field.

2. LITERATURE REVIEW

In the relevant literature, one can find a lot of studies dealing with the financial performance of shipping companies. Most of these studies use accounting variables relevant to their research interests, such as return on assets (ROA), return on equity (ROE), operating profit, turnover, and so on (Randy et al., 2003; Lam et al., 2007; Lun et al., 2010).

Kang et al. (2015) have shown here that, despite the highly capital-intensive nature of the shipping industry, profitability — rather than asset growth, liquidity, and asset efficiency — are the most important factors that influence economic performance and investors' perception of shipping companies.

Many studies attempt to find a relation between the financial performance of ship-owning companies and qualitative shipping variables.

Pawlik et al. (2011) evaluated the value of shipping lines' investments in container terminal operations, using various performance measures, including economic value added (EVA). Randy et al. (2003) examined the effect of corporate governance on the financial performance of 32 Norwegian and Swedish publicly traded maritime firms in 1996–1998, and ROA, ROE, and return on sales were used as measures of firm performance.

Panayides et al. (2011) compare the financial performance of shipping sub-sectors. They examine the relative efficiency of firms in dry, wet, and container shipping markets. They found that the operating performance efficiency of maritime firms is not consistent. Tanker companies are more market efficient, whereas container shipping firms are found to have high operating performance efficiency but are market inefficient. Dry bulk firms were found to have the lowest ratings of market efficiency.

Jenssen and Randy (2006) investigated the impact of innovation on performance in the Norwegian shipping industry and found that innovation contributes to firm performance.

Lam et al. (2007), focusing on the container sector, study the relationship between financial performance and container routes. They conclude that there is no significant relationship between concentration levels in the shipping routes and the financial performance of liner companies.

Lambertides and Louca (2008) examined the ownership structure and operating performance of listed European maritime firms in 2002–2004. In this paper, we examine the relationship between ownership structure and operating performance for European maritime firms. Using a sample of 266 firm-year observations, during the period 2002–2004, they found that operating performance is positively related to foreign-held shares and investment corporation-held shares, indicating better investor protection from managerial opportunism.

Bang et al. (2012), focusing on container ships, examined the relationship between operational and strategic management on operational and financial performance. According to their findings, firm size (in terms of TEU (twenty-foot equivalent unit) capacity), ship size, the ratio of chartered vessels, the use of new vessels, and the formation of alliances all make a positive contribution to the financial performance of liner shipping companies. On the other hand, ship age and ship type did not show a significant contribution to the financial performance, and for operational performance, none of these determinant factors were significant.

Belesis et al. (2021) studied the effect of the adoption of International Financial Reporting Standards 15 and 16 (IFRS 15 & IFRS 16) on the presented financial performance of maritime companies. They found that the effects of IFRS 15 on the maritime sector will be quite limited and mainly concern the charging of some direct voyage expenses, which can be considered contract costs, between accounting periods. On the other hand, the effects of IFRS 16 will have significant effects on financial statements and on the presented financial position of companies. The most significant impacts include a strong increase in leverage ratios, an increase in gross profits, and an enormous increase in balance sheet amounts. The standard leads to an "inflation" of the balance sheet level and to a significant increase in the materiality of financial statements.

Sigalas (2022), focusing on the effects of IMO's sulfur cap regulation in January 2020, demonstrated the business paradigm disruption caused by this regulation. The results of his study indicate that the increased price of IMO-compliant fuel oils and charterers' bargaining power had curtailed ship-owners' gross profit margins.

Acciaro and Sys (2020), focused on innovation in the maritime industry and how the results of an innovation-focused strategy. They concluded that the achievement of innovation in the maritime logistics industry frequently does not align with the strategic goals of a company. Occasionally, success is attained for objectives that are not considered crucial by the company (incidental success), while in other instances, innovation falls short of accomplishing significant objectives (innovation failure). Also, Tijan et al. (2021) performed a literature review of the drivers, success factors, and barriers to digital transformation in the maritime transport sector.

Koutoupis et al. (2022) studied how the shipping sector has been affected by the COVID-19 pandemic. Their findings reveal that the shipping companies' level of systematic risk increased after the pandemic. In addition, the beta coefficient of shipping companies is more affected by changes in bunker prices since the pandemic, and the average daily returns and bunker prices have a lower correlation after the pandemic.

Also, Millefiori et al. (2021) examined the effect of COVID-19 on maritime industry. They found an unprecedented drop in maritime mobility across all categories of commercial shipping. With few exceptions, a generally reduced activity is observable from March to June 2020, when the most severe restrictions were in force. They quantify a variation of mobility between -5.62% and -13.77% for container ships, between +2.28% and -3.32% for dry bulk, between -0.22% and -9.27% for wet bulk, and between -19.57% and -42.77% for passenger traffic.

Even though OPEX are a crucial financial variable in the financial performance of a ship-owning company (or group), this variable is ignored or not fully analyzed in models regarding shipping economics. This occurs because either this variable is considered as an exogenous variable that is insignificantly affected by ship-owning companies, or researchers cannot access data regarding OPEX (a problem that now seems to be solved through access to MMI). Because of this, there are very few papers on shipping economics that actually focus on this very important variable.

Beenstock and Vergottis (1993), in their book titled *"Econometric Modelling of World Shipping"*, include opex as an exogenous factor. They constructed an opex index given by the ratio of the 'industrialized countries wholesale price index' published by IFS2 and the US-Dollar SDR3 exchange rate.

Ådland and Cullinane (2005) demonstrated that the risk premium needs to be dynamic and should systematically rely on freight market conditions and the duration of a time charter period. The study examines the indicators of the risk premium associated with different risk factors and concludes that the theoretical net risk premium is typically negative. However, it may fluctuate in the case of a short-term charter during a robust freight market.

In Adland and Strandenes (2006), the freight rate is determined by the marginal costs of any vessel (i.e., OPEX) that satisfies the demand for transportation. They conclude that when almost all vessels are employed (as was the case in 2003–2005), the possibilities to increase supply are higher speed, reduced port time, shorter ballast legs, and delaying regular maintenance. Therefore, OPEX changes during times of full employment.

Koehn (2008) conducted a study focusing on OPEX and their behaviour in relation to vessel characteristics. He examined the variation of OPEX across vessels of different types, sizes, ages, and hire rate levels. The estimation results show that OPEX depends on these factors in a non-linear way, revealing several different effects that significantly alter OPEX in a non-trivial fashion. Regarding the age, their findings indicate that OPEX is positively correlated, but not linearly, with the vessel's age. OPEX increase with respect to age with a decreasing slope. Vessels between zero and three years of age exhibit a considerably larger positive slope than vessels between four and 20 years of age where the slope seems to be constant. After the age of 20 years, there is the 'near-scrapping-age' effect, where the owner decides that it is not worth any maintenance cost for a vessel that is going to be scrapped in the next few years. Thus, until the end of the vessel's life, efforts are made to maximize profit while reducing costs to a minimum. For these last years, there is a negative correlation between age and OPEX.

Regarding the size, they find that OPEX is also positively and not linearly correlated with the vessel's size. They observe a steeper increase of OPEX for smaller vessel sizes, between approximately 10,000 DWT and 50,000 DWT, and a smaller positive slope for vessels larger than 50,000 DWT. As for vessel type, they find significant differences between the different vessel types, with chemical tankers being the most expensive regarding OPEX.

Finally, regarding the hire rate level, they find a strong correlation between OPEX and the earnings of vessels running under time charter contracts for low hire rate levels. This can be explained because, during periods with low hire rates, low-income operators are able to save money by spending less on OPEX. On the other hand, during periods of high earnings, there seems to be no significant correlation between OPEX and TC earnings, as even though operators can reduce OPEX during times of near break-even point, they do not spend more during times of unexpectedly high rates, which reflects a rational management.

This study adds to the existing literature an OPEX behavioural analysis based on the most recent data from the previous years. Additionally, this study contributes by focusing on the effect of COVID-19 on OPEX.

3. DATA AND METHODOLOGY

Our sample covered the period 2018–2021 and included tankers and bulk carriers. The vessels are categorized as tankers and bulk carriers. The categorization of vessels into subcategories is determined by their deadweight tonnage (DWT). The subcategories, as per the MMI, are displayed in Table 1 and Table 2.

Table 1. Tankers

Vessel category	*DWT*	
	From	*To*
Small tanker	Min	19,999
Handy	20,000	49,999
Panamax	50,000	79,999
Aframax	80,000	119,999
Suezmax	120,000	179,999
VLCC	180,000	319,999

Table 2. Bulkers

Vessel category	*DWT*	
	From	*To*
Handysize	Min	39,999
Handymax	20,000	49,999
Panamax	50,000	79,999
Capesize	125,000	Max

Furthermore, the subcategories are divided based on the age of the vessel. The age categories are displayed in Table 3.

Table 3. Age categories

Built period	*Year*
Built period 1	1998–2002
Built period 2	2003–2007
Built period 3	2008–2012
Built period 4	2013–2017
Built period 5	2018–2022

The OPEX data for the years 2018 to 2022 regarding each of the above subcategories was extracted from the MMI database. We chose this database as the MMI database is one of the largest and most reliable databases in the world regarding maritime operating expenses. The MMI database is operated by Audit Firm Moore Greece, which is a top audit company specializing in the audit of financial statements of maritime companies.

In instances where the sample size of the MMI database was insufficient, the database did not yield data pertaining to this specific category. This omission was implemented to safeguard the confidentiality and anonymity of the ship-owning companies associated with the vessels falling within this limited category. The research was confined solely to tankers and bulkers, with no inclusion of other vessel categories such as LNG, containers, etc. We chose to exclude these categories because data for many subcategories of the other vessel categories were unavailable from MMI due to confidentiality concerns, as explained above. The data for bulkers and tankers are presented in Table 4 and Table 5, respectively.

More specifically, for each vessel type subcategory, we extract the average daily OPEX level from MMI for a specific year and vessel age cluster. Regarding vessel type subcategories, we followed the classification of MMI. In terms of age clusters, we restricted our sample to vessels with a maximum age of 25 years, which is considered the normal useful life of vessels in the maritime industry. We established five clusters, each with a five-year construction period.

Our research is advanced through a quite simple statistical analysis of the data. The average OPEX between different types of vessels is compared for each age category through the examined period. Furthermore, we examined the manner in which OPEX are altered as the vessels age for each respective type of vessel.

In addition, we conduct an analysis of the temporal evolution of OPEX within each subcategory, as well as its impact on OPEX attributable to the COVID-19 pandemic. This analysis involves examining the average price fluctuations between the pre-COVID-19 and during-COVID-19 periods.

As the last step, we compare the OPEX level between bulk carriers and tankers. In all of the aforementioned queries, we take the average OPEX of each vessel subclass and draw conclusions using applicable graphs.

Our study's narrow period sample could be a limitation. Furthermore, because the MMI sample only included non-listed maritime companies, our study is limited to non-listed companies.

Table 4. Data for bulkers

Vessel category	*Built period*	*DWT*		*Daily OPEX*				*Average*	*Standard deviation*
		From	*To*	*2018*	*2019*	*2020*	*2021*		
Handysize	1998–2002	10,000	39,999	5,099.00	4,932.00	4,961.00	5,903.00	5,223.75	397.21
Handysize	2003–2007	10,000	39,999	5,236.00	5,343.00	5,257.00	5,428.00	5,316.00	76.08
Handysize	2008–2012	10,000	39,999	4,991.00	4,886.00	5,004.00	5,135.00	5,004.00	88.39
Handysize	2013–2017	10,000	39,999	4,827.00	5,044.00	5,174.00	5,316.00	5,090.25	179.87
Handysize	2018–2022	10,000	39,999	n/a	n/a	n/a	n/a	n/a	n/a
Handysize	**1998–2022**	**10,000**	**39,999**	**5,076.00**	**5,063.00**	**5,069.00**	**5,496.00**	**5,176.00**	**184.81**
Handymax	1998–2002	40,000	59,999	6,225.00	5,896.00	6,093.00	7,214.00	6,357.00	508.45
Handymax	2003–2007	40,000	59,999	6,058.00	6,088.00	6,081.00	6,649.00	6,219.00	248.51
Handymax	2008–2012	40,000	59,999	5,588.00	5,663.00	5,908.00	5,985.00	5,786.00	164.94
Handymax	2013–2017	40,000	59,999	5,230.00	5,815.00	5,756.00	6,292.00	5,773.25	376.25
Handymax	2018–2022	40,000	59,999	n/a	n/a	n/a	n/a	n/a	n/a
Handymax	**1998–2022**	**40,000**	**59,999**	**5,751.00**	**5,830.00**	**5,968.00**	**6,257.00**	**5,951.50**	**192.72**
Panamax	1998–2002	60,000	124,999	5,397.00	5,373.00	5,913.00	6,152.00	5,708.75	334.70
Panamax	2003–2007	60,000	124,999	5,945.00	5,817.00	5,931.00	6,041.00	5,933.50	79.48
Panamax	2008–2012	60,000	124,999	5,493.00	5,670.00	5,762.00	6,186.00	5,777.75	254.76
Panamax	2013–2017	60,000	124,999	5,213.00	5,319.00	5,468.00	6,081.00	5,520.25	336.18
Panamax	2018–2022	60,000	124,999	n/a	5,279.00	5,114.00	5,554.00	5,315.67	181.49
Panamax	**1998–2022**	**60,000**	**124,999**	**5,471.00**	**5,509.00**	**5,676.00**	**5,999.00**	**5,663.75**	**208.35**
Capesize	1998–2002	125,000	Max	n/a	n/a	n/a	n/a	n/a	n/a
Capesize	2003–2007	125,000	Max	6,206.00	6,511.00	6,546.00	6,499.00	6,440.50	136.49
Capesize	2008–2012	125,000	Max	6,693.00	7,003.00	6,828.00	7,274.00	6,949.50	217.21
Capesize	2013–2017	125,000	Max	5,906.00	n/a	n/a	n/a	5,906.00	0.00
Capesize	2018–2022	125,000	Max	n/a	n/a	n/a	n/a	n/a	n/a
Capesize	**1998–2022**	**125,000**	**Max**	**6,378.00**	**6,669.00**	**6,754.00**	**7,146.00**	**6,736.75**	**274.35**

Table 5. Data for tankers

Vessel category	*Built period*	*DWT*		*Daily OPEX*				*Average*	*Standard deviation*
		From	*To*	*2018*	*2019*	*2020*	*2021*		
Small tanker	1998–2002	Min	19,999	n/a	n/a	n/a	n/a	n/a	n/a
Small tanker	2003–2007	Min	19,999	5,210.00	5,299.00	5,432.00	5,198.00	5,284.75	93.54
Small tanker	2008–2012	Min	19,999	5,264.00	5,303.00	5,654.00	5,684.00	5,476.25	193.53
Small tanker	2013–2017	Min	19,999	n/a	n/a	n/a	n/a	n/a	n/a
Small tanker	2018–2022	Min	19,999	n/a	n/a	n/a	n/a	n/a	n/a
Small tanker	**1998–2022**	**Min**	**19,999**	**5,401.00**	**5,464.00**	**5,752.00**	**5,743.00**	**5,590.00**	**159.10**
Handy	1998–2002	20,000	49,999	n/a	n/a	7,128.00	n/a	7,128.00	0.00
Handy	2003–2007	20,000	49,999	6,897.00	6,776.00	6,790.00	7,124.00	6,896.75	139.30
Handy	2008–2012	20,000	49,999	6,322.00	6,325.00	6,500.00	7,054.00	6,550.25	299.64
Handy	2013–2017	20,000	49,999	n/a	n/a	n/a	n/a	n/a	n/a
Handy	2018–2022	20,000	49,999	n/a	n/a	5,757.00	6,295.00	6,026.00	269.00
Handy	**1998–2022**	**20,000**	**49,999**	**6,760.00**	**6,705.00**	**6,500.00**	**6,942.00**	**6,726.75**	**157.58**
Panamax	1998–2002	50,000	79,999	n/a	n/a	n/a	n/a	n/a	n/a
Panamax	2003–2007	50,000	79,999	7,543.00	6,982.00	7,298.00	7,371.00	7,298.50	203.23
Panamax	2008–2012	50,000	79,999	6,656.00	6,709.00	6,743.00	7,373.00	6,870.25	291.91
Panamax	2013–2017	50,000	79,999	6,509.00	6,514.00	6,363.00	6,674.00	6,515.00	110.02
Panamax	2018–2022	50,000	79,999	n/a	n/a	n/a	n/a	n/a	n/a
Panamax	**1998–2022**	**50,000**	**79,999**	**6,747.00**	**6,730.00**	**6,571.00**	**6,971.00**	**6,754.75**	**142.48**
Aframax	1998–2002	80,000	119,999	7,918.00	n/a	n/a	n/a	7,918.00	0.00
Aframax	2003–2007	80,000	119,999	7,147.00	6,935.00	6,878.00	7,669.00	7,157.25	312.00
Aframax	2008–2012	80,000	119,999	6,886.00	7,122.00	7,327.00	7,500.00	7,208.75	229.40
Aframax	2013–2017	80,000	119,999	6,871.00	7,630.00	7,015.00	6,986.00	7,125.50	296.21
Aframax	2018–2022	80,000	119,999	n/a	n/a	6,622.00	7,043.00	6,832.50	210.50
Aframax	**1998–2022**	**80,000**	**119,999**	**7,095.00**	**7,156.00**	**7,164.00**	**7,190.00**	**7,151.25**	**34.82**

4. DATA ANALYSIS

4.1. Operating expenses and vessel age

This section focuses on examining the relationship between the age of vessels and the corresponding changes in OPEX. Table 6 displays the OPEX pertaining to each vessel category and age cluster. Figures 1a and 1b depict the variations in OPEX levels over the lifespan of vessels.

Table 6. OPEX for bulkers as per vessels' age

Vessel category	*Built period*	*Daily OPEX in $*					*% Change per year*	*Average % change*
Bulkers		***2018***	***2019***	***2020***	***2021***	***Average***		
Handysize	1998–2002	5,099.00	4,932.00	4,961.00	5,903.00	5,223.75	n/a	-0.79%
Handysize	2003–2007	5,236.00	5,343.00	5,257.00	5,428.00	5,316.00	1.77%	
Handysize	2008–2012	4,991.00	4,886.00	5,004.00	5,135.00	5,004.00	-5.87%	
Handysize	2013–2017	4,827.00	5,044.00	5,174.00	5,316.00	5,090.25	1.72%	
Handysize	**2018–2022**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	
Handymax	1998–2002	6,225.00	5,896.00	6,093.00	7,214.00	6,357.00	n/a	-3.12%
Handymax	2003–2007	6,058.00	6,088.00	6,081.00	6,649.00	6,219.00	-2.17%	
Handymax	2008–2012	5,588.00	5,663.00	5,908.00	5,985.00	5,786.00	-6.96%	
Handymax	2013–2017	5,230.00	5,815.00	5,756.00	6,292.00	5,773.25	-0.22%	
Handymax	**2018–2022**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	
Panamax	1998–2002	5,397.00	5,373.00	5,913.00	6,152.00	5,708.75	n/a	-1.71%
Panamax	2003–2007	5,945.00	5,817.00	5,931.00	6,041.00	5,933.50	3.94%	
Panamax	2008–2012	5,493.00	5,670.00	5,762.00	6,186.00	5,777.75	-2.62%	
Panamax	2013–2017	5,213.00	5,319.00	5,468.00	6,081.00	5,520.25	-4.46%	
Panamax	**2018–2022**	**n/a**	**5,279.00**	**5,114.00**	**5,554.00**	**5,315.67**	**-3.71%**	
Capesize	1998–2002	n/a	n/a	n/a	n/a	n/a	n/a	-3.56%
Capesize	2003–2007	6,206.00	6,511.00	6,546.00	6,499.00	6,440.50	n/a	
Capesize	2008–2012	6,693.00	7,003.00	6,828.00	7,274.00	6,949.50	7.90%	
Capesize	2013–2017	5,906.00	n/a	n/a	n/a	5,906.00	-15.02%	
Capesize	**2018–2022**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	
Average								**-2.29%**

Figure 1a. OPEX for bulkers per age (bars)

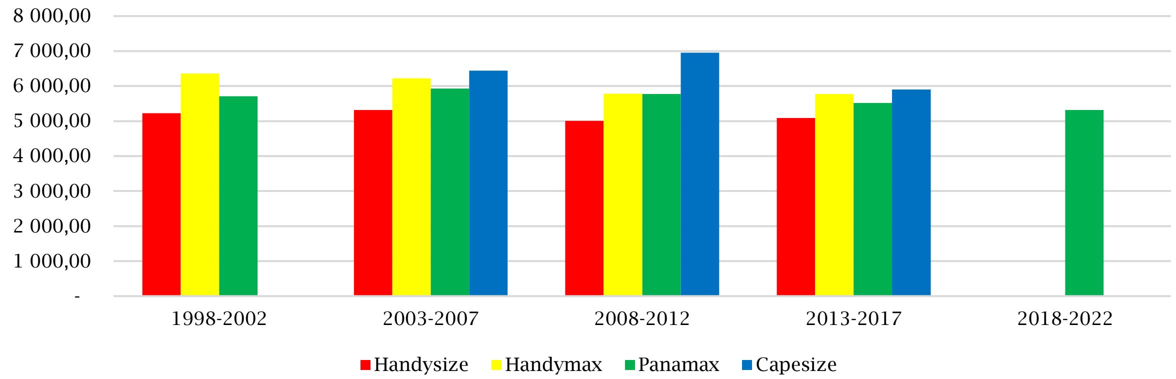
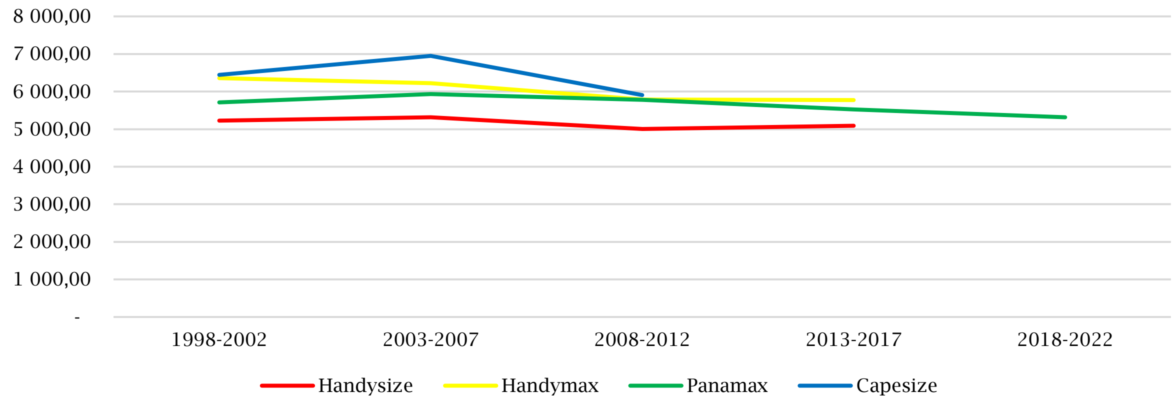


Figure 1b. OPEX for bulkers per age (lines)



Based on the Table 6 and Figures 1a and 1b, it is evident that the anticipated outcome is substantiated, wherein the OPEX exhibit a decline in tandem with the vessel's age reduction. In comparison to older vessels, more recent vessels generally exhibit lower annual OPEX. Additionally, it is evident that larger vessels exhibit a higher rate of decrease of OPEX as the age decreases in comparison to smaller vessels. The annual average reduction in OPEX for Handysize vessels is approximately 0.79%, while for Capesize vessels, it is 3.56%.

Table 7. OPEX for tankers as per vessels' age

Vessel category	*Built period*	*Daily OPEX in $*					*% Change per year*	*Average % change*
Bulkers		*2018*	*2019*	*2020*	*2021*	*Average*		
Small tanker	1998–2002	n/a	n/a	n/a	n/a	n/a	n/a	
Small tanker	2003–2007	5,210.00	5,299.00	5,432.00	5,198.00	5,284.75	n/a	
Small tanker	2008–2012	5,264.00	5,303.00	5,654.00	5,684.00	5,476.25	3.62%	3.62%
Small tanker	2013–2017	n/a	n/a	n/a	n/a	n/a	n/a	
Small tanker	**2018–2022**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	
Handy	1998–2002	n/a	n/a	7,128.00	n/a	7,128.00	n/a	
Handy	2003–2007	6,897.00	6,776.00	6,790.00	7,124.00	6,896.75	-3.24%	
Handy	2008–2012	6,322.00	6,325.00	6,500.00	7,054.00	6,550.25	-5.02%	-4.13%
Handy	2013–2017	n/a	n/a	n/a	n/a	n/a	n/a	
Handy	**2018–2022**	**n/a**	**n/a**	**5,757.00**	**6,295.00**	**6,026.00**	**n/a**	
Panamax	1998–2002	n/a	n/a	n/a	n/a	n/a	n/a	
Panamax	2003–2007	7,543.00	6,982.00	7,298.00	7,371.00	7,298.50	n/a	
Panamax	2008–2012	6,656.00	6,709.00	6,743.00	7,373.00	6,870.25	-5.87%	-5.52%
Panamax	2013–2017	6,509.00	6,514.00	6,363.00	6,674.00	6,515.00	-5.17%	
Panamax	**2018–2022**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	
Aframax	1998–2002	7,918.00	n/a	n/a	n/a	7,918.00	n/a	
Aframax	2003–2007	7,147.00	6,935.00	6,878.00	7,669.00	7,157.25	n/a	
Aframax	2008–2012	6,886.00	7,122.00	7,327.00	7,500.00	7,208.75	0.72%	-0.22%
Aframax	2013–2017	6,871.00	7,630.00	7,015.00	6,986.00	7,125.50	-1.15%	
Aframax	**2018–2022**	**n/a**	**n/a**	**6,622.00**	**7,043.00**	**6,832.50**	**n/a**	
Average								**-1.56%**

Figure 2a. OPEX for tankers per age (bars)

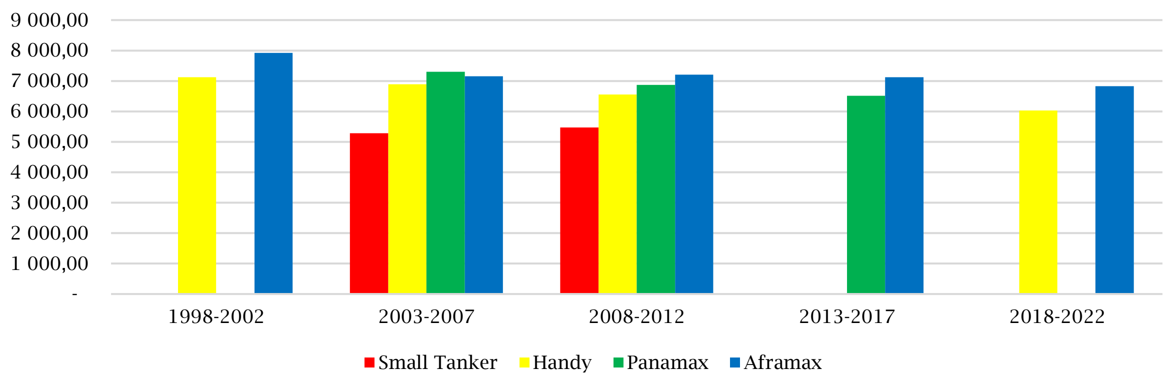
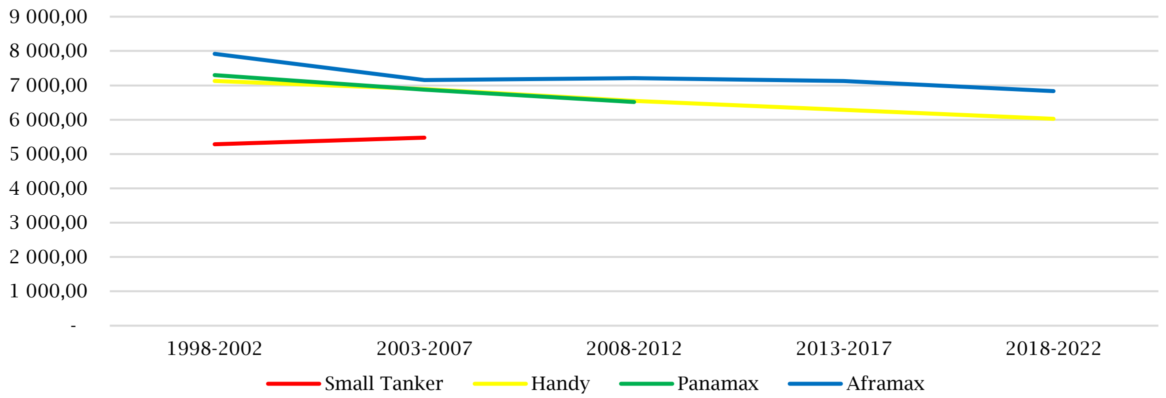


Figure 2b. OPEX for tankers per age (lines)



Based on Table 7 and Figures 2a and 2b, it is evident that the observed trend aligns with logical expectations, wherein the OPEX exhibit a decrease as the age of the vessel decreases. It is important to note that the analysis excludes small tankers due to a notable lack of available data. In comparison to older vessels, more recent vessels generally exhibit lower annual OPEX. Additionally, there is evidence suggesting that larger vessels exhibit a higher rate of decrease in comparison to smaller vessels.

Table 8 displays the mean daily OPEX for both older and newer vessels.

Table 8. OPEX for newer vs older vessels

Vessel category	*Built period*	*2018*	*2019*	*2020*	*2021*	*Average*
Tankers	1998–2002	7,913.00	7,631.00	8,223.00	7,147.00	
Tankers	2018–2022	6,833.00	6,614.00	6,244.00	6,805.00	
Difference $		1,080.00	1,017.00	1,979.00	342	1,104.5
Difference %		-13.65%	-13.33%	-24.07%	-4.79%	-13.96%
Bulk carriers	1998–2002	5,723.00	5,569.00	5,905.00	6,423.00	
Bulk carriers	2018–2022	5,569.00	5,077.00	5,058.00	5,422.00	
Difference $		154	492	847	1,001	623.5
Difference %		-2.69%	-8.83%	-14.34%	-15.58%	-10.36%

As evidenced by the Table 8, the disparity in OPEX between older and newer vessels is notably pronounced for tankers, both in terms of percentage and nominal values.

In relation to tankers, the annual disparity between an older and newer vessel amounts to approximately $400,000 ($1,104.5 multiplied by 365 days). Similarly, for bulkers, the pertinent yearly discrepancy is estimated to be around $228,000 ($623.5 multiplied by 365 days).

Despite the apparent significance of the quantities involved, it is important to acknowledge that these disparities have been progressively increasing during the final years of a vessel's operational lifespan. Moreover, when considering the exorbitant costs associated with acquiring a new vessel, it becomes evident that these discrepancies alone cannot serve as the sole justification for replacing a two-decade-old vessel with a new one. Certainly, the management of shipping companies must take into account the gradual increase in operating expenses over time for the purpose of managerial accounting.

To summarize, we determined from the preceding analysis that the OPEX level is higher for older vessels. The level of OPEX is related to the age of the vessels. This finding is consistent with Koehn (2008), who discovered a positive relationship as well. OPEX logically increases as the vessel ages because as the vessel ages, it requires more expenses for maintenance and repairs, such as spare parts, and therefore the relevant cost (repair and maintenance cost are components of OPEX) rise. Because of the requirement for repair and maintenance, the crew must work more hours on these duties, which raises salary costs (a component of OPEX).

Additionally, as stated by Koehn (2008), it is necessary to consider certain distinct consequences resulting from the actions of shipowners. During the initial two-three years of a vessel's lifespan, OPEX are notably lower in comparison to older vessels. The reason for this is because the vessel is newly built and it is necessary to conduct its first routine drydocking, special class, or survey during the first two years of operation. Moreover, these are less expensive initially compared to their subsequent costs over the working period. Consequently, there is an anticipation that operational expenses will experience a rapid escalation in the initial years, in contrast to the subsequent duration of the project. Furthermore, as a vessel approaches the end of its anticipated lifespan, the owner may exhibit less commitment to ship maintenance or drydocking. They will operate the yacht only for as long as it is financially advantageous while reducing expenses on operational expenditures.

4.2. Operating expenses in the period 2018–2022

4.2.1. Bulk carriers

Subsequently, we proceed with our analysis by examining the fluctuations in OPEX throughout the specified time frame. Table 9 and Figures 3 to 7 depict the variations in OPEX throughout the span of four years.

Table 9. Bulkers OPEX changes through time

Vessel category	*Built period*	*2018–2019*	*2019–2020*	*2020–2021*	*Average change per year*	*Entire period change %*	*Pre-COVID 2018–2019*	*COVID 2020–2021*	*% change*
		Yearly change % 2018–2019	*Yearly change % 2019–2020*	*Yearly change % 2020–2021*			*Average*	*Average*	
Handysize	1998–2002	-3.28%	0.59%	18.99%	5.43%	16%	5,015.50	5,432.00	8.30%
Handysize	2003–2007	2.04%	-1.61%	3.25%	1.23%	4%	5,289.50	5,342.50	1.00%
Handysize	2008–2012	-2.10%	2.42%	2.62%	0.98%	3%	4,938.50	5,069.50	2.65%
Handysize	2013–2017	4.50%	2.58%	2.74%	3.27%	10%	4,935.50	5,245.00	6.27%
Handysize	2018–2022	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Handysize	**1998–2022**	**-0.26%**	**0.12%**	**8.42%**	**2.76%**	**8.27%**	**5,069.50**	**5,282.50**	**4.20%**
Handymax	1998–2002	-5.29%	3.34%	18.40%	5.48%	16%	6,060.50	6,653.50	9.78%
Handymax	2003–2007	0.50%	-0.11%	9.34%	3.24%	10%	6,073.00	6,365.00	4.81%
Handymax	2008–2012	1.34%	4.33%	1.30%	2.32%	7%	5,625.50	5,946.50	5.71%
Handymax	2013–2017	11.19%	-1.01%	9.31%	6.49%	20%	5,522.50	6,024.00	9.08%
Handymax	2018–2022	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Handymax	**1998–2022**	**1.37%**	**2.37%**	**4.84%**	**2.86%**	**8.80%**	**5,790.50**	**6,112.50**	**5.56%**
Panamax	1998–2002	-0.44%	10.05%	4.04%	4.55%	14%	5,385.00	6,032.50	12.02%
Panamax	2003–2007	-2.15%	1.96%	1.85%	0.55%	2%	5,881.00	5,986.00	1.79%
Panamax	2008–2012	3.22%	1.62%	7.36%	4.07%	13%	5,581.50	5,974.00	7.03%
Panamax	2013–2017	2.03%	2.80%	11.21%	5.35%	17%	5,266.00	5,774.50	9.66%
Panamax	2018–2022	n/a	-3.13%	8.60%	2.74%	n/a	5,279.00	5,334.00	1.04%
Panamax	**1998–2022**	**0.69%**	**3.03%**	**5.69%**	**3.14%**	**9.65%**	**5,490.00**	**5,837.50**	**6.33%**
Capesize	1998–2002	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Capesize	2003–2007	4.91%	0.54%	-0.72%	1.58%	5%	6,358.50	6,522.50	2.58%
Capesize	2008–2012	4.63%	-2.50%	6.53%	2.89%	9%	6,848.00	7,051.00	2.96%
Capesize	2013–2017	n/a	n/a	n/a	n/a	n/a	5,906.00	n/a	n/a
Capesize	2018–2022	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Capesize	**1998–2022**	**4.56%**	**1.27%**	**5.80%**	**3.88%**	**12.04%**	**6,523.50**	**6,950.00**	**6.54%**

Figure 3. OPEX for bulkers built in the period 1998–2002

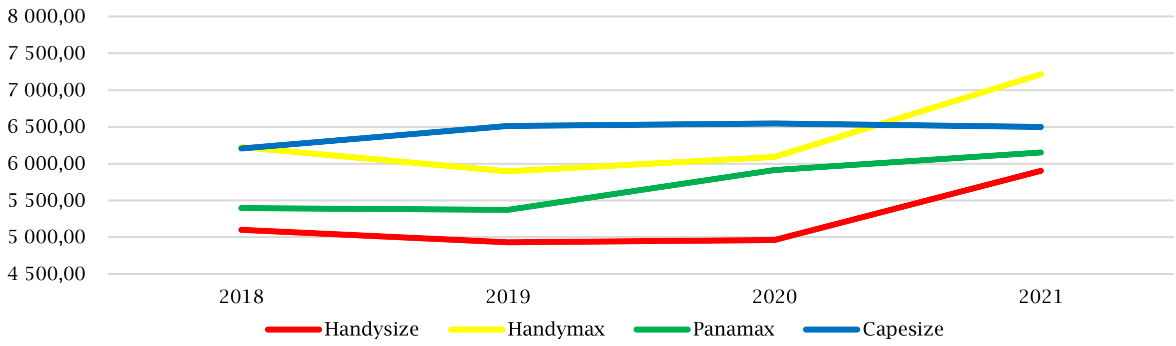


Figure 4. OPEX for bulkers built in the period 2003–2007

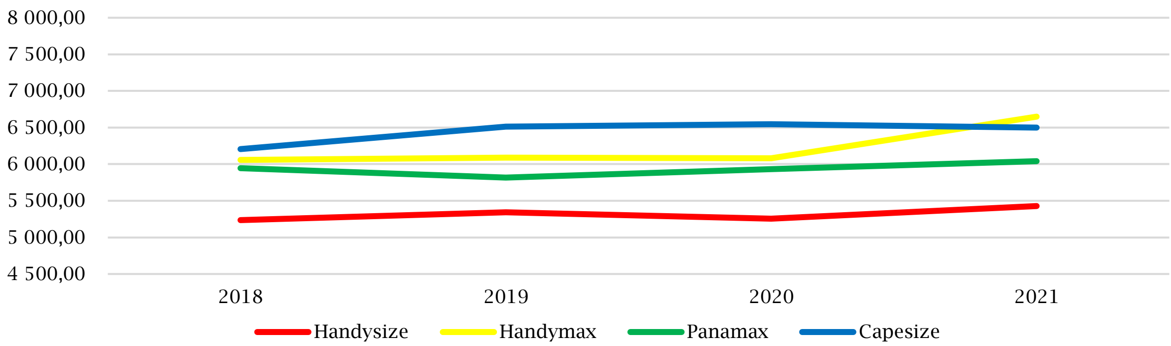


Figure 5. OPEX for bulkers built in the period 2008–2012

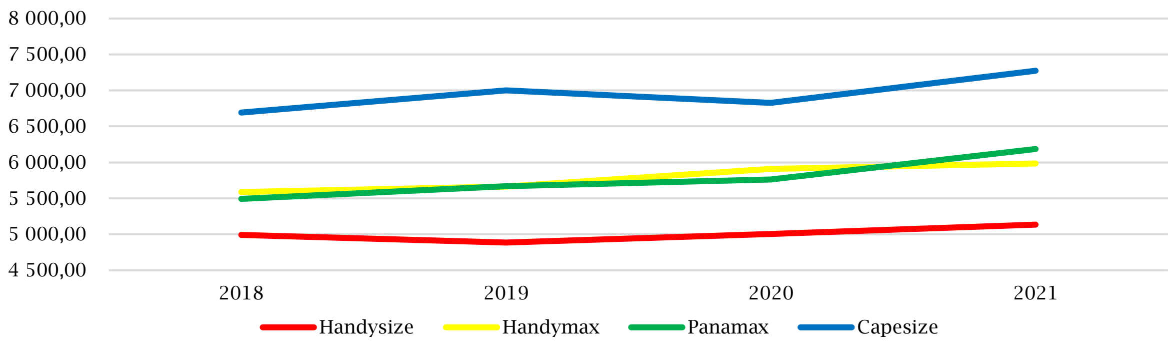


Figure 6. OPEX for bulkers built in the period 2013–2017

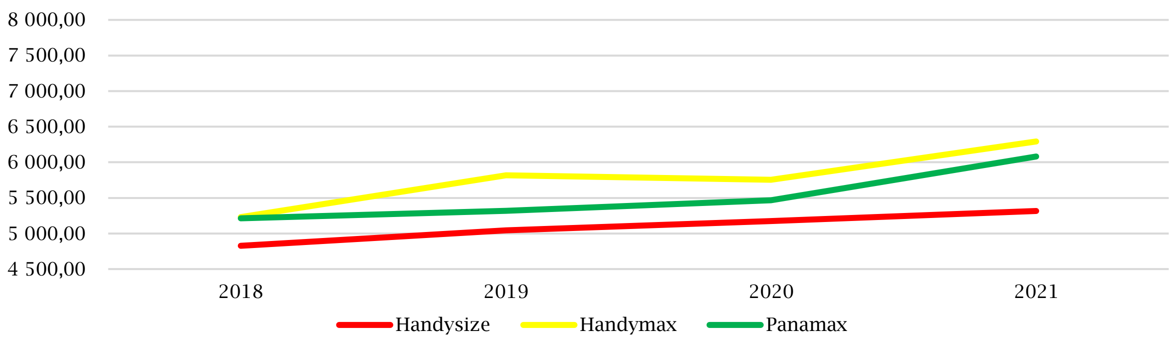
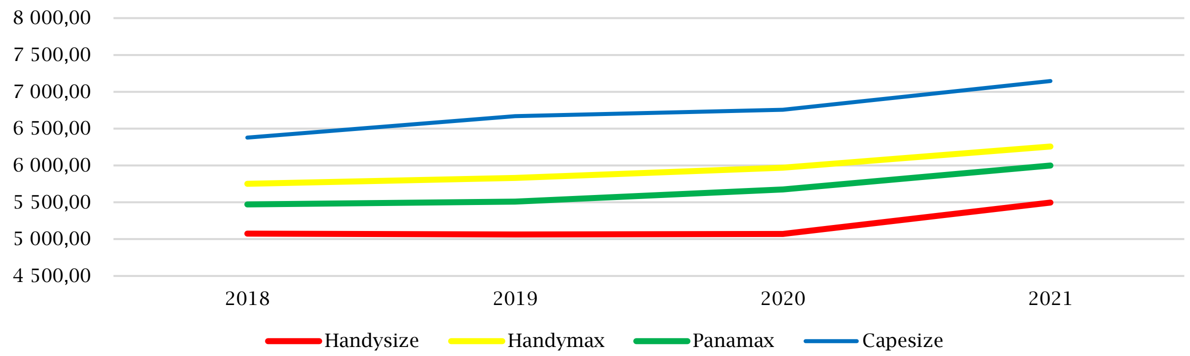


Figure 7. OPEX for bulkers



The data presented in Table 9 and Figures 3 to 7 indicate a positive correlation between vessel size and OPEX, aligning with logical and anticipated expectations. Furthermore, there was an observed increase in OPEX across all categories of bulk carrier vessels and their respective age clusters during the period under study. When examining the size of vessels, it was observed that the rate of increase exhibited a positive correlation with vessel size. It is expected that larger vessels will experience higher percentages of OPEX growth. The annual rate of change ranged from 2.76% for the smaller Handysize vessels to 3.88% for the largest Capsize vessels. The cumulative growth rate observed over the entire duration ranged from 8.27% for the smaller Handysize vessels to 12.04% for the largest Capsize vessels.

Upon initial examination, it is evident that the expenditures during the COVID-19 period (2020–2021) were greater in comparison to OPEX prior to the onset of the COVID-19 pandemic. There was a notable rise in the percentage, specifically from 4.20% for Handysize vessels to 6.54% for Capesize vessels, which is consistent with the respective sizes of these vessels.

At this juncture, it is imperative to ascertain whether the observed rise in OPEX during the COVID-19 period is attributable to the pandemic or to the broader inflationary trends in OPEX. This is essential to prevent significant methodological errors that may lead to erroneous conclusions.

To address the aforementioned inquiry, an examination of the yearly fluctuations in OPEX is conducted. This analysis aims to compare the annual increase in OPEX during the outbreak of the pandemic in 2020 with the previous annual increase observed between 2019 and 2018. However, the results are inconclusive, and the issue is exacerbating by the absence of historical data predating 2018, which hinders the availability of earlier annual OPEX fluctuations related to the COVID-19 pandemic.

In a more specific analysis, the impact of the pandemic outbreak on OPEX for Handysize vessels is negligible. Similarly, the deviation in OPEX from the previous year is also insignificant. However, for Handymax vessels, there is a noticeable increase in OPEX, with the percentage rising from 1.27% to 2.37%. Nevertheless, it is important to note that this difference cannot be regarded as significant. Based on the analysis of these two vessel categories, it can be deduced that the occurrence of the pandemic did not have any impact on OPEX. The Panamax data reveals a notable rise in the growth rate of OPEX during the outbreak of the pandemic, suggesting a direct correlation between the outbreak and the increase in OPEX. Conversely, a contrasting trend is observed in the case of Capesize vessels. In this instance, it can be observed that the rate of growth in OPEX experienced a notable decline, suggesting that the outbreak resulted in a stabilization or reduction of OPEX inflation.

When considering the upcoming year of the ongoing pandemic, it becomes evident that the growth rate of OPEX is poised to experience a substantial increase in comparison to the two preceding annual increments.

Based on the analysis of Bulkers, it can be inferred that the initial impact of the pandemic did not have a discernible effect on OPEX. However, in the subsequent year, a notable rise in OPEX was observed. One potential rationale for this phenomenon could be attributed to the significant reduction in crew turnover and subsequent decrease in crew expenses in 2020, which can be attributed to the widespread cancellation of flights.

At this juncture, it is imperative to ascertain whether the annual escalation stems from an inflationary surge in OPEX prices or from the advancing age of the vessel. In order to address this inquiry, we conducted an examination of OPEX specifically pertaining to vessels that were constructed in the previous year and were one year old, focusing on the time period spanning from 2018 to 2021.

Table 10 illustrates the OPEX and their annual fluctuations for bulkers that are one year old.

Table 10. OPEX for bulkers: 1-year-old vessels

Year/Built	*2018*	*2019*	*2020*	*2021*
Bulkers (2017)	5,059.00	-	-	-
Bulkers (2018)	-	5,245.00	-	-
Bulkers (2019)	-	-	4,819.00	-
Bulkers (2020)	-	-	-	5,617.00
% change	-	3.68%	-8.12%	16.56%
Average yearly change	-	4.04%		

The analysis reveals a decline in the OPEX level and growth rate of newly acquired vessels during the outbreak, followed by a substantial increase in the subsequent year. The observed increase in OPEX was not merely a reversal or correction of the preceding period's decrease. Rather, it was a substantial rise that resulted in a notably higher OPEX level compared to that of 2019. The current finding aligns with our previous research, which indicated an elevated level of OPEX and an increased growth rate during the second year of the pandemic.

On the contrary, these data partially align with our previous discovery that the pandemic outbreak did not result in an increase in the growth rate of OPEX. The data indicates that during the pandemic outbreak, there was not only an absence of OPEX growth but also a notable decrease in OPEX. Due to the limited range of the data samples, which span from eight to 37, it is not prudent to assert that there was a statistically significant reduction in OPEX during the outbreak of the pandemic.

In any event, the data pertaining to vessels aged one year aligns generally with our prior research findings and does not provide substantive evidence to suggest that our conclusions have been influenced by the ageing of vessels.

4.2.2. Tankers

Regarding tankers, Table 11 and Figures 8 to 11 presents OPEX changes over the four years period.

Table 11. Tankers OPEX changes through time

Vessel category	*Built period*	*2018–2019*	*2019–2020*	*2020–2021*	*Average change per year*	*Entire period change%*	*Pre-COVID 2018-2019*	*COVID 2020-2021*	*% change*
		Yearly change % 2018–2019	*Yearly change % 2019–2020*	*Yearly change % 2020–2021*			*Average*	*Average*	
Small tanker	1998–2002	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Small tanker	2003–2007	1.71%	2.51%	-4.31%	-0.03%	0%	5,254.50	5,315.00	1.15%
Small tanker	2008–2012	0.74%	6.62%	0.53%	2.63%	8%	5,283.50	5,669.00	7.30%
Small tanker	2013–2017	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Small tanker	2018–2022	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Small tanker	**1998–2022**	**1.17%**	**5.27%**	**-0.16%**	**2.09%**	**6.33%**	**5,432.50**	**5,747.50**	**5.80%**
Handy	1998–2002	n/a	n/a	n/a	n/a	n/a	n/a	7,128.00	n/a
Handy	2003–2007	-1.75%	0.21%	4.92%	1.12%	3%	6,836.50	6,957.00	1.76%
Handy	2008–2012	0.05%	2.77%	8.52%	3.78%	12%	6,323.50	6,777.00	7.17%
Handy	2013–2017	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Handy	2018–2022	n/a	n/a	9.35%	9.35%	n/a	n/a	6,026.00	n/a
Handy	**1998–2022**	**-0.81%**	**-3.06%**	**6.80%**	**0.98%**	**2.69%**	**6,732.50**	**6,721.00**	**-0.17%**
Panamax	1998–2002	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Panamax	2003–2007	-7.44%	4.53%	1.00%	-0.64%	-2%	7,262.50	7,334.50	0.99%
Panamax	2008–2012	0.80%	0.51%	9.34%	3.55%	11%	6,682.50	7,058.00	5.62%
Panamax	2013–2017	0.08%	-2.32%	4.89%	0.88%	3%	6,511.50	6,518.50	0.11%
Panamax	2018–2022	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Panamax	**1998–2022**	**-0.25%**	**-2.36%**	**6.09%**	**1.16%**	**3.32%**	**6,738.50**	**6,771.00**	**0.48%**
Aframax	1998–2002	n/a	n/a	n/a	n/a	n/a	7,918.00	n/a	n/a
Aframax	2003–2007	-2.97%	-0.82%	11.50%	2.57%	7%	7,041.00	7,273.50	3.30%
Aframax	2008–2012	3.43%	2.88%	2.36%	2.89%	9%	7,004.00	7,413.50	5.85%
Aframax	2013–2017	11.05%	-8.06%	-0.41%	0.86%	2%	7,250.50	7,000.50	-3.45%
Aframax	2018–2022	n/a	n/a	6.36%	6.36%	n/a	n/a	6,832.50	n/a
Aframax	**1998–2022**	**0.86%**	**0.11%**	**0.36%**	**0.44%**	**1.34%**	**7,125.50**	**7,177.00**	**0.72%**

Figure 8. OPEX for tankers built in the period 2003–2007

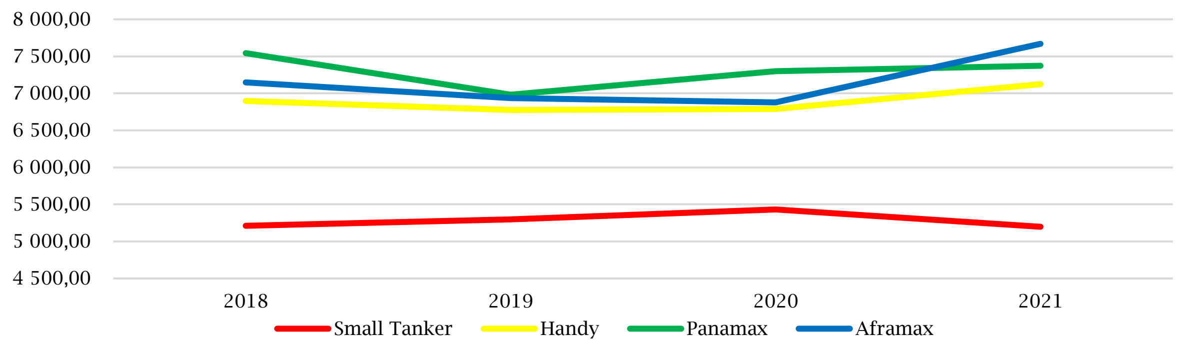


Figure 9. OPEX for tankers built in the period 2008–2012

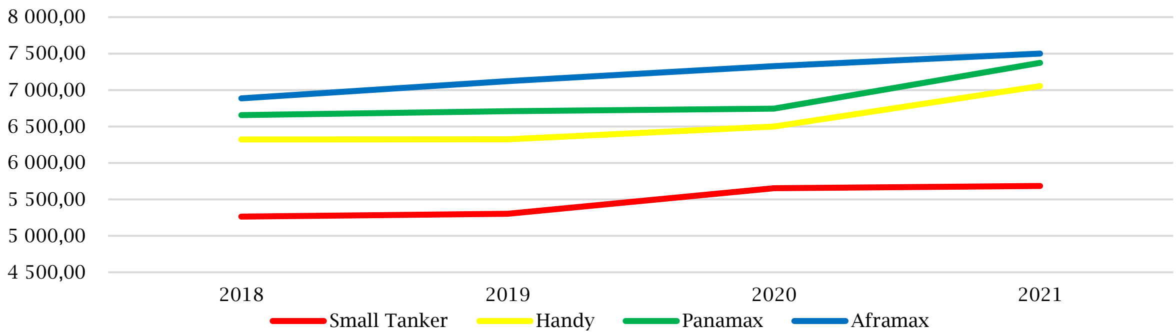


Figure 10. OPEX for tankers built in the period 2013–2017

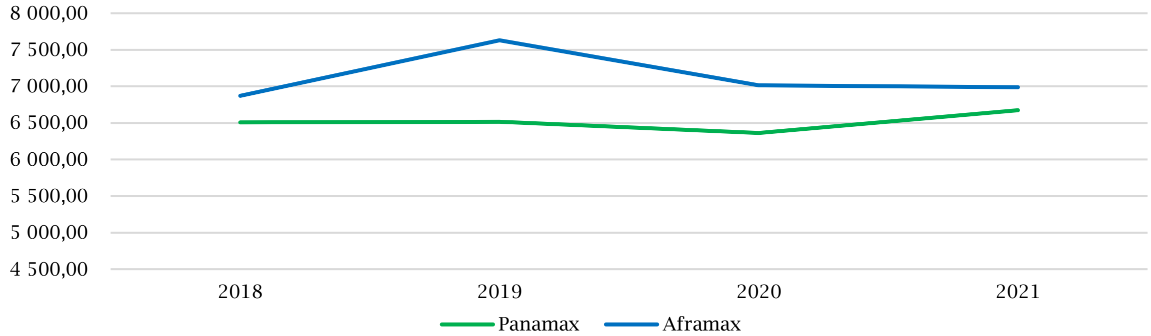
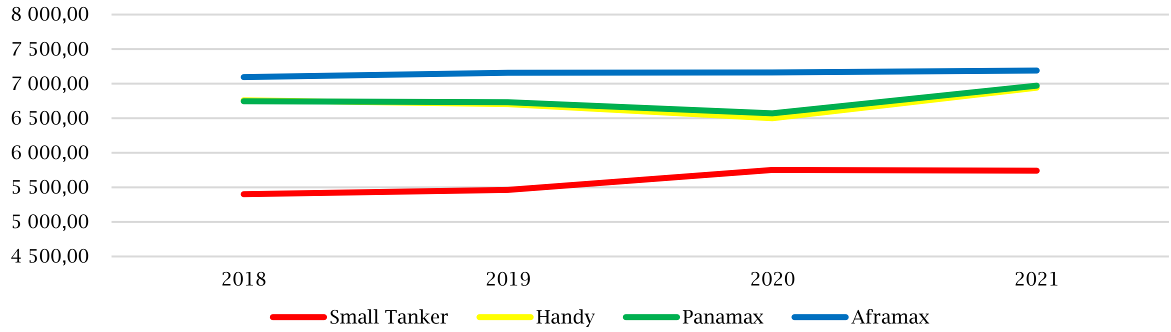


Figure 11. OPEX for tankers



Based on the Table 11 and Figures 8 to 11, it is evident that there exists a positive correlation between vessel size and OPEX, a result that aligns with logical expectations. Furthermore, it was observed that there was an increase in OPEX levels for all categories of bulk carrier vessels and their respective age clusters, with the exception of Panamax vessels constructed between the years 2003 and 2007, during the period under investigation. Contrary to bulkers, the rate of increase appears to be unrelated to vessel size.

Upon initial examination, it is evident that the expenditures during the COVID-19 period (2020–2021) were greater in comparison to the operational expenses prior to the onset of the COVID-19 pandemic. The sole anomaly pertains to the Handy vessels, as their OPEX appear to exhibit minimal fluctuations. The small tankers experienced the most notable increase, with a growth rate of 5.80%. The Panamax and Aframax vessels also observed a slight increase in their respective rates.

It is essential to thoroughly examine whether the rise in OPEX during the COVID-19 period can be attributed to the pandemic or to the overall inflation of OPEX in order to prevent significant methodological errors that may result in erroneous conclusions.

In order to address the aforementioned inquiry, an examination of the yearly fluctuations in OPEX is conducted. This study aims to analyze the disparity in the yearly growth of OPEX during the onset of the pandemic in 2020, specifically comparing the increase between 2019 and 2020 with the preceding annual increase observed between 2019 and 2018. In this particular instance, the findings appear to lack clarity, exacerbating the issue. The problem is further compounded by the absence of historical data predating 2018, which limits the availability of prior annual changes in OPEX related to the COVID-19 pandemic.

Specifically, regarding the Panamax vessels, it is evident that the growth rate of OPEX during the pandemic outbreak has significantly increased. This serves as a clear indication that the outbreak has resulted in an increase in OPEX. Conversely, concerning Handy and Panamax vessels, there was a reduction observed in OPEX levels. The Aframax tanker segment appears to have experienced minimal impact from the outbreak.

When examining the upcoming year within the context of the ongoing pandemic, it becomes evident that in 2021, there has been a notable rise in the growth rate of OPEX for Handy and Panamax vessels. This increase stands in contrast to the decrease observed in the previous year.

Based on the available evidence, it can be inferred that there was a reduction in OPEX for Handy and Panamax vessels during the initial stages of the pandemic. However, in the subsequent year, a notable upsurge in these expenses was observed. One potential explanation for this phenomenon could be attributed to the significant reduction in crew turnover and subsequent decrease in crew expenses in 2020, which can be attributed to the widespread cancellation of flights.

At this juncture, it is imperative to assess the potential bias in these findings attributable to the ageing of vessels. In order to address this inquiry pertaining to Bulkers, we conducted an analysis of OPEX costs specifically for vessels that were one year old, constructed in the preceding year, during the period spanning from 2018 to 2021.

Table 12 displays the OPEX and their annual fluctuations for Tankers that are one year old.

Table 12. OPEX for tankers: 1-year-old vessels

Year/Built	*2018*	*2019*	*2020*	*2021*
Tankers (2017)	6,716.00	-	-	-
Tankers (2018)	-	6,748.00	-	-
Tankers (2019)	-	-	6,131.00	-
Tankers (2020)	-	-		6,596.00
% change from previous year	-	0.48%	-9.14%	7.58%
Average yearly change	-	-0.36%		

The analysis reveals that there was a notable decline in the OPEX level and growth rate of newly acquired vessels during the outbreak. However, it is noteworthy that there was a substantial increase in these metrics in the subsequent year. The present discovery aligns with our prior observation that during the second year of the pandemic, there was a notable rise in OPEX and its corresponding growth rate.

However, the data appears to contradict our previous discovery of a general rise in operational expenditures (OPEX). The data indicate that there was a decrease in the overall OPEX during the period from 2018 to 2021, albeit a slight one. Due to the limited range of data samples (ranging from 26 to 43), it is not advisable to draw a definitive conclusion regarding a decrease in OPEX during the study period.

In any event, the data pertaining to vessels that are one year old aligns with our previous research findings and does not provide any substantial evidence to suggest that our findings have been manipulated by the ageing of vessels.

4.3. Tanker vs bulk carriers

In the subsequent analysis, we shall undertake a comparison of OPEX between vessels classified as Tankers and Bulkers. To ensure the statistical robustness of the comparison, two samples of vessels are created, each possessing identical capacity and age. According to the Ship Finance Danish — Shipping Market Review of May 2023, it is noteworthy to focus on vessels that are between 10 to 15 years old, as this age range represents the largest proportion of both tankers and bulkers in the current global fleet. Specifically, approximately 30% of vessels in each category fall within this age cluster. We have selected a capacity range of 80,000 to 120,000 DWT due to the abundance of observations within this range for both vessel categories in our database, specifically the Maritime Management Information (MMI) system. Table 13 displays the OPEX of the samples under consideration for the time frame spanning from 2018 to 2021.

Table 13. OPEX comparison: Tanker vs bulkers

Vessel category	*2018*	*2019*	*2020*	*2021*	*Average*
Bulkers	5,846.00	5,835.00	5,915.00	6,261.00	5,964.00
Tankers	7,046.00	7,171.00	7,505.00	7,433.00	7,289.00
Bulkers OPEX/tankers OPEX	82.97%	81.37%	78.81%	84.23%	81.85%
Correlation coefficient	58.34%				

The data from Table 13 indicates that tankers continuously have higher operational costs than bulkers, with an average OPEX of 7,289 for tankers compared to a somewhat lower number of $5,964 for bulkers for the four-year period. These findings indicate that tankers may necessitate greater maintenance, involve more intricate operations, or incur higher expenditures compared to bulkers. It is natural that tankers have a higher risk level in terms of environmental pollution, which is why their costs are higher to account for this risk.

An in-depth analysis of the annual OPEX ratios for bulkers and tankers reveals a shifting pattern. In 2018, the OPEX of bulkers accounted for 82.97% of tankers' expenses. Over the next two years, this percentage decreased to 78.81% in 2020. This decline suggests a potential time of cost optimization or lower operational activity for bulkers compared to tankers. Nevertheless, the ratio experienced a significant surge in 2021, reaching 84.23%. This suggests a likely rise in costs for bulk carriers or a corresponding decline for tankers. The average ratio during the four-year period is 81.85%, indicating a generally consistent distribution of OPEX when considering the longer term.

The correlation value of 58.34% highlights an intriguing element of the connection between the OPEX of bulkers and tankers. The moderate positive correlation indicates that there is a propensity for the OPEX of bulkers and tankers to move together to some degree. When the OPEX of one increase, there is a likelihood that the OPEX of the other will also increase, and vice versa. Nevertheless, the connection lacks sufficient strength to suggest a direct or consistent relationship that would allow for the prediction of changes in one type of vessel's OPEX based on changes in the others. These expenses and their linkage may be influenced by external variables such as market dynamics and regulatory changes. The data supplied is crucial for stakeholders in the shipping sector to have a deeper understanding of the financial dynamics and maybe predict future operating expenses.

5. CONCLUSION

As for the correlation between vessel age and OPEX, the analysis indicates that newer tankers and Bulkers generally exhibit lower daily OPEX compared to older vessels. OPEX exhibit an upward trajectory in tandem with the vessel's age, with a more pronounced effect observed in larger vessels. This tendency is more pronounced on tankers. Moreover, it is important to note that the rise in operating expenditure (OPEX) levels in terms of value cannot be regarded as insignificant.

Based on our analysis of OPEX during the study period, we observed a consistent rise in OPEX levels across all categories of bulk carrier vessels and their respective age clusters. There was a positive correlation between vessel size and the rate of increase in OPEX. The expenses incurred during the COVID-19 period (2020–2021) were greater compared to pre-COVID-19 OPEX, with the magnitude of this increase directly proportional to the size of the vessels. Initially, the OPEX of Bulkers were not evidently impacted by the onset of the pandemic. However, in the subsequent year, a notable rise in OPEX was observed. One potential explanation for this phenomenon could be attributed to the significant reduction in crew turnover and subsequent decrease in crew expenses resulting from flight cancellations in 2020.

In relation to tankers and all types of bulk carrier vessels and their age clusters, an increase in OPEX levels was observed during the study period. However, unlike bulk carriers, there was no discernible correlation between the rate of increase in OPEX and the size of the vessels. During the COVID-19 pandemic, there was an observed increase in OPEX for the period spanning from 2020 to 2021 compared to pre-pandemic levels. Bulker vessels exhibited a notable disparity in OPEX during the pandemic outbreak. Specifically, there was a substantial decline in OPEX in the initial year, followed by a subsequent material upswing in the subsequent year that effectively reversed the preceding decrease observed in 2020.

Based on the analysis, it can be observed that the OPEX for bulkers consistently accounts for approximately 82% of the OPEX for tankers. Furthermore, a significant correlation of approximately 58% exists between these respective OPEX figures.

To summarize, this study found that OPEX level and vessel age are positively related, with the relationship being stronger for larger vessels. Additionally, OPEX increased during the research period, with the increase being greater for larger vessels. The COVID-19 pandemic appears to have had little effect on OPEX. Finally, the OPEX level for tankers is higher than the OPEX level for bulkers, and the OPEX levels for both types of vessels are positively associated.

The study's findings have significant implications for marine economics, particularly concerning OPEX, which is a crucial accounting variable. It is one of the two most significant expenses, and often the most significant, for shipping businesses. This expense has a significant impact on their profitability. The practical consequences of the findings pertain to several areas such as budgeting, cash flow estimates, valuation of shipholding businesses and vessels, investment decisions, break-even point analysis, and the computation of vessels' value in use in accordance with IFRS.

Future research could investigate the variations in OPEX between different vessel types and their subcategories, in particular in relation to age and size. Specifically, it will be intriguing to establish and evaluate an econometric model using OPEX level as the dependent variable and vessel type, age, size, and other macroeconomic variables as the independent variables. Additionally, a machine learning model can be developed to provide more accurate predictions of future OPEX levels.

Finally, the most important disadvantage of the primary study is that it did not include liquid gas carriers and container ships due to a lack of available data. Subsequent research in the field may surpass this drawback.

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