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# Can commodity prices predict stock market returns? The case of dry bulk shipping companies

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**Abstract**

We explore the relationship between the returns of 45 dry bulk shipping company stock prices and the main 15 commodities that bulk carriers transport. Using a principal component analysis to reduce the dimensionality of the commodities dataset and a panel methodology, we find that a change in the commodity price principal component would result in a 0.6% change in the returns of the shipping stock prices. Minerals appear to have a stronger impact, as a 1% change in the minerals principal component results in a 1.1% change in the returns. This is mainly due to the fact that minerals account for larger trade volumes in the dry bulk market and they employ mostly bigger vessels, while the price of Brent oil is also an important factor affecting shipping stock prices.

**Keywords:** Shipping, Dry bulk market, Commodities, Principal component analysis

**JEL Classification:** G11, G12, G13, G20

## Introduction

Despite the dominance of the shipping industry in global trade (UNCTAD 2023), it was not until the early 2000s that shipping companies started to be listed in the stock markets as a viable financing option (Merikas et al. 2009). Due to the fact that companies shifted their funding from bank loans to stock and bond issuance, their profitability, as well as their corporate governance (Giannakopoulou et al. 2016; Koufopoulos et al. 2010) and their ESG practices (Lee et al. 2023) has been under more scrutiny by both investors and lenders.

The shipping industry, i.e. the sea-going transportation of goods and passengers has three main distinctive segments that the companies operate in, namely the dry bulk segment, the wet bulk segment, and the liner segment. The dry bulk segment constitutes of the trade of dry commodities that are transported in very large batches usually from one continent to another. The main commodities in this trade are coal, iron ore and grains (UNCTAD 2023). Likewise, the wet bulk segment consists of tanker vessels that transport liquids, the most important of which is Brent oil. Finally, the liner trade consists of vessels that carry out predetermined voyages on a regular basis. In the liner segment, the containership and passenger vessels are the two major categories.

All three segments have been examined by maritime economists, as they have different characteristics. Initially, the dry bulk segment has been extensively studied for its capability to act as a leading indicator with regards to the state of the world economy (Funashima 2020; Hamilton 2019; Kilian 2009, 2019). Concerning the tanker market, the main point of research has been the relationship between tanker vessels and oil prices or energy prices as a whole (Beenstock and Vergottis 1989; Khan et al. 2021; Lyridis et al. 2004; Shi et al. 2013). Finally, given the importance that timely schedules have for the liner shipping, research on this segment has been concentrated on the optimization of their procedures (Ancona et al. 2018; Aydin et al. 2017; Fusillo 2003; Lam and Yap 2011).

As already discussed, many studies have already documented how the plurality of the commodities that dry vessels carry is highly correlated to the broader macroeconomic environment. For example, Michail (2020) shows that dry bulk transport quantity is positively associated with the world GDP, Kamal et al., (2021) demonstrates a relationship with stock markets, while other researchers connect it with geopolitical risk (Drobetz et al. 2021; Michail and Melas 2022). Similarly, Kavussanos and Alizadeh (2002) report a relationship with Brent oil prices, with Michail and Melas (2020) showing that unexpected macro shocks also affect them. Recently, Monge (2022) provided evidence of a structural change during Covid-19, a behaviour driven by a demand shock, which has led to an increase in the price of fuel.

At a more detailed level, some research findings explicitly link commodity prices to freight rates. Angelopoulos et al. (2019) have extensively examined the relationship between all the major commodities that are transported via sea and the freight rates of the respective vessel types, concluding that there is no one-size-fits-all approach when it comes to the relationship between commodity prices and freight rates in the dry bulk industry. While metal and ore prices do in fact lead the freight rate markets, sugar and other agricultural commodities have a lag time mainly due to cyclicality issues. As they argue, this type of commodity price volatility could be mitigated by using various financial instruments.

However, other studies have shown that, apart from the airlines industry (Carter et al. 2006), it is not common for companies to hedge the risk of commodity prices (Guay and Kothari 2003), while the ones that do barely minimize their exposure (Carter et al. 2017; Hentschel and Kothari 2001). Additionally, while ship owners do have the possibility of hedging their risk for future freight rates (FFAs), this option is not often employed due to the inherent difficulty of measuring the actual price of these contracts (Alexandridis et al. 2018; Kavussanos et al. 2007).

Given the already established relationship between freight rates and commodity prices, we explore how the latter affect the stock prices of listed dry bulk companies. Conceptually, this research stands on the ground that freight rates are the main income of any shipping company, thus there will be a positive relationship between the company's income and its profitability. Thus, an increase in freight rates should increase dry bulk shipping companies' stock returns (Liu and Thomas 2000; Penman and Zhang 2002; Strong and Walker 1993). Since freight rates are mainly affected by commodity prices

(Ahn 2018), our research question lies on our hypothesis that there is a positive relationship between commodity prices and stock returns.

In this study, in order to explore the commodity price and shipping company returns nexus we are using a sample of 45 listed dry bulk shipping firms and 15 dry bulk commodities. By using the principle component analysis to aggregate the prices of the commodities used, we establish a clear relationship between the variables examined. To our knowledge, this is one of the very few studies, which, in a shipping context, explicitly account for the role of commodity prices on shipping stock market returns. Furthermore, this is the first study that also provides a forecasting exercise with regards to how past values of commodity prices are useful in predicting a constructed shipping equal-weighted index.

Our results show that shipping stock market returns are affected positively by the first principle component of commodity prices, with the latter having a leading impact on the former. Our results bare implications not only for shipping stakeholders but also for the global economy. Given the fact that dry bulk freight rates have been long documented to be a leading indicator of global economic activity (Kilian 2009), our results enhance these findings by providing additional evidence on the relationship between global economic-oriented prices and the shipping markets.

## Literature review

Concerning shipping companies their profitability can come through two different modi operandi, namely asset play or shipping charters. Asset play is the business practice that the management of the company is buying a vessel when prices are low and selling her when prices are high, (Ådland 2000). While this practice is common in the maritime industry, given that the average shipping business cycle lasts around seven years (Stopford 2013), it is viewed with skepticism by outside investors since it lacks consistency in profitability and dividend pay-outs (Duru 2013). As such, the industry relies on long-term charters or tramp for continuous profitability. However, since shipping companies are highly affected by their relationship with the macroeconomic environment systematically underperform the financial market from an investment perspective (Merikas et al. 2009).

Nevertheless, the literature about the relationship between shipping companies' stock market returns and their potential relationship with macroeconomic effects remains thin. The first results concerning the relationships that macroeconomic variables have on the prices of the shipping stock returns have been introduced by Grammenos and Arkoulis (2002) who show that industrial production, inflation, oil prices and fluctuations in the exchange rate of the US dollar have negative effect on shipping stocks. Similarly, Drobetz, et al. (2010) have shown that the industrial production for the G7 countries and the oil price explain better the returns of shipping stocks across all the sectors of the industry. Furthermore, El-Masry et al. (2010) show that interest rates are also an important factor for shipping company returns. Nevertheless, while the price of commodities is one major factor in the freight rates fluctuations not light have been shed on the matter, the reason being that the results are not consistent among all the commodities transported. Thus, the relationship between the price of the dry commodities and the shipping freight rates remains a factor that has certain conundrums.

While evidence have already shown that there is a relationship between commodity prices and freight rates (Gu et al. 2019; Yang et al. 2020), the conundrum between the positive or the negative effect that commodity prices have on shipping companies profitability remains to be answered. Although, some studies suggest that the rising price of commodities will positively affect the profitability of companies (Michail and Melas 2021), others suggest that the relationship between iron prices and bulk freight rates is negative (Lim 2021).

Moreover, while Angelopoulos et al. (2019), provide evidence on the mixed signs between lead and lag times between commodity prices and freight rates, one must bear in mind that since the financialization of commodities (Basak and Pavlova 2016; Bruno et al. 2017; Henderson et al. 2015) the latter are not only affected by the supply and demand of the product itself but also from the market sentiment for each commodity. As studies have shown, both psychological factors and the de-regulation of the markets have increased the volatility of the markets (Algieri 2021). This de-regulation has helped academics construct commodity market sentiment indices that rely on both statistical and financial variables (such as skewness and IPO's) to capture the phenomenon (Baker and Wurgler 2007; Gao and Süss 2015). Nevertheless, analyses concerning trading behavior of commodity market players are still at a relatively early stage with clear evidence still lacking. For example, players who engage in commodity futures would rather hedge their agricultural or energy commodities with gold, traditionally considered a safe haven, rather sell or short futures of their own commodities (Ji et al. 2020).

Given the above, it is thus clear that the complexity of both commodity markets and the trading strategies employed, as well as the inherent and practical need for their transportation, create a conundrum concerning the relationship between the two industries. Additionally, the reason results are mixed is mainly attributed to the complexity of the dry bulk ocean trade. While the tanker market has mainly one commodity that transports, the dry bulk market has around twelve (Angelopoulos et al. 2019). Thus, the latter bears difficulties both for the shipowners but also for the charters as to in which geographical area a vessel should be any time of the year. For example, the ports of the Black Sea where full of available dry bulk vessels around autumn due to the fact that both Russia and Ukraine are two of the major producers of wheat (Michail and Melas 2022). This created a conflict among the available vessels and subsequently the shipowners as to which vessel would be more suitable for the cargo's transportation. Obviously, variables like a vessel's age, engines, other technical characteristics are important when a charter is deciding the vessel that he or she will use but, ceteris paribus, the trade has specific boundaries, the first being the time that one has to be available in the specific area and of course being able to transport the goods (Arslan and Er 2008).

Nevertheless, one of the main issues that usually arises in shipping is the vessel substitution effect (Tsouknidis 2016). For example, while the large Capesize vessels (i.e. vessels that can carry cargo between 130,000 and 199,999 dead weight tonnage) are mainly used in the trade of iron and coal, if they are not freely available in the market, or near the port needed, charterers may choose to use smaller vessels to transport the same cargo. Of course, the latter may be more costly but substitution between larger and smaller vessels is something that takes place often ((Alizadeh-Masoodian 2001; Chen et al. 2010).

Dry bulk shipping companies now do not use usually invest in one size of vessel but they are taking such investing decisions based on internal traits of companies, the environment of the shipping market and the performance of rivals (Fan et al. 2018; Fan and Luo 2013; Fan and Xie 2023). The reason for this is obviously that they want to diversify as possibly in the specific segment. Previous researches (Fan et al. 2021; Greenwood and Hanson 2015; Merika et al. 2018) have shown that the specifics of each vessels (the size being one of them) is a crucial factor when companies are investing either in new-building or secondhand dry bulk vessels.

In the current study, to mitigate any negative effects of the substitution effect or the different relationships that may exist between specific commodities and the dry bulk freight rates, we proceed in the creation of principal component analysis (PCA) of the commodity prices and then account for the whole universe of the listed dry bulk companies. In particular, the use of the principal components methodology permits for a reduction in the dimension of the dataset, allowing us to employ just one or two variables instead of the whole matrix of commodity prices. Furthermore, the use of the PCA method, along with the reduction in dimensionality, prevents any cross-variable correlation that can lead to multicollinearity issues (see Michail and Massouras 2014), given that these are dealt with in the first step of the methodology. The following section provides more details on the empirical method and the dataset employed.

## Methodology and data

To test our research question, we employ the monthly returns of all listed dry bulk companies that are included in the Clarksons Shipping Intelligence Network Database (Appendix 1). In the database, 126 companies that own at least one dry bulk vessel are listed. As we know from the literature (Stopford 2013) small companies are usually more affected by other, idiosyncratic, factors rather than broader macroeconomic developments or and commodity prices. As such, we have eliminated companies that own less than ten vessels from our estimation. In addition to the small company issue, companies with less than ten vessels usually have other economic activities and employ vessels to support that purpose (e.g. the shipping arm of an iron company). To avoid biasing our data, we avoid using such companies.

The inclusion of additional variables follows Angelopoulos et al., (2019), who use the main 15 shipping-related commodities (see Appendix 2 for variables and sources). As often used in the literature, we employ a Principal Components Analysis (PCA), as popularized by Stock and Watson (2002), and used by other authors in a variety of applications (e.g. Bernanke et al. 2005; Michail et al. 2017; Prüser and Schlösser 2020) to aggregate the commodities. Reader may refer to Stock and Watson (2002, 2006) for more information regarding the PCA methodology.

In this application, a single principal component is created via the combination of all the agricultural and metal/ore commodities we employ. The first principal component explains around 28% of the total variation of the series. Given that the share of the total explained variation marginally large, under the usual threshold of 30%, we also proceed with a further breakdown of the commodities into agricultural and metal/ore, where we obtain a principal component for each type of bulk cargo. The improvement in explained volatility is important, as in the case of agricultural commodities, the first principal component explains around 36% of the total, while for minerals, the number stands at 48%.

After the creation of the principal components, we test whether these can serve as leading indicator for the stock market returns of shipping companies. In particular, following the literature on the topic (Papapostolou et al. 2014), we specify the following equation:

$$R_{i,t} = \alpha_i + \beta_1 M_{i,t} + \beta_2 Brent_t + \beta_3 PC_t + \varepsilon_{i,t} \tag{1}$$

where $R_{i,t}$ is the stock market return of company $i$ at time $t$, $M_t$ is the stock market return of that month, as proxied by the Wilshire 5000 index, and $PC_t$ is the estimated principal component. As already suggested, we start our estimation in a more generic way, by using the principal component obtained from all 15 variables, and we then break it up to $PC_{minerals}$ and $PC_{agricultural}$ as described above.

Stock market returns and oil prices have been found to be highly relevant in explaining a large part of the freight rate variation by the recent literature, (inter alia Melas and Michail 2021; Michail et al. 2021). In particular, Brent oil prices serve as a proxy of costs for ocean-going carriers, given that fuel is the largest operating expense in most vessels. This supply-side effect is usually passed on to the people who charter the vessel, either for the voyage or for a longer period (El-Masry et al. 2010). As such, Brent oil prices are expected to have a positive impact on shipping freight rates. At the same time, the stock market serves as a proxy for the global macroeconomic environment, evidenced by the recent literature. Shipping is a derived demand system, meaning that high demand for the goods transported will imply higher freight costs. As such, given that higher stock market prices suggest that the economic outlook is rosier both in the present and in the future, then this is should be beneficial for trade and, in the end, have a positive impact on freight rates (see Michail and Melas 2020; Melas and Michail 2021; Michail et al. 2021).

Given that freight rates are the most important determinant of shipping company profits, we expect that the independent variables used above will also be significant determinants of shipping company stock market returns. This is also in line with the literature on the topic, such as Grammenos and Arkoulis (2002) and Melas and Michail (2021). The same holds for the principal components, as per Angelopoulos et al., (2019). The analysis promoted by the authors supports our view that what holds at the macro level should hold at the individual stock level.

We note here that to examine whether the PCAs are leading indicators, we also employ the lags of the principal components. Furthermore, to account for any idiosyncratic effects, company fixed effects were used. Robust standard errors are also employed in the estimation. Our total sample contains 45 companies and ranges from 2005M01 to 2021M07, resulting in 9713 observations. All variables are in log first differences in order to avoid any stationarity issues.

Before we proceed with the estimation results, it would be useful to see how the dry bulk segment has performed over time. In particular, we proceed with the calculation of an equally-weighted dry bulk shipping index (excluding any dividends), which would allow us to obtain a deeper insight with regards to the workings of the industry. The return from an investment of USD 1000 in said index is found in Fig. 1 (in the exercise

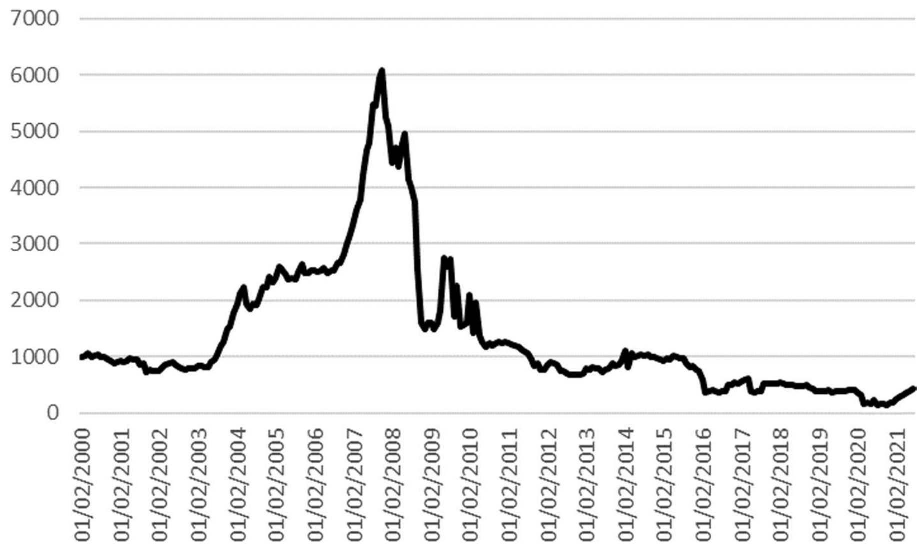


**Fig. 1** An equally-weighted dry bulk shipping index

we employ the returns from the index). In particular, the index, as presented in Fig. 1, suggests that the industry peaked in mid-2008, despite the ongoing financial crisis. Since then, it has been on a continuous decline, suggesting that, by the beginning of 2021, an investor would have been at around its breakeven point. On the background of this industry setup, we proceed with the estimation and provide the results in the following section.

## Results

Table 1 presents the estimation results. As expected based on the literature presented in the previous section, the Brent oil price is significant across all specifications, with the impact of ranging from 0.17 to 0.20%. This implies that when oil prices rise, this spills

**Table 1** Panel estimation results

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Brent | 0.203** (0.076) | 0.187*** (0.069) | 0.194*** (0.064) | 0.217*** (0.071) | 0.186** (0.072) | 0.187*** (0.062) |
| Wilshire | | 0.002 (0.002) | 0.002 (0.001) | | 0.002 (0.002) | 0.002 (0.001) |
| Wilshire (− 1) | | | | 0.001 (0.002) | | |
| PC | 0.014** (0.006) | 0.012 (0.004) | | | | |
| PC (− 1) | | | 0.011** (0.007) | 0.016** (0.008) | | |
| PC.Min | | | | | 0.001** (0.004) | |
| PC.Min (− 1) | | | | | | 0.012*** (0.004) |
| PC.Agri | | | | | − 0.001 (0.004) | |
| PC.Agri (− 1) | | | | | | − 0.000 (0.003) |
| Constant | 0.002 (0.000) | 0.001 (0.001) | 0.001 (0.001) | 0.002 (0.001) | 0.002 (0.001) | 0.002 (0.001) |
| F-stat | 33.26 | 35.75 | 41.22 | 40.07 | 23.98 | 44.98 |
| Obs | 9713 | 9713 | 9708 | 9708 | 9713 | 9707 |

*, **, ***denote significance at the 10%, 5%, and 1% level respectively. Fixed effects and robust standard errors have been used in all equations. Source: author calculations

**Table 2** RMSE per model

| | 2019M3 | 2019M6 | 2019M12 | 2020M12 | 2021M07 |
|---|---|---|---|---|---|
| Random walk | 0.009836 | 0.049888 | 0.038506 | 0.135339 | 0.138169 |
| Random walk with drift | 0.006641 | 0.049996 | 0.038148 | 0.135853 | 0.136138 |
| Random walk with drift plus PCA | 0.006409 | 0.047794 | 0.036013 | 0.129215 | 0.135677 |

over to freight rates. However, the results suggest that investors appear to believe that shipping companies are able to increase their freight rates by around a fifth more than the fuel price increase, hence generating more profit. This would lead to excess return of the shipping stock companies.

In contrast to Brent oil, it appears that neither the contemporaneous nor the lagged value of the stock market index has a significant impact on returns. This is intuitively meaningful given that the index is not expected to create any excess returns phenomena in the markets. Furthermore, shipping stock returns are not usually correlated with the overall stock market but they actually provide hedging opportunities.

On the other hand, the overall principal component (PC) also supports view that excess returns can be created in periods where higher commodity prices are observed. The fact that this holds in both the contemporaneous and the lagged form suggests that leading indicator abilities appear to hold. The minerals PC is the main driven of the impact as specifications (5) and (6) suggest. In contrast, the agricultural PC has an insignificant effect. The minerals PC has a leading impact of around 1.1%, and its economic impact for investors appears significant as it has a standard deviation of around 1.2%. Our results suggest the crucial role that the price of iron ore and coal have on the shipping stock returns, since a positive shock or a negative shock in the above mentioned commodities while affect the shipping returns the day after.[1]

To complement our analysis, we proceed with a quasi-real time forecasting exercise: in particular, we create an equally weighted index of stock returns, using the companies we have used in the estimation. We use January 2000 to December 2018 as our sample period and we proceed with examining the forecasting performance of a series of GARCH (1,1) models, as specified by Bollerslev (1986). The reason behind the use of said models is that they tend to capture heteroscedasticity issues better and perform well when the variance is high, as evidenced by the literature (e.g. Chong et al. 1999).

Table 2 presents the forecasting exercise results. In particular, it presents the performance of a random walk model, a random walk with a drift, and a model where the lagged value of the mineral PCA is used as an independent variable. Root Mean Squared Errors (RMSE) are then employed to gauge the best performing model. In particular, the table shows that augmenting a standard GARCH (1,1) with the PCA poses a significant improvement of forecasting performance across all horizons. The difference between the models subsides as the horizon increases, as the last column of Table 2 shows. This is an expected result, given that as the horizon increases the forecast ability of a model declines and requires re-estimation. Still, the conclusions reached here underline the importance of considering mineral commodity prices when investors seek to forecast

[1] Although not reported here, we have also employed the use of seasonal dummies, to account for any commodity-related seasonality. However, they did not come out statistically significant.

shipping stock market returns. In addition, they also underline the fact that prices of the underlying dry cargo matter for the determination of freight rates: similar to tankers (Kilian et al. 2020; Shi et al. 2013; Yang et al. 2015), when commodity prices increase, freight rates are also expected to rise along them.

## Conclusions

In this paper, we have elaborated on the relationship between the returns of 45 shipping stocks and the prices of the commodities they are carrying. In particular, taking the first principal component of the prices of the 15 main commodities that dry bulk carriers transport, we find that a change in commodity prices results in a 0.6% change in shipping stock returns. To elaborate further on this finding, we break down the transported commodities to agricultural products and minerals, and find that the effect stems mainly from the latter, with a 1% change in the minerals principal component resulting in a 1.1% change in the stock returns. This finding is intuitively appealing given that minerals account for much larger trade volumes in the dry bulk market, while such trades also tend to use bigger vessels (Melas and Michail 2021).

The results also suggest that the price of oil has an important bearing on shipping returns, in line with Grammenos and Arkoulis (2002). Finally, we employ a forecasting exercise to elaborate on whether employing the minerals principal component improves the forecasting performance of the usual random walk model. The results show that employing the principal component improves the root mean squared error of the estimates across all forecast horizons.

Our results expand and support the findings of Kilian (2009, 2019), and Kilian and Zhou (2018), who show that the dry bulk shipping segment acts as a leading indicator of the world economy. At the same time, it also provides a workhorse for shipping investors, who can also employ commodity prices to obtain a better understanding on the future path of freight rates. More precisely, ship managers can predict the movement of their stock prices given the principal component analysis used in this study. Such an exercise can help them forecast the value of their company and take actions when needed (including stock splits, buybacks etc.). Additionally, despite the fact that, as discussed previously, hedging is not used extensively in the shipping industry, hedging techniques to protect against a commodities bear market that could potentially spill over to freight rates and the company valuation could potentially be evaluated by the affected firms.

Naturally, in the current study, several caveats exists: first, the results of our study are conditional of the state of the dry bulk shipping market during that period, which may not be representative of the future. Second, any future developments in modeling and forecasting techniques could provide more insights and a better forecasting performance compared to our best-performing model. Third, the prevailing macroeconomic conditions during that period also play a very important role. As such, further research is required for these conclusions to be more concrete. Finally, as we establish the link between commodity prices and shipping stock prices, it would be useful for future research to examine the potential relationship that may exist between a commodity sentiment index and freight rates.

## Appendix 1: List of companies

| Rank | Owner group | TICKER | Fleet No | Region | Website |
|---|---|---|---|---|---|
| 1 | Nippon Yusen Kaisha | 9101.T | 154 | Japan | www.nyk.com |
| 2 | Star Bulk Carriers | SBLK | 124 | Greece | www.starbulk.com |
| 3 | K-Line | 9107.T | 104 | Japan | www.kline.co.jp |
| 4 | Golden Ocean Group | GOGL | 81 | Bermuda | www.goldenocean.no |
| 5 | Mitsui OSK Lines | MILA.DU | 89 | Japan | www.mol.co.jp |
| 6 | Pan Ocean | 028670.KS | 76 | South Korea | www.panocean.com |
| 7 | China Merchants Shpg | 601,872.SS | 51 | Hong Kong | www.cmenergyshipping.com |
| 8 | NS United KK | 9110.T | 44 | Japan | www.nsuship.co.jp |
| 9 | Navios Holdings | NM | 72 | Greece | www.navios.com |
| 10 | Wisdom Marine Group | 2637.TW | 121 | Taiwan | www.wisdomlines.com.tw |
| 11 | U-Ming Marine | 2606.TW | 35 | Taiwan | www.uming.com.tw |
| 12 | Mitsubishi Corp | 8058.T | 63 | Japan | www.mitsubishicorp.com |
| 13 | Pacific Basin Shpg | 2343.HK | 118 | Hong Kong | www.pacificbasin.com |
| 14 | Diana Shipping | DSX | 37 | Greece | www.dianashippinginc.com |
| 15 | COSCO Shipping Dev | CITAF | 17 | China P.R | https://development.coscoshipping.com/index.html |
| 16 | Mitsui & Co | 8031.T | 46 | Japan | www.mitsui.com |
| 17 | Jiangsu Shagang | 002075.SZ | 21 | China P.R | www.sha-steel.com |
| 18 | Eagle Bulk Shipping | EGLE | 51 | United States | www.eagleships.com |
| 19 | Seanergy Maritime | SHIP | 15 | Greece | www.seanergymaritime.com |
| 20 | Chinese Maritime Transport | 2612.TW | 10 | Taiwan | www.cmt.tw |
| 21 | Meiji Shipping | 9115.T | 25 | Japan | www.meiji-group.com |
| 22 | China Shenhua Ltd | 1088.HK | 41 | China P.R | www.shenhuagroup.com.cn |
| 23 | SFL Corporation | SFL | 22 | Bermuda | www.sflcorp.com/ |
| 24 | Marubeni Corp | 8002.T | 33 | Japan | www.marubeni.co.jp |
| 25 | Ningbo Marine | 600,798.SS | 31 | China P.R | www.nbmc.com.cn |
| 26 | ITOCHU Corp | 8001.T | 21 | Japan | www.itochu.co.jp |
| 27 | Xiamen ITG | 600,755.SS | 22 | China P.R | www.itg.com.cn |
| 28 | Shih Wei Navigation | 5608.TW | 41 | Taiwan | www.swnav.com.tw |
| 29 | Taiwan Navigation | 2617.TW | 18 | Taiwan | www.taiwanline.com.tw |
| 30 | Precious Shipping | PSL.BK | 32 | Thailand | www.preciousshipping.com |
| 31 | Norden A/S | DNORD.CO | 18 | Denmark | www.ds-norden.com |
| 32 | Thoresen Thai Agen | TTA.BK | 24 | Thailand | www.thoresen.com |
| 33 | Wilmar International | F34.SI | 20 | Singapore | www.wilmar-international.com |
| 34 | Great Eastern Shpg | GESHIP.BO | 14 | India | www.greatship.com |
| 35 | Jinhui Shpg & Trans | JIN.OL | 19 | Hong Kong | www.jinhuiship.com |
| 36 | D'Amico Soc di Nav | DIS.MI | 18 | Italy | www.damicoship.com |
| 37 | COSCO Shpg Spec | 600,428.SS | 21 | China P.R | https://spe.coscoshipping.com/main/index |
| 38 | Shipping Corp of India | SCI.NS | 15 | India | www.shipindia.com |
| 39 | Orix Corporation | IX | 24 | Japan | www.orix.co.jp |
| 40 | Uni-Asia Holding | CHJ.SI | 21 | Hong Kong | www.uni-asia.com |
| 41 | Yang Ming Marine | 2609.TW | 11 | Taiwan | www.yangming.com |
| 42 | Inui Global Logistic | 9308.T | 22 | Japan | www.inui.co.jp |
| 43 | Algoma Central Corp | ALC.TO | 15 | Canada | www.algonet.com |
| 44 | Belships | BELCO.OL | 12 | Norway | www.belships.com |
| 45 | Sumitomo Corp | SSUMY | 13 | Japan | sumitomocorp.com |

The above table is based on the Clarksons Shipping Intelligence database, with a cut-off point of 10 dry bulk vessels. See text for more details.

## Appendix 2: List of commodities

| Commodity | Database | Units | Category |
|---|---|---|---|
| Ammonia | Bank of Japan | Corporate goods price index (2015 base)/producer price index; commodity/liquid ammonia | Agro-chemical |
| Barley | Federal reserve economic data | Producer price index by commodity for farm products: barley | Agricultural |
| Brent | Federal reserve economic data | Crude oil prices: brent—Europe | Energy |
| Canola | Federal reserve economic data | Producer price index by commodity for farm products: canola | Agricultural |
| Coal | IMF cross country macroeconomic statistics | Coal; South African export price; US$ per metric ton | Metal/Ore |
| Copper | IMF cross country macroeconomic statistics | Copper; grade A cathode; LME spot price; CIF European ports; US$ per metric ton | Metal/Ore |
| Corn | IMF cross country macroeconomic statistics | Maize (corn); U.S. No.2 Yellow; FOB Gulf of Mexico; U.S. price; US$ per metric ton | Agricultural |
| Diammonium phosphate | IMF cross country macroeconomic statistics | Diammonium phosphate; US Gulf NOLA DAP Export Spot Price per MT; USD/metric tonne | Agro-chemical |
| Iron | IMF cross country macroeconomic statistics | China import iron ore fines 62% FE spot (CFR Tianjin port); US dollars per metric ton | Metal/Ore |
| Rice | Federal reserve economic data | Producer price index by industry: rice milling | Agricultural |
| Scrap | Bank of Japan | Output price index/manufacturing industry sector; output (commodity group)/__scrap generated by pig iron and crude steel | Metal/Ore |
| Soybean | Bank of Japan | Input price index/manufacturing industry sector; input (commodity group)/soybeans (imported) | Agricultural |
| Sugar | Bank of Japan | Output price index/manufacturing industry sector; output (commodity group)/refined sugar | Agricultural |
| Urea fertilizer | IMF cross country macroeconomic statistics | US gulf NOLA urea granular spot price; USD/ST | Agro-chemical |
| Wheat | Bank of Japan | Output price index/manufacturing industry sector; output (commodity group)/wheat flour | Agricultural |

## Appendix 3: List of abbreviations

| | |
|---|---|
| ESG | Environmental, social and Governance |
| GARCH | Generalized autoregressive conditional heteroskedasticity |
| GDP | Gross domestic product |
| PCA | Principal components analysis |
| RMSE | Root mean squared Errors |

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**Availability of data and materials**
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**Competing interests**
The authors certify that they have NO affiliation with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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