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RESEARCH ARTICLE

Unraveling the link: Examining the influence of dollar strength on dirty tanker freight rates

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ABSTRACT

This study explores the asymmetric relationship between the U.S. dollar index (DXY) and dirty tanker freight rates, a largely unexamined area within maritime economics despite the dollar's profound influence on global oil prices and economic stability. Tanker shipping, the primary mode of transportation for global oil and a capital-intensive sector, plays a crucial role in oil supply chains. Given that oil prices are quoted in U.S. dollars, fluctuations in dollar strength directly impact oil costs, demand for tankers, and the operational costs of tanker shipping. This study employs an asymmetric model, recognizing that dollar value changes affect the tanker market differently depending on whether the dollar is strengthening or weakening. Findings reveal that decreases in the DXY drive up tanker freight rates, while increases do not correspondingly decrease rates, highlighting the unique non-linear dynamics between currency strength and freight costs. This asymmetric approach provides a more accurate framework for understanding these interactions than traditional linear models.

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Introduction

Oil is an indispensable element of production processes. However, oil is exploited from different parts of the world and often has to be transported from these areas to production centers (Stopford, 2009). Today, crude oil is usually transported by pipeline, barge or tanker (Rodrigue et al., 2013; Coles & Watt, 2009). The tanker, one of these transport vehicles, emerged in the 1940s and 1950s to meet this need. Tanker is defined as a ship designed to transport liquid cargoes (Grammenos, 2010). The most transported cargo by tanker is crude oil. Tanker transport is divided into two as "clean tanker" and "dirty tanker". Clean tankers refer to product tankers carrying clean oil products such as diesel fuel and jet fuel, while

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dirty tankers refer to crude oil and black products (Stopford, 2009). Dirty tankers carrying crude oil and other unrefined petroleum oil products are an integral part of the global supply chain. Data on dirty tanker freight rates is provided through the Batic Dirty Tanker Index (BDTI). The other concept that we will evaluate the relationship between dirty tanker freight rates is dollar strength. United States Dollar (USD) is an important currency due to its effects on the world economy (Hakkio & Whittaker, 1985). The concept of dollar strength refers to the relative value of the U.S. dollar compared to other currencies. Since oil prices are quoted in dollars, fluctuations in the dollar's value directly impact the cost of oil in international markets. Consequently, the price of oil in import and export transactions is effectively determined in U.S. dollars (Farley, 2024). Similarly, oil exporters are paid in dollars, meaning that shifts in the dollar exchange rate influence the effective price of oil for all countries outside the United States. Consequently, fluctuations in the dollar's value can impact global oil prices by driving adjustments in both supply and demand (Coudert & Valérie, 2016). The price of oil significantly influences dirty tanker freight rates, affecting both the demand for oil and the operational costs of tanker shipping. When the dollar weakens, oil becomes relatively cheaper, potentially boosting demand and lowering transportation costs. However, as demand for tanker shipping rises in response, freight rates may not decrease proportionately with costs. Conversely, in a stronger dollar scenario, these dynamics may play out very differently. This generates an asymmetric and non-linear relationship between the dollar index and tanker freight rates, making asymmetric models a more suitable choice for analyzing the interactions between these variables than traditional linear models.

Leading indicators play a critical role in the tanker shipping industry by providing foresight into future market conditions, allowing stakeholders to make informed decisions (Karamperidis et al., 2013). These indicators help in anticipating changes in demand, operational costs, and overall market dynamics. In terms of shipowners: (i) Indicators like the dollar index help shipowners forecast fuel costs, allowing for better budgeting and operational planning; (ii) Understanding economic trends aids in implementing hedging strategies to manage financial risks associated with currency and fuel price fluctuations. In terms of shippers: (i) Shippers use indicators to anticipate changes in shipping costs, enabling better pricing strategies and contract negotiations; (ii) Predictive indicators help in planning shipment schedules and routes, ensuring timely delivery and cost-efficiency; (iii) By monitoring economic indicators, shippers can anticipate disruptions and adjust their supply chain strategies accordingly. In terms of countries: (i) Governments use indicators to forecast trade volumes and balance of payments, essential for economic planning and policy formulation; (ii) Economic indicators guide policies on import/export tariffs, subsidies, and trade agreements to enhance national economic stability; (iii) Anticipated changes in shipping demand influence national decisions on port development and transportation infrastructure investments.

Although the U.S. dollar is widely recognized for its significant impact on the global economy, and its influence on global oil prices has been extensively studied and confirmed in the literature (Sadorsky, 2000; Lizardo & Mollick, 2010; Beckmann & Czudaj, 2013; Couder & Valérie, 2016; Kisswani et al., 2019), to the best of the authors' knowledge, no study has specifically examined its impact on the tanker shipping market, which plays a critical role in oil transportation. Tanker shipping is the primary mode of transportation for global oil and is a capital-intensive sector due to the high costs associated with ships. Presenting findings that can serve as decision-support mechanisms for this sector is therefore highly valuable. Furthermore, examining the potential relationship through an asymmetric approach offers a distinctive contribution by aligning with the inherent characteristics of tanker transportation. This method acknowledges that external factors, such as currency fluctuations and oil price shifts, do not affect the tanker market symmetrically.

Our findings suggest that policymakers and industry participants should focus on robust hedging strategies to manage currency risk, revise contractual terms for flexibility, and invest in fuel-efficient technologies to mitigate the impacts of currency fluctuations. This research not only contributes to the nuanced understanding of maritime economics but also offers practical recommendations for enhancing operational stability in the shipping industry. In the second part of the study, the theoretical framework of the research was drawn, in the third part, the data set and method were introduced, and the characteristics of the series were examined, in the fourth part, the results were presented, and in the last part, conclusions and recommendations were made.

Background of the Study

Since the US Dollar is one of the main exchange rates of international trade, the strengthening and weakening of its value has significant effects for countries, companies and individual investors (Bertaut et al., 2021). The strengthening and weakening of the dollar primarily affect the American

economy. Export volumes could decline as a stronger dollar makes American exports more expensive for foreign buyers. Similarly, since this situation makes international products cheaper, there may be an increase in import levels of the country. The weakening of the US dollar may increase exports because it will make the country's products cheaper, while it may reduce imports because international products will become more expensive (Eguren Martin et al., 2017).

For other countries, especially developing countries, the strengthening of the dollar may generate financial stress and inflationary effects as it will increase import and energy costs (Boz et al., 2017). On the other hand, if their economies are dependent on export revenues, positive effects such as their products being cheaper in the international market and increased demand may also be seen. However, if the country borrows from international markets at the exchange rate, it will need a lot of money to pay these debts, which may trigger a depreciation in its own currency and therefore inflation (Nguyen et al., 2024). In terms of international commodity markets, a stronger dollar could reduce demand for commodities by making them more expensive (Reboredo, 2012).

In terms of investment, the strengthening of the dollar will increase foreign investments in American assets as it will cause higher returns, while the weakening of the dollar may cause investments to outflow from American assets to other countries (Klein & Rosengren, 1994). Therefore, the strengthening of the dollar may result in accelerated money outflows from developing countries and further depreciation of local currencies. Due to the strengthening dollar, the growth of developing countries is also decreasing (Druck et al., 2018). As can be seen, since the global economy's dependence on the dollar is high, the effects of increases and decreases in the value of the dollar are very large and widespread.

Some indicators were needed to follow the change in the value of the dollar and to develop proactive measures and policies according to its situation. DXY, which is used to measure whether the dollar is strengthening or weakening in global markets, stands out as an important indicator (Euromoney, 2012). Countries, companies and individuals make their monetary and fiscal policies, hedging strategies and commercial decisions according to the movement of the index (Köse & Yılmaz, 2022).

The effect of the strengthening or weakening of the dollar on crude oil tanker freights can occur in two ways: (i) its effect on oil demand by affecting international oil price, (ii) its effect on tanker transportation demand by affecting international tanker shipping price. The final price of oil for countries and companies can be simplified into the sum of the price of the product and transportation costs. The dollar's impact on the demand for oil will also affect the demand for tanker ships, which have a derived demand structure (Lun et al., 2013). More oil demand could lead to more ship demand. On the other hand, since international transportation is priced in dollars, the change in the value of the dollar may cause tanker transportation to become more expensive or cheaper (Chen et al., 2014). However, the relationship becomes complicated because the tanker freight price also depends on the balance of supply and demand in the tanker market. For this reason, a network of relationships that can be captured with linear models may not be established.

In order to determine the effects of the dollar on the global economy and therefore on the tanker market, it would be useful to draw a framework using the literature on subjects such as exchange rate & oil, oil & gold, exchange rate & international trade, and oil & global economy. Of course, there are hundreds of studies on these subjects, but only those that fit our theoretical framework will be selected and included. The relationship between oil prices and exchange rates has been extensively studied, revealing a complex and dynamic interaction. Lizardo & Mollick (2010) found an inverse relationship between the variables. Since the US is a country that imports a large amount of oil, the increase in oil prices has a depreciation effect on the value of the dollar. Based on the fact that this relationship can change over time, Beckmann & Czudaj (2013) identified that there is a time-varying pattern among the variables and that the effect is mainly formed from the exchange rate to the oil price, although it varies according to the country's economic profiles. Another study revealed that relations vary according to the economic profiles of countries, Kisswani et al. (2019) found asymmetric effects in ASEAN countries. While there is a causality from exchange rates to oil prices in some countries, the opposite relationships have been found in some other countries. Couder & Valérie (2016) found that an increase in the dollar strength leads to a decrease in the oil price by decreasing the demand for oil and increasing its supply, which implied the causality running from the dollar to the oil price. Sadorsky (2000), on the other hand, examined the relationship between exchange rates and oil prices through the prices of energy products in future markets and revealed that exchange rates have an impact on energy future prices. Since the interaction between variables may also differ depending on whether the country is a net oil exporter or importer, the study conducted by Nandi et al. (2024) on Bangladesh, a net importer

country, has shown that the exchange rate and oil price interact and that the shock from the oil price has a long-term effect on the exchange rate. The findings of these studies suggest that policymakers and industry participants should consider the time-varying and asymmetric nature of the oil-exchange rate interaction. For oil-importing countries, monitoring and managing currency strength is crucial to mitigate the adverse effects of oil price volatility on the exchange rate. Although the direction of the effect varies from country to country, it is of great importance to follow hedging strategies to stabilize the effect of exchange rates on oil prices and the effect of oil prices on exchange rates. Since the impact of the US dollar on oil prices is primarily demand-driven, studies on oil demand are also common. A stronger dollar index could negatively affect demand as it would make oil more expensive for other countries. A study by Chen et al. (2016) identified that a stronger US dollar causes less oil demand globally. For oil-exporting countries, a strong dollar can reduce demand for oil exports, necessitating policies to diversify their economies and reduce dependency on oil revenues. Conversely, oil-importing countries might benefit from a strong dollar by facing lower oil import costs. Strategic reserves and alternative energy investments can mitigate the impacts of dollar index fluctuations on oil demand.

Since the price of gold is closely related to the global economic situation, it also interacts with oil. In an environment where the dollar strengthens, demand for gold may decrease because it will be relatively expensive, or vice versa. On the other hand, global uncertainties may increase demand for gold, which is seen as a safe-haven investment instrument. In addition, not only gold but also other precious metals such as silver, platinum and palladium are used as alternative investment tools. In its study, Sari et al. (2010) identified the relationship between precious metals and oil prices and determined that the two sectors have positive effects on each other. Since gold is considered a safe-haven investment, Reboredo (2013) examined whether it can be used as a hedge against fluctuations in oil prices. The results show that it cannot be used as a hedge because there is a positive dependence on the average between gold and oil prices, but since the tail values are independent, gold can only be used as a hedge against extreme oil prices. The information flow between oil price and gold price was examined by Zhang & Wei (2010) and it was found that the oil price Granger causes the gold price in linear sense. In the research conducted by Mensi et al. (2021), based on the fact that there are relationships between variables in the current period and that there may be interactions in future markets, it was determined that while precious metals and oil commodities are risk takers in the bear market, oil prices are risk givers in the bull market. The source of risk may differ depending on the market type. In addition, the relationship between variables may differ depending on whether any of them is too low or too high, and this was determined in the study conducted by Alomari et al. (2022). When general studies are evaluated, oil prices and gold prices are related to each other. Policymakers and investors should recognize the co-movement between oil and gold prices when designing investment portfolios and economic policies. Additionally, understanding the influence of the US dollar on these commodities can aid in making more informed financial decisions.

Since a stronger or weaker dollar will affect international trade, it will also affect the demand for oil, which is used as a raw material and energy source, and therefore the tanker market. So, the dollar index significantly influences international trade dynamics. A study by Goldberg & Tille (2008) found that a stronger US dollar contributes to the trade deficit because it makes US exports more expensive and imports cheaper. In addition, since the exchange rate is a determining factor not only in exports or imports of goods but also in exports and imports of services, the study conducted by Eichengreen & Gupta (2013) found that the increase in the real exchange rate increased service exports more than goods exports. Gopinath et al. (2020) investigated that dollar index movements influence global trade patterns, affecting both advanced and developing economies. An increase in the value of the dollar causes a decrease in global trade volume. Considering the effects of the dollar on trade, policymakers should monitor the dollar index to understand its impact on trade balances. For the US, managing the dollar's strength can help balance trade deficits and surpluses. For other countries, currency strategies, such as pegging or floating exchange rates, can be adjusted to mitigate adverse impacts on trade balances due to dollar index fluctuations.

The situation in the global economy also directly affects oil demand since oil is used as raw material, energy source and fuel in many sectors. The relationship between oil demand and the global economy is intricate and has significant implications for both macroeconomic stability and policy-making. In his study, Hamilton (2009) explored the effects of increasing oil prices on the global economy and determined that there were downturns in the global economy because the increase in prices also caused an increase in costs and decrease in disposable income. Another study by Joo et al. (2020) examined the impact of the global financial crisis on the crude oil market, finding that economic

slowdowns lead to decreased oil demand, which in turn affects global oil prices negatively. Stock exchanges are also one of the important indicators for the economic situation of countries and the positive and negative situations in the economy can be felt directly. In this context, He et al. (2022), which examined the effects of oil prices on stock exchanges, determined that the asymmetric effects of oil price uncertainties on the stock exchanges of oil exporting countries are stronger than the importer countries. In addition, since the main oil producing and consuming countries are geographically located in certain regions, geopolitical events and energy security-related situations also affect oil demand and supply and spread to the economic structure. The research conducted by Khan et al. (2023) examined the effects of disruptions in the oil supply chain caused by such factors on national economies. These studies underscore the significant impact of oil demand on the global economy and vice versa. Policymakers should consider strategies to stabilize oil demand, such as promoting energy efficiency and investing in alternative energy sources. Diversifying energy portfolios can help mitigate the economic risks associated with oil price volatility. Additionally, understanding the geopolitical factors that influence oil demand is crucial for developing comprehensive energy policies that enhance economic resilience.

The relationship between dollar strength and crude oil also has an effect on dirty tanker freight rate. An increase in the dollar strength will lead to a decrease in the demand for crude oil and thus a decrease in the demand for maritime transport of crude oil, i.e., transport by dirty tanker. With the decrease in demand, dirty tanker freight rate will decrease. As a result, an increase in dollar strength may cause a decrease in the dirty tanker freight rate. Increasing dollar strength makes oil more expensive globally, reducing demand and this effect may cause dirty tanker freight rates to decrease. However, a decrease in dollar strength due to reasons such as economic conditions and operational costs does not necessarily mean that dirty tanker freight rates will increase. Considering all these, it can be assumed that as the dollar strength increases, the dirty tanker freight rate will decrease. This hypothesis is based on the relationship between dollar strength and the dirty tanker freight rate, which enables the transport of crude oil by sea.

Material and Methods

In order to assess the relationship between dirty tanker freight rates and dollar strength, a comprehensive data set covering different market conditions and more than twenty-one years is used. The monthly dataset covers the dates between August 2002 and April 2024 and consists of 261 observations. We used US Dollar Index (DXY) and Baltic Dirty Tanker Index (BDTI) variables to investigate the relationship between US dollar and tanker freight rates.

DXY, which was developed in 1973, is defined as the US Dollar Index and allows to measure the relative value of the United States dollar against the values of exchange rates in a basket of currencies of 6 countries (Parboteeah & Cullen, 2018). The weights of the exchange rates in this basket are as follows: 57.6% EURO, 13.6% Japanese Yen, 11.9% British Pound, 9.1% Canadian Dollar, 4.2% Swedish Krona, and 3.6% Swiss Franc (ICE, 2024). Instead of using the value of a single currency against the dollar, we chose to use the U.S. Dollar Index (DXY). A single currency comparison is insufficient to capture the relative strength of the dollar globally. In contrast, the DXY, with its comprehensive basket of currencies, better represents the dollar's global strength. This makes it a more effective indicator for analyzing international demand for dollar-denominated products.

BDTI is a freight index published by Baltic Exchange, developed to measure freight rates on the main routes where crude oil and heavy oil products are transported (Alizadeh & Nomikos, 2009). By following this index, it becomes possible to analyze global crude oil demand, tanker fleet utilization rate, seasonal factors and the cost of transportation of the crude oil. It is currently calculated by taking the weighted average of the values of 16 frequently used routes (Baltic Exchange, 2024). The BDTI is a comprehensive representation of the crude oil freight market. Published daily, the index enables industry stakeholders to respond promptly to market fluctuations. While it is somewhat limited in its route representation, covering only specific routes, and can be influenced by market sentiment, it remains a highly useful index for monitoring conditions in the crude oil market through a single indicator.

Descriptive statistics of the data set used in the study are presented in Table 1. Both variables are indices generated by weights of different components. Descriptive statistics are presented both as raw data and as log returns. Thus, detailed evaluations can be made about the characteristics and distributions of the variables. During the period under consideration, the average growth rate of BDTI is positive, while that of DXY is negative. In other words, while tanker freight rates increased on average, the strength of the dollar decreased. The skewness of both return distributions is positive, which shows that the effects of positive news were higher in the period under consideration. In addition, this shows that

extreme positive news is more than negative news, that is, sudden increases are more than sudden decreases, especially in the BDTI as it has a higher skewness. In addition, the fact that the returns do not have a normal distribution indicates the asymmetry in the variables when evaluated together with the long tail effects. The distribution characteristics of the variables also confirms the difficulty of finding a meaningful relationship with linear modeling. When monthly changes are examined, it is seen that the biggest increase in BDTI is 66.6% and the biggest decrease is 55.1%, while the biggest increase in DXY is 7.7% and the biggest decrease is 7.4% in 1 month. This is also important in terms of understanding how volatile and risky the BDTI market is. When the coefficients of variation of the raw data are examined (standard deviation/mean), the coefficient is calculated as 43% for BDTI and 10.3% for DXY, indicating how volatile the maritime sector is.

The graphical illustration of the relationship between dollar strength and dirty tanker freight rate is presented in Figure 1. DXY value dropped to its lowest value of 71.80 in March 2008. This situation resulted from events during the 2008-2009 global economic crisis such as the decrease in the demand for the dollar, lowering interest rates to support the economy, injecting cash into the market through security purchases (Quantitative Easing), and economic support packages (FED History, 2024). As a result, the stable fluctuation in the value of the dollar continued until 2014, and then the increasing trend of the dollar began. The reason for this increase after 2014 was the announcement by the FED that the Quantitative Easing program was concluded (FED, 2014).

BDTI fell to its lowest value in October 2020. At that time, the decrease in oil demand due to the global economic slowdown due to COVID-19 also reduced the demand for tankers and freight rates hit the bottom level. In addition, the drop in oil prices due to falling demand also reduced transportation costs, and this supported the further decline in freight rates. In fact, at that time, oil prices were negatively priced for the first time in history (MOL, 2020). However, compared to other shipping markets, tanker freight rates were in better shape. The main reason for this is that tanker ships have been chartered and used by countries and large companies to store excess oil supply (Marine Insight, 2020). A similar decrease in demand was experienced after the 2008 global crisis, and as the demand for tankers decreased, freight rates dropped to low levels. As a result, since the demand for crude oil transportation is a derived demand, any developments in the economy due to global events are directly reflected in freight rates (Lun et al., 2013).

When the relationship between the variables is examined in Figure 1, no significant linear relationship can be seen. In addition, the applied correlation analyzes also give insignificant results. The main reasons for this are that oil is both a customer burden and a source of cost for tankers, and the supply in the tanker market is affected by the ship construction period. In other words, market supply consists of the orders accumulated from previous periods being delivered at that moment rather than instant demand. This delay may vary between 1-4 years depending on the market situation and the ship type (Tsolakis, 2005).

Table 1. Descriptive statistics of the variables

Parameters	BDTI	DXY	Dln BDTI	Dln DXY
Mean	1002.280	89.72667	0.001540	-6.83E-06
Median	855.0000	90.03000	-0.001441	4.19E-05
Maximum	3008.000	112.1200	0.666120	0.077353
Minimum	411.0000	71.80000	-0.551870	-0.074127
Std. Dev.	431.8196	9.294691	0.170817	0.022073
Skewness	1.487712	0.080314	0.142807	0.010348
Kurtosis	5.728688	2.039517	4.485708	3.938621
Jarque-Bera	177.2504	10.31308	24.79646	9.548899
Probability	0.000000	0.005762	0.000004	0.008443
Observations	261	261	260	260

Note: Source: Trading View (2024); Investing (2024)

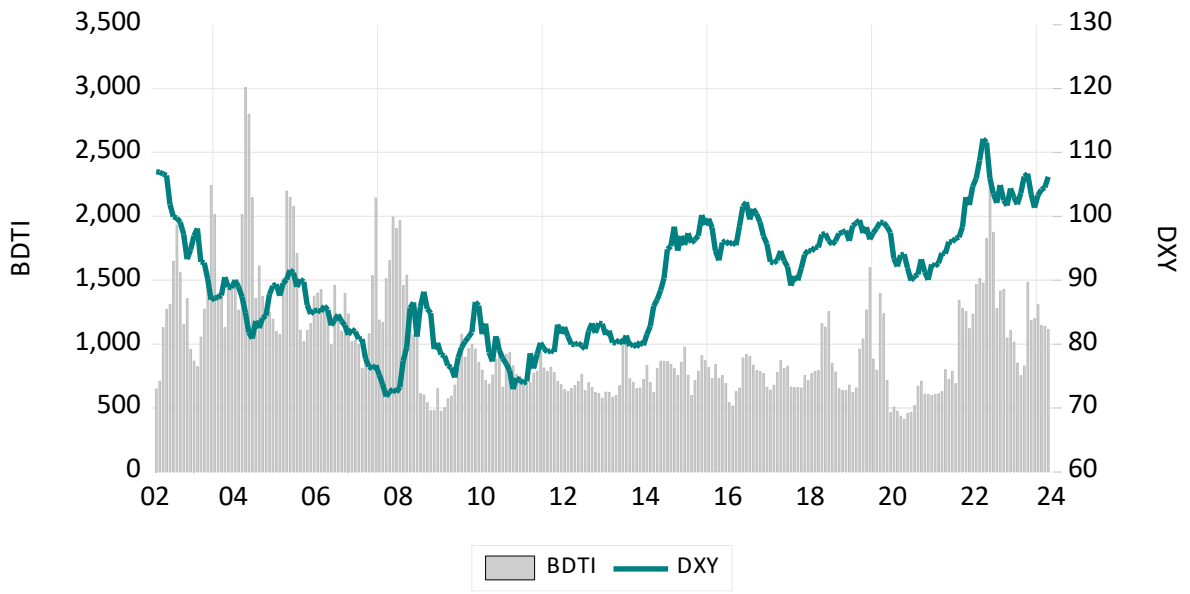

Figure 1. Relationship between Dollar Strength and Dirty Tanker Freight Rate (Source: Trading View (2024); Investing (2024))

The asymmetric causality test we preferred in our study was developed by Hatemi-J (2012). Traditional Granger (1969) causality analysis assumes a symmetric relationship between variables. However, this scenario is slightly simplified to explain the relationship between variables in the real world. In order to eliminate this limitation, asymmetric causality method tests the relationship from one variable to another in 4 different combinations by decomposing the variables into positive and negative components. In this way, it is possible to determine whether positive shocks in one variable affect positive shocks, negative shocks, or both positive and negative shocks in the other variable. In the real world, information spreads very quickly and there are many different players in the market, and each player's reactions to similar shocks may vary. Traditional symmetric causality tests may be inadequate to capture such asymmetric relationships. Asymmetric causality test has a similar logic to the traditional Granger (1969) method. It is based on the logic of applying the logic of the Granger test, which reaches its conclusion by testing whether the past values of one variable explain the current value of the other variable in a significant way, through the shocks in the series.

In real-world dynamics, assuming symmetric interaction between variables oversimplifies the complexity of market reactions, as responses to shocks vary widely. In fast-paced global markets, traders, fleet managers, financial institutions, and policymakers may react differently to similar shocks due to unique positions, risk profiles, and strategic goals. By adopting an asymmetric approach, we aimed to capture this diverse reactivity and potential differences in responses within the tanker market. This approach allows us to better align the intricate relationship between DXY and BDTI with real-world market behavior, compared to other symmetric methods.

In this method, the series do not have to be stationary. The maximum integration degrees (dmax) of the variables included in the analysis must be known. This can be determined by unit root tests. If one or both two analyzed variables contain a unit root, dmax is set as 1, and if neither of them contains a unit root, it is set as 0. We preferred to apply augmented Dickey-Fuller (ADF) (Dickey & Fuller, 1981) and Phillips and Perron (PP) (Phillips & Perron, 1988) tests to the series to determine the maximum degree of integration. The null hypotheses of these tests indicate the existence of a unit root in the series. PP test is an improved version of ADF, and it becomes robust to serial correlation and heteroscedasticity in error terms (Enders, 2004) by making non-parametric considerations in the test statistics (Das, 2019). Therefore, PP test was also applied as a complement to ADF test.

Logarithmic transformations were applied to the series in our analysis. To remove potential seasonal effects, we first used Seasonal-Trend decomposition using Loess (STL) method, producing seasonally adjusted series. This method allows time series to be separated into seasonal, trend, and irregularity components (Chen et al., 2021). This was particularly relevant for the BDTI variable, which likely experiences seasonal fluctuations driven by demand shifts. Unit root tests were then conducted on the seasonally adjusted series to determine their maximum degrees of integration. Additionally, we assessed whether shocks to these series had temporary or permanent effects. After establishing the degrees of integration, we proceeded with the asymmetric causality test to evaluate the relationship between the variables.

Results

In analyses of the relationship between the dollar and the dirty tanker freight rate, it is essential to seasonally adjust the data. By adjusting the data for seasonality, seasonal effects are eliminated, and thus more appropriate comparisons can be made between different periods.

Seasonal demand, policy and spending changes in exchange rates may cause exchange rates to follow seasonal patterns. At the end of the year, multinational companies may increase the demand for other currencies in order to take their profits to home countries, causing a downward trend in the US dollar. Similarly, increased import spending during holiday seasons may increase demand for foreign exchange rates and cause a decline in the local currency. In addition, since tourism activities in countries vary seasonally, the local currency may gain value due to tourism-related foreign exchange expenditures in the country. Since agricultural exports also increase in certain seasons, foreign currency inflow to the country may increase in the relevant calendar period. Similarly, since the demand for raw materials such as coal increases in certain months, there may be seasonal fluctuations in the exchange rates of the exporting and importing countries of the relevant product. In short, it is inevitable that there will be seasonal effects in the DXY variable.

In order to correctly interpret the seasonality in BDTI, it is necessary to understand the seasonality in oil prices. There may be increases in oil demand for heating purposes in winter and for fuel purposes in summer. Demand for oil for fuel purposes may also increase during periods when agricultural activities are at their peak. In addition, seasonal hurricanes and storms in some important oil production and refining regions may cause disruptions in the oil supply chain, so seasonal changes may occur at certain times of the year. These changes in oil demand may affect the price of oil and therefore the demand and cost of tanker shipping, thus causing seasonal patterns in freight rates.

For these reasons, seasonal effects must be determined, and the variables must be studied in a seasonally adjusted manner. The monthly averages of the seasonal adjustment factor obtained as a result of the STL decomposition method applied are presented in Figure 2. When the seasonality in BDTI is examined, it is seen that while freight rates experience a seasonal decrease in the summer period, they experience a seasonal increase in the winter period. A seasonal peak occurs at the beginning of the winter period due to the increase in demand for oil because of the need for heating in the Northern Hemisphere. This seasonal increase continues in the first 3 months of the new year. Towards the end of the fall season, refineries and distributors begin to stockpile oil in anticipation of increased demand, which leads to a rise in demand for oil transport. With the arrival of spring, there is often a decrease in demand, particularly in regions where oil is used for heating, resulting in lower freight rates. Additionally, during summer, demand for oil may decrease as refineries increase their maintenance activities to prepare for the busy fall and winter seasons.

When the DXY seasonal adjustment factor is examined, it is seen that it generally follows a stable course, while there are seasonal significant decreases in January and April, the dollar strengthens seasonally in November. The decline in the DXY, particularly in April, is largely attributed to tax season in the U.S. During this period (IRS, 2024), individuals and companies make substantial tax payments, which can lead to a temporary decrease in dollar demand and, consequently, a drop in its value. The seasonal increase in November may be driven by heightened dollar demand as companies and institutions engage in budget balancing and year-end financial planning. These activities often require increased dollar reserves and adjustments to dollar-denominated assets, contributing to a rise in the Dollar Index (DXY).

Unit root analysis is one of the methods applied to evaluate the analyses more accurately. Unit roots are nonstationary autoregressive (AR) or autoregressive moving average (ARMA) time series processes that may include an intercept or trend. These processes are common in economics and finance, and also appear in other scientific fields. Unit root tests address whether a series has a unit root (nonstationary) or is stationary (or trend stationary).

Since the series do not have to be stationary in the asymmetric causality test, ADF and PP unit root tests were applied to the series to determine the maximum order of integration value (dmax) in the models and the results are presented in Table 2. According to the ADF test, the unit root null hypothesis was rejected at the 5% confidence level for BDTI, but not for DXY. Similarly, according to the PP test, the unit root null hypothesis was rejected at the 5% confidence level for BDTI, but not for DXY. It was rejected only for DXY at the 10% confidence level in Intercept & Trend. When the 5% confidence level is taken as the basis for both tests, the results are exactly the same. Accordingly, the maximum integration degree was determined as 1 by assuming that BDTI is I(1) and DXY is I(0).

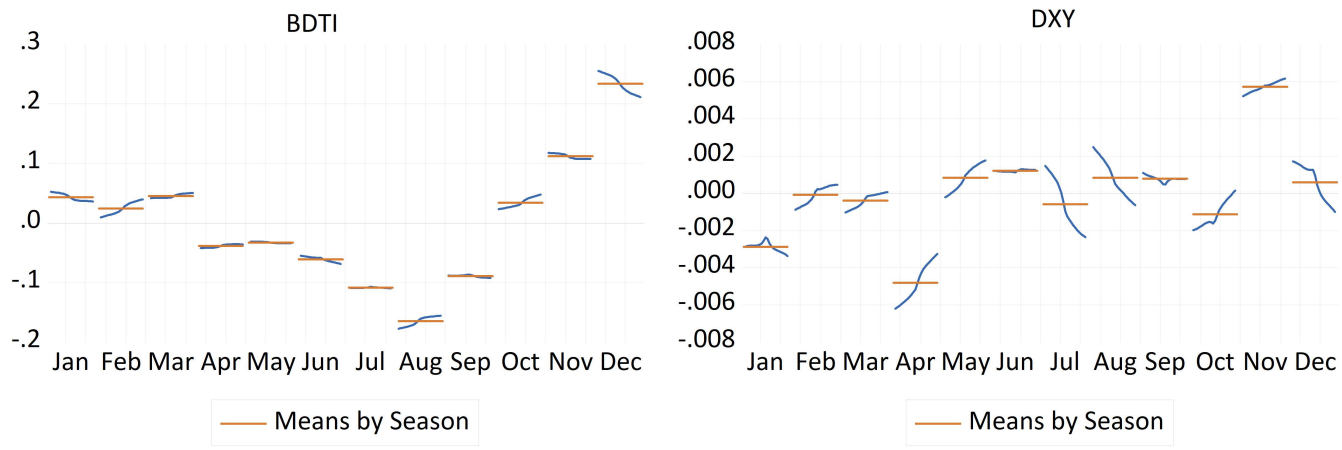

Figure 2. Seasonal factors in BDTI and DXY

Table 2. Unit root analysis result

Test	Variable	Level		First Difference		
		Intercept	Intercept & Trend	Intercept	Intercept & Trend	Conclusion
ADF	BDTI	-3.8017***	-4.1018***	-13.671***	-13.645***	I(0)
	DXY	-1.7291	-3.1105	-15.564***	-15.716***	I(1)
PP	BDTI	-3.7859***	-4.1408***	-16.236***	-16.201***	I(0)
	DXY	-1.9016	-3.1592*	-15.599***	-15.736***	I(1)

Note: Schwarz information criterion was selected in ADF test for optimum lag selection. ADF and PP critical values -3.455387 for ***1%, -2.872455 for **5%, -2.572660 for *10% at Intercept; ADF and PP critical values -3.993746 for ***1%, -3.427203 for **5%, -3.136898 for *10% at Trend and Intercept.

Table 3. Asymmetric causality test results

			Dollar => Freight			
			D+F+	D+F-	D-F-	D-F+
Optimal Lag; Var(p)			1	1	1	1
Additional Lags			1	1	1	1
Test Stat (MWALD)			0.066	0.292	2.255	4.533**
Asym. chi-sq. p-value			0.798	0.589	0.133	0.033
Critical Value	**1%*** **		6.398	7.534	9.431	8.075
		5%**	3.691	4.0.41	4.449	4.026
		10%*	2.575	2.940	2.829	2.724

Note: **Significant at %5*

The econometric meaning of the unit root is related to whether the effects of shocks are permanent. In other words, a unit root shows that statistical properties such as mean, and variance change over time. Since the BDTI variable contains a unit root, it can be said that it carries the shocks it was exposed to in the period under consideration and does not tend to return to its mean in the long run. In other words, the effects of the shocks the sector is exposed to are permanent in freights. On the other hand, the shocks in the DXY variable have a temporary effect and the variable tends to return to its mean in the long term. These results also show that BDTI moves randomly and is unpredictable, while DXY is predictable. The reason why BDTI is difficult to predict is because it is affected by many factors such as global trade, supply chain disruptions, oil prices, economic cycles, geopolitical events, ship orders, and inelastic supply in the short term. Any of these factors can

significantly affect freight rates. On the other hand, DXY is mainly affected by limited factors such as interest rates, inflation expectations, and geopolitical risk. Although these factors also have a relatively volatile effect, it can be said that DXY is on a more stable course because their effects are more predictable compared to freight.

The analyses were carried out using GAUSS software codes. Since there is a unit root in the BDTI variable from the series, the dmax value is determined as 1. Since the data set frequency is monthly, the maximum lag is determined as 12 to determine the lag in causality estimation. The number of bootstrap simulations for calculating critical values was determined as 1000. The Schwarz information criterion value was taken into account to determine the optimum value within the maximum lag. The test results for the asymmetric causality relationship from DXY to BDTI are presented in Table 3. The null hypothesis of no causality could be rejected for only 1 case, where negative shocks in DXY were determined as the cause of positive shocks in BDTI. No causality relationship could be determined in other combinations. Accordingly, a decrease in the dollar strength has an increasing effect on the dirty tanker freight rate. However, it was not found that an increase in dollar strength has a decreasing effect on dirty freight rate.

Discussion

Tanker transport, which is one of the most common methods preferred for the transport of oil, is also affected by the fluctuations in the oil price and therefore the dollar. This research paper provides a unique contribution to existing literature by exploring the asymmetric relationship between the dollar index and tanker freight rates, a topic not extensively covered in previous studies. While significant research has been conducted on the interactions between oil prices, exchange rates, gold price, and global economic factors, the specific focus on tanker freight rates adds a new dimension to the discussion. The paper builds on the foundational work in the field by examining how fluctuations in the dollar index uniquely affect tanker freight rates, highlighting an asymmetric relationship that has been observed.

In the asymmetric causality test, our unit root tests, applied to determine the maximum order of integration, indicated that BDTI is I(1) while DXY is I(0). These findings carry practical significance. BDTI's unit root implies that shocks impart lasting effects, causing the series to move unpredictably. This necessitates accounting for the permanence of shocks in forecasting models. Key factors contributing to this include the shipbuilding process, which spans 1-4 years and complicates rapid supply adjustments; unexpected supply chain disruptions; direct ties to global trade volumes and geopolitical tensions; and the impact of oil supply decisions, often influenced by political agendas. This inherent unpredictability underscores the need for stakeholders in the crude oil sector to adopt more complex and diversified risk management strategies. These strategies include hedging through derivative markets, diversifying routes and suppliers, securing long-term contracts with built-in flexibility, conducting real-time market analysis, managing exchange rate risk through currency hedging, and fostering strategic collaborations. The other variable, DXY, being I(0), indicates that shocks have only temporary effects, making long-term forecasts relatively more reliable and predictable. This allows stakeholders to base strategies on trends and expectations in indicators like interest rates and inflation. Consequently, simpler hedging strategies are likely sufficient for managing DXY-related risks compared to the more complex strategies required for BDTI.

The study's findings on the asymmetric causality between the dollar index (DXY) and tanker freight rates underscore a critical dynamic in maritime economics: currency fluctuations affect the tanker market in complex and uneven ways. A decrease in the dollar index leads to an increase in tanker freight rates, while an increase in the dollar index does not correspondingly decrease the freight rates. This asymmetry suggests that factors influencing tanker freight rates are more sensitive to decreases in the dollar index. This finding contributes to the broader understanding of how currency fluctuations impact the maritime shipping industry, particularly in the context of tanker operations.

The observed asymmetries in the relationship between the dollar index and tanker freight rates can be attributed to several potential causes: (i) Tanker operations are heavily dependent on fuel costs, which are influenced by oil prices (Alizadeh & Nomikos, 2009). When the dollar index decreases, oil prices typically rise, leading to higher operational costs for tankers. This increase in costs is directly passed on as higher freight rates. Conversely, when the dollar index increases, the reduction in oil prices may not proportionally lower operational costs due to fixed operational expenses and other non-variable costs. (ii) Freight rates are often determined through long-term contracts (Lyridis & Papleonidas, 2019). These contracts may not be immediately adjusted to reflect short-term fluctuations in the dollar index, leading to an asymmetric response. (iii) The demand for tanker shipping services may be more elastic in response to decreases in the

dollar index. A weaker dollar can stimulate global trade by making US goods cheaper internationally, increasing the demand for shipping services. However, an increase in the dollar index might not result in an immediate decrease in trade volume, especially if global economic conditions are strong. (iv) Companies involved in tanker operations may employ hedging strategies to manage currency risk (Karatzas, 2016). These strategies could mitigate the impact of an increasing dollar index on operational costs, thereby dampening the expected decrease in freight rates.

Our research reveals that only decreases in the DXY are responsible for increases in the BDTI. This relationship can be understood by examining how changes in U.S. exchange rates influence oil prices. Literature by Lizardo & Mollick (2010), Beckmann & Czudaj (2013), and Kisswani et al. (2019) has demonstrated the immediate effect of exchange rates on oil prices, while Sadorsky (2000) highlighted this impact in futures markets. According to our findings, a decrease in the DXY signifies a depreciation of the U.S. dollar, making it cheaper in international markets. This lower dollar value makes oil relatively more affordable, boosting demand for oil and, consequently, raising oil prices. Since the tanker market operates on derived demand, this rise in oil demand translates into increased demand for tankers, driving up tanker freight rates. Additionally, a secondary effect arises from the calculation of tanker freight rates in U.S. dollars; as oil prices increase, transportation costs also rise, further benefiting tanker rates. Conversely, our findings indicate that increases in the DXY do not result in lower tanker freight rates. Couder & Valérie (2016) observed that an increase in DXY typically reduces oil prices by making it relatively more expensive. However, this effect may not translate directly to tanker markets due to the prevalence of long-term contracts among tanker stakeholders, which buffer freight rates from short-term currency fluctuations.

The findings of this research have important implications for policymakers and industry stakeholders: (i) Stakeholders should develop robust hedging strategies to manage the impact of currency fluctuations on operational costs. (ii) Revising contractual terms to allow for more flexibility in response to currency changes can help mitigate the impact of asymmetries. (iii) Investing in more fuel-efficient technologies and alternative energy sources can reduce dependency on oil prices and mitigate the effects of a decreasing dollar index on operational costs.

By foreseeing changes in freight rates due to fluctuations in the US dollar, these companies can make informed decisions on when to deploy more vessels or adjust charter rates, thereby increasing profitability and operational efficiency. Industry stakeholders can better navigate the complexities of the relationship between the dollar index and tanker freight rates, ensuring more stable and predictable operational outcomes. This paper's originality lies in its detailed analysis of these asymmetric effects and its contribution to a more nuanced understanding of maritime economics.

Conclusion

In our current study, we employed a method focused on two-variable modeling to precisely capture the interactions between dollar strength and tanker freight rates. Consequently, other potential influencing factors on tanker freights could not be directly included in our model. Future research can enhance the comprehensiveness of these findings by adopting multivariable modeling approaches that incorporate additional relevant variables, such as oil prices, active fleet size, average fleet speed, and average haul distances, etc. to provide a more robust understanding of the determinants impacting tanker freight rates.

Compliance With Ethical Standards

Authors' Contributions

HOS: Writing – original draft, Writing – review & editing

AA: Conceptualization, Formal analysis, Data curation, Supervision

All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

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Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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