

WACC IN OECD COUNTRIES (SK NACE 1920) AND SPECULATIVE TRADING VOLUMES ON THE OIL MARKET: A FIVE-YEAR CORRELATION STUDY

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Abstract:

Research background: The petroleum products manufacturing sector is a key industry in the international trade of crude oil. The activities of this sector exert a significant influence on the global economy, particularly through the production and processing of oil, which represents a vital commodity for the daily functioning of societies worldwide.

Purpose of the article: The main goal of this research is to calculate the correlations between the WACC and the volume of speculative trading positions in the crude oil market. Speculative trading in the context of this research is considered the trading volume of futures or options contracts without any direct involvement in the underlying physical commodity. The analysis primarily examines the relationship between the WACC and Brent crude oil futures prices, emphasizing the significant role of the futures price volatility in the companies' costs of capital.

Methods: The article calculates the weighted average cost of capital (WACC) for the petroleum products manufacturing sector in the member states of the OECD. Overall, 96 calculations of WACC are made for companies from 16 OECD member countries.

Findings & Value added: Country-specific disparities in WACC are identified, with Greece, Poland and Germany showing the highest values, which reflects the variable economic and market conditions. While speculative trading is proven to have no direct effect on the WACC, its indirect impact through crude oil price volatility is significant. A potential indirect effect through crude oil futures price volatility emphasizes its role as a significant factor influencing the financial environment for companies in the petroleum manufacturing sector. If we assume a continually rising trend in the traded oil futures positions, we consider further studies on the relationship between the WACC and speculative trading of great importance. The findings of this research contribute to understanding the financial implications of crude oil market dynamics and provide actionable insights for corporate risk managers.

Keywords: weighted average cost of capital; speculative trading; oil market; OECD countries; correlation analysis

JEL Classification: G12; G15; E44

1. Introduction

The petroleum products manufacturing sector is a key industry in the international trade of crude oil, which is arguably the most important commodity. The activities of this sector exert a significant influence on the global economy, particularly through the production and processing of oil, which represents a vital commodity for the daily functioning of societies worldwide. This impact is further underscored by the role of oil in ensuring a stable supply to the market. The price of oil is distinguished by a long and complex history, characterized by significant price volatility, the formation of price bubbles (Quinn and Turner, 2020), and periodic price slumps, setting it apart from other traded commodities.

Crude oil is primarily traded in the form of financial derivatives, most notably as futures contracts (Kang et al., 2020) listed on exchanges. While commercial participants, such as energy and aviation companies, utilize futures contracts to hedge against adverse price fluctuations in their future commodity purchases, non-commercial traders generally view the physical delivery of the commodity as undesirable. Historically, the demand for oil futures contracts has consistently exceeded the physical demand for oil by a factor of at least 1,16. The largest disparity between physically traded oil and oil traded as financial derivatives was observed in March 2020 (Bakas and Triantafyllou, 2020), during the peak of the global impact of the COVID-19 pandemic. During this period, the demand for exchange-traded oil derivatives surged to 2,6 times (Cepelova, 2024) the level of physical demand for oil.

The trading of oil futures contracts represents the most prevalent method of speculating on future movements of oil prices. Currently, the demand for oil, reflected in realized futures positions, exceeds the physical volume of oil traded by nearly 21 times. This trend has been increasing since 2011, with the average annual volume of Brent crude oil futures contracts traded by exchange speculators having quadrupled over this period. Speculative demand in the oil market is currently not clearly quantifiable. However, historical analysis indicates that sharp shifts in the sentiment (Umar et al., 2021) of exchange speculators during periods of high market volatility can lead to artificially inflated prices (Harrison et al., 2023) or significant reductions in oil demand.

The evolution of oil market prices and the factors influencing their development have long been a focus of research for numerous authors and scholars. Oil market dynamics serve as a critical indicator for exchange traders, including physical buyers of oil. Equally important, however, is an examination of the other side of market relations – the companies that extract, process and sell oil, which form the basis of the physical supply of this fundamental commodity. In this research, we aim to gain an insight into how the external market dynamics influence the overall financial stability of companies in the petroleum products manufacturing sector.

Generally, oil processing companies rely heavily on external financing for investments in refinery operations infrastructure and operational costs. External financing constitutes foreign capital that oil processing companies acquire through borrowing from banks or other non-bank entities. This borrowed capital incurs costs in the form of interest payments, which companies must manage as part of their financial operations. Uncertainty in oil prices can significantly influence long-term investment decisions by potential lenders (Yang et al., 2019), including banks and non-bank financial institutions. Speculative trading and oil price fluctuations can intensify perceptions of risk (Fan et al., 2021), leading lenders to view oil processing companies as less financially stable. Consequently, this elevated risk perception can increase the cost of borrowing, either through higher interest rates or stricter loan conditions.

Volatility in oil prices also has a direct impact on the profitability of petroleum products manufacturing companies through its effect on refining margins, which represent a critical source of income. Fluctuating margins weaken the financial performance of these companies,

reducing their ability to generate stable profits. For equity investors, including shareholders and potential buyers of company shares, these dynamics increase the perceived risk (Wang et al., 2021) associated with the company's stocks. As a result, the cost of equity rises due to higher expected returns demanded by investors to compensate for increased risk. The increased cost of equity can further constrain the financial flexibility of oil processing companies (Prodromou and Demirer, 2022), particularly in volatile market conditions.

Based on these theoretical foundations, we conclude that it is of importance and meaningful to evaluate the impact of oil price fluctuations and the volume of speculative trading positions on the crude oil futures market on the average cost of capital of petroleum products manufacturing companies. We note that in the issue of this research, literature is linked to oil price fluctuations, investor decisions, speculative demand or market sentiment analysis, yet the impact of the speculative transaction volume on the oil processing companies' average cost of capital in the OECD countries has not been studied to greater extent.

Research highlights the importance of market architecture and trading transparency in reducing WACC values in companies in general. Studies have shown that migrating from dealer to hybrid auction systems enhances trading information quality (Chelley-Steeley and Lambertides, 2017), reducing the cost of equity capital, especially for smaller companies with higher initial levels of information asymmetry. Similarly, information asymmetry is identified as a key driver of capital costs (Toski et al., 2020), with higher probabilities of informed trading increasing both equity and debt costs. This effect is particularly identified in ownership structures with limited information, such as family-owned companies, where the inequalities in access to the information and potential risk increase.

As part of studies on the factors influencing the cost of capital of companies, the role of institutional quality and regulatory frameworks is emphasized in the context of strong insider trading laws and high institutional quality (Kwabi et al., 2018), which lower the cost of capital by strengthening market confidence and reducing perceived risks. Higher weighted average cost of capital, on the other hand, is associated with illiquidity and highly volatile market conditions (Belkhir et al., 2020), particularly in markets with weak investor protections. Stock markets with higher illiquidity tail risk face higher equity costs, which might result in a more intensive effect during an economic downturn.

In the context of commodity markets, price volatility has been linked to the variability of financing costs in previous studies. Speculative trading is recognized as a significant contributor to price volatility, indirectly influencing WACC (Christensen and Qin, 2014) through heightened risk perceptions and market uncertainty. While not directly linking speculative trading to WACC, studies on commodity markets and volatility have consistently shown that speculative trading drives price volatility, which indirectly affects companies' cost of capital. These insights draw attention to the importance of accurate WACC calculation (Miller, 2009) for industries highly exposed to external market fluctuations, such as the petroleum manufacturing sector (SK NACE 1920).

Following on from the obtained research conclusions, the research goal of this study is set to perform an accurate calculation of the weighted average cost of capital of 96 public limited companies in the petroleum products manufacturing sector from 16 OECD member countries and additional calculations of the correlations and linear regressions of the relationship between the crude oil future prices and WACC and the volume of speculative trading positions in the crude oil market and WACC.

2. Methodology

This article defines speculative transactions in the crude oil market as the implemented positions of non-commercial traders. A non-commercial trader is defined by the Commodity Futures Trading Commission (2023) as a market participant who engages in trading futures or options contracts without any direct involvement in the underlying physical commodity. These traders do not intend to take physical delivery of the commodity but instead participate in the market to capitalize on price movements. Such traders are commonly referred to as exchange speculators.

To perform the calculations and analysis in this study, we utilize crude oil price data aggregated from daily prices of Brent crude oil futures contracts as reported by the Intercontinental Exchange (ICE). The choice of Brent crude oil prices is justified by its status as a global benchmark for oil pricing and its widespread use in economic analyses and policy discussions. Furthermore, data from ICE ensures consistency and reliability, as it represents a significant part of the international crude oil market.

The analysis focuses on the correlations between speculative demand and the average cost of capital of petroleum products manufacturing companies based in the countries of OECD. Brent crude oil is particularly relevant in this context, given its significant influence on the energy policies and economic structures of OECD member states. From the OECD member states, data for oil processing companies were analyzed based in these countries: Austria, Belgium, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal and Slovakia.

The weighted average cost of capital (WACC) serves as a critical financial metric that reflects the overall cost of financing for a company, incorporating both equity and debt. It is particularly relevant in this research as it enables assessment of the cost of capital across the analyzed countries and provides valuable insights into how differences in economic conditions, corporate structures and market dynamics influence financing costs in these regions. To compute WACC for the listed countries, we utilized the following financial and economic data over a 5-year period (2019-2023): shareholder funds, non-current and current liabilities, long-term debt and interest paid. Corporate tax rates, beta coefficients and market risk premiums were sourced from Aswath Damodaran's datasets, tailored for each country and industry. The risk-free rate is based on the 10-year U. S. Treasury bond yield, reflecting a stable benchmark commonly used in international WACC calculation.

WACC is calculated as:

$$WACC = \left(\frac{E}{E + D} \cdot r_e \right) + \left(\frac{D}{E + D} \cdot r_d \cdot (1 - t) \right) \quad (1)$$

where

E is equity

D is debt

r_e is cost of equity, calculated using the CAPM formula

r_d is cost of debt, derived from interest paid and long-term debt

t is corporate tax rate

The weighted average cost of capital formula is a fundamental concept in corporate finance (Allen et al., 2016) and does not have a single author, as it has evolved over time through collective work of academics and practitioners in this field. It is, however, widely associated

with the foundational work of Modigliani and Miller (1958). The WACC formula is now a standard tool in corporate finance.

The research goal of this study is to calculate the correlations between the WACC of 96 public limited companies in the petroleum products manufacturing sector from 16 OECD member countries and the volume of speculative trading positions in the crude oil market. To examine these relationships, correlation analysis is conducted using IBM software. Specifically, the analysis is performed using IBM SPSS Statistics, which provides robust tools for statistical computations.

The Spearman correlation coefficient is used to assess the strength and direction of the relationship between the variables. Unlike the Pearson correlation coefficient, which measures linear relationships, the Spearman correlation evaluates whether an increase in one variable corresponds to an increase or decrease in another variable, regardless of the actual linearity of the relationship. The formula applied by the software for Spearman correlation is as follows:

$$r_s = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)} \quad (2)$$

where 6 is constant numeric value

d_i is difference between the ranks of each pair of observations

n is number of observations

The Spearman correlation is chosen for this analysis due to the potential non-linear relationships among the studied variables, as speculative trading volumes and WACC may not always reflect a linear interaction with crude oil futures prices. This method ensures a more robust assessment of associations under such conditions.

To support the results of the correlation, linear regression analysis is conducted also using the IBM SPSS software. This approach is implemented to further investigate the relationship between the volume of speculative trading transactions in the crude oil market and WACC, as well as between crude oil prices and WACC. Linear regression allows for a deeper examination of the predictive power and significance of these variables in explaining variations in WACC, complementing the correlation analysis by providing additional insights into the strength and direction of these relationships. The regression models are designed with WACC as the dependent variable and the volume of speculative trading transactions and crude oil futures prices as independent variables, ensuring an intense exploration of these associations.

Furthermore, we set a main hypothesis to validate the present research and a hypothesis to alternate the main:

H₀: There is no significant correlation between the volume of speculative trading positions in the crude oil market and the weighted average cost of capital (WACC) of petroleum products manufacturing companies.

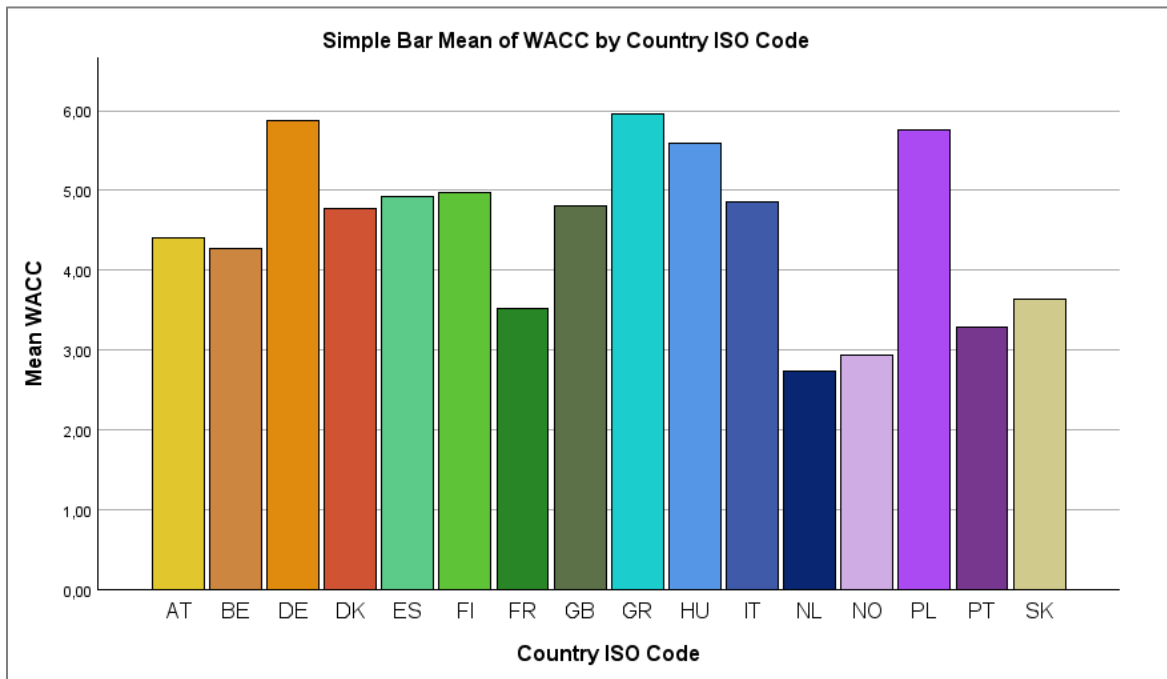
H₁: There is a significant correlation between the volume of speculative trading positions in the crude oil market and the weighted average cost of capital (WACC) of petroleum products manufacturing companies.

3. Results

First, the calculated WACC for petroleum manufacturing companies in 16 member countries of OECD is evaluated. A comparative overview of the financing costs faced by oil manufacturing companies in different national contexts is presented in Figure 1 below. The 5-

year WACC offers a high-level perspective on the variation in financial conditions across countries, reflecting differences in macroeconomic environments, risk profiles and capital structures. By visualizing this data, Figure 1 highlights the disparities in financing costs and establishes a baseline for interpreting the subsequent analysis of correlations between speculative trading, crude oil prices and WACC.

Figure 1: Histogram of average WACC by country (5-year average)

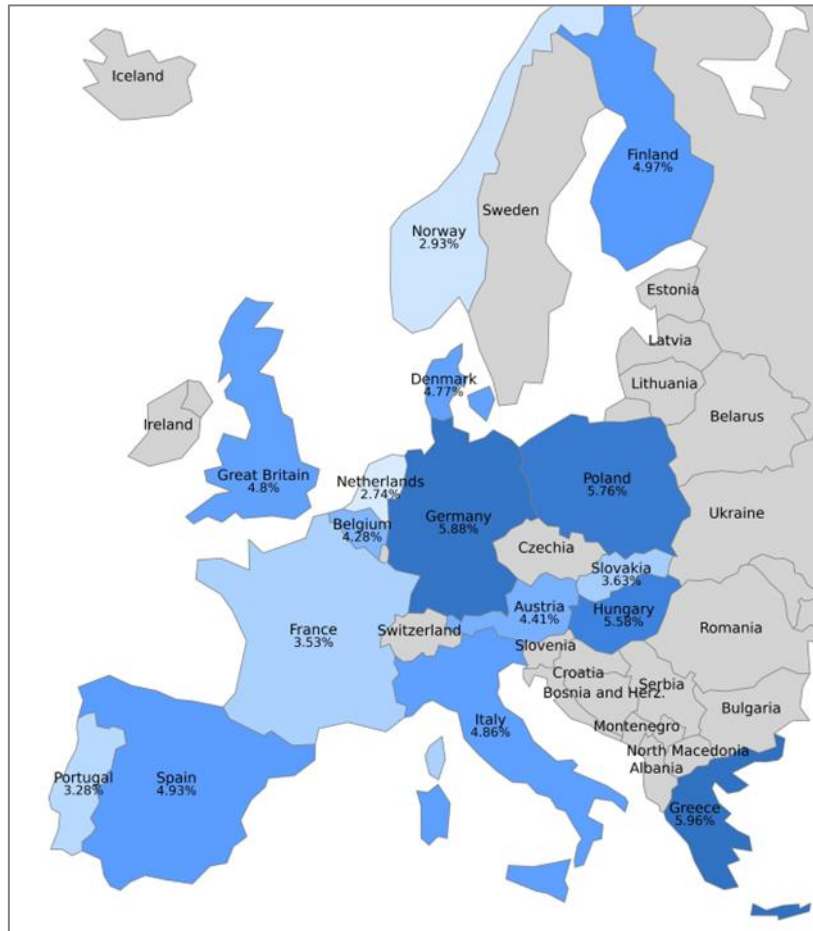


Source: own processing

Each bar represents the average WACC for its corresponding country, with variations indicating differences in financing costs across countries. The average WACC values range between approximately 3 %, at the lower end being Netherlands and Norway, and 6 %, which the higher end reached by Greece and Germany. A higher average WACC might suggest relatively more expensive financing conditions for oil processing companies. Greece exhibits the highest average WACC, which could reflect less supportive debt and equity financing conditions. Poland also shows a relatively high WACC, likely driven by macroeconomic conditions or historical market perceptions of risk. However, recent economic developments suggest a positive shift (Sultana et al., 2024), as Poland’s GDP per capita has risen from 48 % to 82 % (Albert and Bienvenu, 2024) of the EU average since 2004. As these positive trends continue, it is reasonable to assume that Poland’s WACC will decrease. For countries with average WACC at the lower end, this might indicate a more optimal financing environment. These are represented by the Netherlands and Norway, which might be due to their robust economy and lower perceived risk in the oil sector.

For better visualization, we also created a cartogram illustrating a geographical distribution of 5-year average WACC across European countries, presented in Figure 2. Countries included in the study of this research paper are colored blue, with a spectrum ranging from light blue, indicating the lowest values of the average weighted cost of capital, to dark blue, indicating the highest values of the observed indicator.

Figure 2: Geographical Distribution of WACC in OECD member countries



Source: own processing

Based on the regional clustering, we conclude, that Western Europe countries, such as Austria and Belgium, tend to cluster around moderate WACC values, values of 4 % to 5 % WACC. This might reflect balanced financing conditions. Southern Europe countries, such as Portugal and Spain, show slightly higher values, potentially reflecting regional economic challenges.

Next, we analyzed the correlations between speculative trading volumes in the crude oil market and the weighted average cost of capital of 96 petroleum products manufacturing companies. Spearman correlation for this relationship provided a conclusion of a weak and statistically insignificant dependence. To support these results, we also calculated linear regression based only on the relationship of these two variables. The quality of this model is lower than 0% and the relationship between the two variables has proven insignificant. The volume of speculative trades on the crude oil futures market has no direct effect on the average weighted cost of capital of oil manufacturing companies in the OECD.

Lastly, the correlations between the aggregated crude oil futures prices and the weighted average cost of capital of 96 petroleum products manufacturing companies were examined. The Spearman correlation for the relationship between these two variables is, in contrast to previous results, statistically significant. Dependence is interpreted as a weak increasing relationship. This indicates that with increasing crude oil futures prices, the WACC of crude oil manufacturing companies could have the tendency to rise. Crude oil futures prices, even though only a low portion of the transactions lead to physical delivery of crude oil, might change the

risk perception of investors in the petroleum manufacturing sector. In addition, the increase in crude oil futures may reduce consumer demand for refined products, particularly in price-sensitive regions. This reduction in demand puts downward pressure on product prices, negatively affecting the margins of crude oil manufacturing companies.

To support the results, we repeated the linear regression for the relationship between the two variables of WACC and the aggregated crude oil futures prices. The results are included in Figure 3 and show that the linear regression supported the statistical significance of this relationship. The quality of this linear regression model, according to the adjusted R squared value, interprets as the ability of this relationship to explain 11,1 % of the variability in the calculated WACC values.

Table 3: Regression Coefficients for the impact of Brent crude oil futures prices on WACC

Coefficients ^a					
		Unstandardized Coefficients		Standardized Coefficients	
		B	Std. Error	Beta	t
1	(Constant)	1.232	0.469		2.627
	Brent Futures Price	0.049	0.006	0.336	7.804
					Sig.
					0.009
					<0.001

a. Dependent Variable: WACC

Source: own processing

The unstandardized coefficient shows that for every one dollar increase in Brent futures prices, the WACC increases by approximately 0,049 %, holding other factors constant. The positive value of the coefficient implies that higher Brent futures prices are associated with higher WACC for oil manufacturing companies of the OECD. This result underscores the importance of Brent futures prices as a key variable influencing the cost of capital, making it critical for companies and investors to monitor oil price trends in financial planning and risk management.

4. Discussion

The most important findings in the context of the research for this paper highlight the positive correlation between Brent crude oil futures prices and the WACC calculated for 96 oil manufacturing companies in 16 member countries of OECD. With increasing crude oil futures prices, the analyzed companies' WACC, in a small amount of approximately 0,049 % with a one dollar rise in the Brent futures prices, but with a statistical significance, increases. Rising Brent crude oil prices directly impact the cost of capital, possibly due to an increased market risk perception linked to the unpredictability of the crude oil futures price development, or the direct impact on the petroleum manufacturing companies profit margins, where the rising prices create a downward pressure on the petroleum products' consumer demand affecting the sales of the companies and the investor perception of the profit potential.

These findings are consistent with the conclusions of research held by Prodromou and Demirer (2022) about the relationship between oil price shocks and the cost of capital estimates from 34 global economies. According to the outcomes of the research, oil price volatility increases systemic risk, which raises the equity risk premium entering the calculations of capital costs. Higher oil price-driven equity risk translates into increased capital costs, particularly in oil-importing economies.

Our own research indicates that an increase in crude oil prices by one dollar stimulates an increase in the weighted average costs of capital by 0,049 %. The results of another research led by Ghossoub and Reed (2014) do not, however, offer the same view. According to these authors, a rise in asset prices, if driven by favorable monetary policy or increased productivity

in the capital sector can reduce the cost of capital, enhancing investment activity. These contrasting perspectives underscore the complexity of the factors influencing the cost and the importance of context when interpreting these relationships.

In the research, the country specific WACC disparities were illustrated, pointing out the highest average WACC values in countries, such as Greece, Poland and Germany. These variations reflect the influence of a country's specific economic conditions, risk profiles and market perceptions on the cost of financing for petroleum manufacturing companies. High average WACC values calculated for the companies based in Greece could be explained by the high-risk profiles due to the prolonged economic instability, elevated public debt levels and investor concerns about the financial health of its economy. These factors contribute to higher borrowing costs and greater equity risk premiums, which in turn raise the WACC for companies operating in Greece's petroleum sector.

In Poland, the high values of the average WACC calculated for the petroleum manufacturing companies appear to be primarily driven by historical market perceptions of risk, particularly in the context of the country's transition from an emerging (Afzal et al., 2023) to a developed economy. Recent economic developments such as robust GDP growth, however, suggest improved investor confidence and a positive trajectory for future economic stability. The trends indicate that Poland's WACC is likely to decrease over time as market perceptions of risk continue to diminish and financial conditions improve.

For Germany, the tendency for high average weighted cost of capital values might be linked to its heavily industrialized economy, which has faced an increasing energy transition pressures and regulatory risks. The shift towards renewable energy and the cost of capital associated with reducing reliance on fossil fuels might contribute to higher perceived risk for companies in the petroleum sector, resulting in increasing financial costs. Additionally, Germany's strong emphasis on equity financing over debt (Koch et al., 2022) could result in a higher WACC, given the generally known higher costs of equity compared to debt.

It is also important to note the role of speculative trading in the crude oil market and its potential impact on the WACC of petroleum manufacturing companies. While speculative trading itself may not directly influence the WACC, it is reasonable to suggest the possible indirect effects. Speculative trading can inflict significant volatility in crude oil futures prices, creating artificial price movements that are disconnected from supply and demand fundamentals (Christensen and Qin, 2014). This volatility in crude oil futures prices has important implications for the WACC values of petroleum manufacturing companies.

As shown in this research, there is a positive correlation between Brent crude oil futures prices and the calculated WACC, which indicates that changes in crude oil futures prices can influence financing costs. Speculative trading, by amplifying crude oil price volatility, indirectly impacts WACC by altering the risk perception of investors and creditors. Higher volatility in crude oil futures prices can lead to increased uncertainty in market conditions, prompting lenders to require higher interest rates and investors to expect greater returns on equity.

Therefore, while speculative trading might not have a direct causal relationship with the calculated WACC of petroleum manufacturing companies, its indirect effects through crude oil futures price volatility emphasize its role as a significant factor influencing the financial environment for companies in the petroleum manufacturing sector. Future research could analyze this connection greater in depth, examining how speculative driven volatility impacts not only crude oil prices, but also the broader financial indicators of companies in energy dependent industries.

5. Conclusions

This research paper analyzed the relationship between crude oil futures prices, speculative trading volume and the weighted average cost of capital (WACC) for 96 petroleum manufacturing companies from 16 member countries of the OECD organization. The research provides a country-specific perspective, showcasing significant disparities in WACC and how these variations are influenced by macroeconomic conditions, historical risk perceptions and sector specific factors such as energy transition pressures. The highest averages of the WACC values observed in Greece, Poland and Germany highlight the role of macroeconomic conditions, historical risk perceptions and capital structure factors in the capital costs development. For instance, Greece's high WACC is linked to its risk profile, while Poland's high WACC reflects persisting market perceptions of risk despite its improving economic outlook. Germany's high WACC, in the contrast of Greece and Poland, may be based on the energy transition pressures and reliance on equity financing.

The research for this paper also proves a positive correlation between Brent crude oil futures prices and WACC, underscoring the influence of crude oil price dynamics on capital costs. While speculative trading does not directly affect WACC, its role in amplifying crude oil price volatility indirectly impacts financing conditions by increasing the inability to predict its future development and risk perceptions among investors and creditors. This analysis contributes to the literature by linking Brent crude oil futures prices and speculative trading volumes with the WACC for petroleum manufacturing companies. By examining the relationship between speculative trading activity and crude oil price volatility, the study adds to the understanding of how non-physical market activities, such as the futures trading, impact financial conditions in energy-intensive industries.

The demand for oil, reflected in realized futures positions on the stock market, exceeds the physical volume of oil traded by nearly 21 times. This trend has been increasing since 2011, with the average annual volume of Brent crude oil futures contracts traded by exchange speculators having quadrupled over this period. If we assume the continuity of this trend, we consider of great importance more studies about the relationship between the WACC of companies from the petroleum manufacturing sector and the speculative trading on the crude oil market. A study aimed at different sectors linked to trading on other stock markets could be very reasonable and of high use in the context of monitoring the speculative trading on stock markets, the development of its volumes and the effects on commodities or other objects of trade.

The research bridges a gap between commodity market behavior and corporate finance by demonstrating how speculative trading indirectly amplifies financial risks for companies, enriching the dialogue on commodity-linked financial indicators. The analysis is based on 96 companies from 16 OECD member countries, which may not fully capture global market dynamics or the specific conditions in non-OECD countries. The research limitations are also found in the focus on the petroleum manufacturing sector, limiting the applicability of findings to other industries or sectors with different capital structures and risk profiles.

Future studies could explore the relationship between speculative trading, commodity price volatility and WACC in other energy-intensive sectors tied to commodity markets, such as mining, chemicals or agriculture. Expanding the analysis to include non-OECD countries would provide a more comprehensive understanding of how regional conditions shape WACC. The role of energy transition pressures, particularly in countries like Germany, also deserves further investigation to understand how regulatory and environmental policies influence WACC and financing conditions.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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