Master Thesis U.S.E

Evaluation of energy efficiency impact on corporate financial performance of companies in western Europe[1]

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Abstract

Transition from fossil fuel economics to green ones is underway in the western Europe. The research paper answers whether there are potential benefits for corporate financial performance derived from increasing energy efficiency of the companies. Moreover, I extended the problem by implementing COVID19 pandemic and war in Ukraine period in the analysis. In this research paper I employed fixed and random effect model to perform analysis on 4 financial metrics: ROE, ROA, Tobin's q and FOCF for companies in industrial, energy, basic materials and technology sectors in western Europe. The research was conducted in the period of stable energy prices (2015-2019) and fast increase in them (2020-2022) with distinction of COVID19 pandemic and war in Ukraine influence. I found that during safe times energy efficiency negatively impact corporate financial performance and during energy crises positively. The latter offset and even surpass in some cases the former.

JEL: C23, O13, O16

Key words: Energy efficiency, Financial performance

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Introduction

There is a growing interest whether the cost to become energy efficient (EF), not only impacts the ecological influence of companies but also gives a rise to financial benefits. Since the Kyoto protocol in 1997, Paris Agreement in 2016 and more recently climate conference in Glasgow in 2021 which aim to reduce greenhouse gasses (GHG) emissions in signatures' countries by 55% by 2030 and to become net zero by 2050 pressured companies to be more environmentally responsible (European Commission, 2020). There is still a green transformation from fossil fuels-based economies to green ones (Sims et al., 2003). However, the main source of electricity in Europe is still coal and gas (Topic: Global Electricity Prices, Statista, 2023). Improvements in energy efficiency may help with achieving the emission reduction target, mitigating the potential penalties and hedge against rise of energy prices in recent years (EU: Monthly Electricity Prices by Country 2023 | Statista, 2023). Energy intensive industries are currently one of the main polluters and power is one of the most important variable or semi-variable cost in the modern manufacturing processes (Dessus & Bussolo, 1998). Moreover, in the future, falling short to emission targets can cause financial penalties. The energy efficiency helps to fight global warming by reducing the demand for electricity and greenhouse emissions (Bergmann et al., 2017).

The majority of countries in the region of western Europe as main source of electricity use non-renewable fuels. The green transformation advancements in the matter of transforming to renewable sources are at best average (Jonek-Kowalska, 2022). Energy is derived from natural gas (20%), coal (14%) and nuclear (25%) plants and only 37% from renewable energy sources and 4% from others. Therefore, in this research the EF will be equivalent to carbon efficiency. Furthermore, western European countries due to Covid-19 pandemic and war in Ukraine have experienced an increase in prices and high volatility on energy market. This negatively influenced contribution per unit of the energy intensive companies for whom it is an important direct production cost.

All of western European countries (Austria, Belgium, France, Germany, Luxembourg, Monaco, Netherlands and Switzerland) have decreased their energy consumption in the past decade (EU: Change in Power Consumption by Country 2010-2021, Statista, 2023). It has been found that non-renewable and renewable energy consumption are positively correlated with gross domestic product (GDP) growth (Gozgor et al., 2018) and these countries have increased their (GDP) slightly since 2015 compared to eastern European countries. Moreover, consumers in these countries are becoming more and more self-aware of the consequences of their purchases and therefore there is an increase in people who try for their consumption to cause as low carbon footprint as possible (Rondoni & Grasso, 2021). Therefore, companies which can increase their energy efficiency and implicitly lower carbon emissions per unit may be better off in the longer.

The existing literature, analyzing the influence of energy efficiency on the corporate financial performance (CFP), have not given a clear answer to this phenomenon. Depending on the industry, methodology, country or years on which the research has been conducted either the relationship has been found or not (e.g. Fan et al., 2017; Trinks et al., 2020; Sueyoshi & Goto, 2009; Moon & Min, 2020.

The aim of this study was to see if there are any potential financial benefits from increasing energy efficiency in the companies with headquarters in western Europe. Therefore, this study will contribute to the current knowledge of the problem by investigating it on different sample of the western European countries and period of 2015 to 2022. The recent COVID19 crises and the conflict between Ukraine and Russia have influenced rise in energy prices on the world markets (Topic: Global Electricity Prices, Statista, 2023). Therefore, the research paper will examine how the war in Ukraine and the COVID-19 pandemic have influenced the relations between EF and CFP. Based on the results, we will be able to assess whether EF impacts resistance of firms to the crises on energy market caused by war and pandemic. The results of this research paper are in line with observations made by Ferriani and Gazzani (2022), Subrahmanya (2006) and Xie et al. (2018). However, contrary to the Porter hypothesis (Porter, 1991).

The master thesis is structured as follows: in the next section I presented a helicopter view on the relationship between energy (carbon) efficiency and corporate financial performance. Then the research hypothesis were formulated, statistical test performed and models which will be used were put forward. Information about data to be utilized in the regressions were explained. Afterwards, descriptive statistics and empirical analysis were performed using 13 models; 3 for ROE, ROA and FOCF and 4 for Tobin's q. Lastly the results were presented and discussed in relation to other academic literature.

Literature Overview

Porter hypothesis (Porter, 1991) argue that companies can benefit from environmental regulations. He asserts that by having them well planned they may stimulate innovations and favorable changes for productivity for firms and therefore their financial performance. Porter implies that environmental regulations not only bring benefits for society but also they would be good for companies. However, even without regulations a need for sustainability and reduction of greenhouse gas emissions give a rise to the companies to improve their energy efficiency and therefore reduce pollutions. Firms may be willing to emit less GHG, if they know whether the improvement of energy efficiency translates into better financial performance and therefore competitiveness in their markets. Moreover, GHG emissions targets in the given country may be overestimated if countries do not take into account that the energy demand increases with the countries' development (Sadorsky, 2011). Therefore, high energy efficiency should offset the rise in demands and consequently help with the green transformation. In response to these needs, a few studies have been conducted.

Authors argue that, in principle, better EF (lower GHG emissions) improves firms' CFP (e.g. Fan et al., 2017; Trinks et al., 2020, Chiou et al., 2011; Subrahmanya, 2006; Bergmann et al., 2017). However, contrary results have also been observed (e.g. Pons et al., 2013, Nagesha & Balachandra, 2006). Meta-analysis conducted on 52 research papers have shown that better environmental performance translates into a better financial one (Orlitzky et al., 2003). In China it was noticed that in the period between 2010 and 2014, in the energy intensive manufacturing companies, lower energy intensity positively impacts CFP, especially when the same output is achieved by lower energy input (Fan et al., 2017). Companies which are energy inefficient are more keen to be sensible on changes of its price and regulations regarding CO2 emissions. Their production may become less optimal and profitable when the price increase or regulations become stricter (Trinks et al., 2020). Hart and Ahuja (1996) studied how fast did pollution prevention impact the CFP. They performed research on the 127 manufacturing firms from S&P500 between 1988 and 1992 and found out that after 1 or 2 years it appeared that improvement in carbon efficiency influence the bottom line. They discuss that the operating performance increased in the 1st year after the pollution prevention was introduced in the companies and after 2 return on equity (ROE) improved. They reasoned that bigger lag on ROE could be due to the fact that it not only reflects operating performance, but also the capital structure of the company. Moreover, they argue that poor environmental performance can lead to exposure to the liabilities and therefore highest cost of capital which affect the ROE. In a more recent study, it was observed across 1572 international firms between 2009 and 2017, that better carbon efficiency translates directly into better CFP compared with the companies which are emitting more. Trinks et al. (2020) even noticed that on average 0.1 higher carbon intensity translates into 1% increase in profitability and 0.6% decrease in the systematic risk. The authors suggest that best practice firms (lower carbon emissions) may improve their operating performance and therefore, the sensitivity to the carbon pricing regulations.

In India in the brick and the foundry clusters the EF made an important impact on the financial performance of the small companies (Subrahmanya, 2006). He found that in the both industries energy intensity has a negative effect on productivity and the value addition per unit. He suggests that the higher energy efficiency the higher value of output. Subrahmanya (2006) observed that energy was a significant factor in the return to scale. The researcher notes that the government should create a programme to support the EF investments to make the companies more competitive on the market. Clarkson et al. (2011) found that firms which improve their environmental performance improve in the long term their CFP. Moreover, these companies have real economic benefits following the improvement in the EF (higher profitability and better cash flows) compared to firms which chose not to focus on it. Based on the meta-analysis conducted by Busch and Lewandowski (2018), the market based measures are more favorably influenced by energy efficiency than the accounting-based measures. Therefore, the researchers argue that the value of the EF is seen in the long term by the investors and not short term in the production. It was observed that a proactive environmental strategy can positively impact the CFP however not all firms can achieve that. The authors suggest that only firms with sufficient capital and adequate management can pursue such strategy.

Pons et al., 2013 did research on Spain and Slovenia, across 120 companies. They have detected that implementation of the energy saving technologies (EST) does not clearly impact energy performance. Therefore, the authors discuss that the investment in the EST are helping to be more environmental friendly rather than improving competitiveness of the company. Moreover, in Australia it was observed that low emission of the GHG (high EF) does not necessarily translates into better CFP (Sueyoshi & Goto, 2009). Therefore, researchers argue that firms should not care about EF and GHG emissions to increase their economic benefits. In South Korea, where there is still a debate concerning usefulness of the CO2 emission trading scheme similar to the European Emission Trading System (EU-TS), it was observed that there is a weak connection between better energy performance and the CFP (Moon & Min, 2020).

To ensure long-term energy efficiency and sustainability investments, Thollander & Ottoson (2008) have suggested to create a planned programs beneficial to creating an environment for companies to encourage them to make such investments. Therefore, the researchers suggest that the government should not create punitive regulations for poor energy efficient firms but rather create an environment which would encourage customers to appreciate products with lower carbon footprint and give subsidies to the companies which invest in the EST. Researchers argue that the governmental allowances may help ensure that cost of energy oriented investments can be eased without the need of the financial incentives from customers. Authors argue that thanks to these politics energy efficiency could become more profitable for the companies than they are right now (Safarzadeh & Rasti-Barzoki, 2019).

Moreover, there is no general agreement on the results with examining different industries. For instance, the electric utility industry in USA shows no significant relationship between the emission performance and the CFP (Sueyoshi & Goto, 2009). However, for the listed manufacturing firms in Indonesia (Rokhmawati et al., 2015), and for small brick and foundry clusters in India (Subrahmanya, 2006) such link has been found. The authors argue that some industries should be examined by different criteria. Also, use of different methodology shows different results. Wagner (2005) presents that by using fixed model the relationship between environmental and financial performance has been found, however when the pooled model is implemented the relationship drops. Consequently, better energy (emission) performance does not always translates into better financial one.

Yoo et al. (2021) performed an analysis on cross sectional data consisting of 2887 firms in the period from 2019 and 2020. They wanted to test which companies are more resistant to COVID19 pandemic in regard to the ESG score. They observed that entities with higher E-score perform better under duress of this crises than the firms with lower. It was argued that high E-score translates into higher returns and lower volatility in this period. However, the GC- E score shows that improving it does not positively influence the stock value of the companies but rather decrease it. Similar topic was researched by Ferriani and Gazzani (2022). They tested how war in Ukraine influenced financial performance of companies through energy efficiency. They found that since the Russian aggression started, which influenced rapid increase of the prices and volatility on the energy market, the companies with high energy efficiency are more resistant to these changes than ones with low EF. They observed that the energy intensity is positively impacting corporate financial performance during this crises.

Based on the previous literature and the research gap the following research hypothesis were put forward:

H1: Energy efficiency positively influence corporate financial performance

Some studies shows that firms investing in the green finance are more resistant to the crises due to their high ESG score (in that energy efficiency) (Ferriani and Gazzani, 2022). Gas and coal is the main source of electricity production in Europe. Therefore, since the war between Ukraine and main supplier of blue gold Russia started the energy prices increased in EU (Topic: Global Electricity Prices, Statista, 2023). Between 23.02.2022, the day prior to the Russian invasion and start of the conflict, and 31.07.2022, wholesale prices in Europe increased by 115% for gas and 237% for oil (Ferriani & Gazzani, 2022). Therefore, firms with better EF should be less sensitive to these changes. Consequently the 2nd hypothesis was proposed.

H2: The relationship between the EF and the CFP has positively increased since the war in Ukraine started

Moreover, the uncertainty and restarting the economy during 2nd half of 2021 increased the demand for energy and therefore increased its price (Topic: Global Electricity Prices, Statista, 2023). Since mid-2021 when the pandemic restrictions started to be lifted energy prices increased by almost 60% between 07.2021 and 02.2022 (Producer and consumer energy prices in the EU, European Council, 2023). Therefore, the question: whether the energy efficiency makes firms more resilient to crises such as the COVID19 pandemic. Therefore the following 3rd hypothesis has been made.

H3: The relationship between EF and CFP favorably increased during COVID-19 pandemic

Methodology

The dataset contained panel data because the research will use cross sectional and time series inputs at the same time. The raw figures were downloaded from the Eikon Thomson Reuter database and to get input (transform raw values) for the regression power query was used. In the sample following industries were utilized: industrial companies, firms from technology, energy and basic materials. The sample has been created by the following criteria: firstly the company headquarters needs to be in the region of western Europe (determined by EIKON Reuters) which is Austria, Belgium, France, Germany, Luxembourg, Monaco, the Netherlands and Switzerland. Secondly, firms need to be in one of the industries mentioned above, and lastly these entities need to report the total use of energy in at least one of the years in the period between 2015 and 2022. Thereafter, 326 companies were derived which is 33.96% of the population of 960. In total number of observations is 326*7= 2282, however, since the unbalanced panel data was used it varies depending on the variable. Further down the research paper, share of observations is reported broken down by the years.

There are many approaches to measure energy efficiency, from simple to complex ways. Example of the latter could be the total factor energy efficiency index expressed by nonparametric or parametric frontier approach (Fan et. al., 2017). Simpler way to measure EF is a basic-unit measurement of energy intensity. It considers the change between firms' production and changes in the energy input (Pons et al. 2013). Another method to measure EF is the energy intensity which is expressed by ratio of the total energy used divided by the operating revenue (Fan et al., 2017). In this research paper the latter method will be utilized. Also, control variables size, industry, leverage (Debt to Equity ratio) and book to market (B/M) ratio will be used (e.g. Trinks et al., 2020). In table 1. are presented corporate financial performance measures used in other academic papers on the problem.

Table 1.

Summary of the CFP measures used in the literature concerning the energy efficiency influence on the corporate financial performance

Research paper	CFP measures
Clarkson et. al. (2011)	ROA, FOCF
Fan et. al. (2017)	ROE, ROA, ROI, ROIC, ROS, Tobin's q
Wagner (2005)	ROCE, ROE, ROS,
Trinks et. al. (2020)	ROA, Tobin's q, systematic risk, total risk
Delmas et. al. (2015)	ROA, Tobins'q,

Based on the previous literature the following CFP ratios were put forward. To assess the relationship between the EF and the CFP return on equity (ROE) will be used to measure financial performance. Moreover, return on assets (ROA) will be the dependent variable to show impact of the energy efficiency on the operating performance, and Tobin's q will be used to assess impact on the market measures of the companies (Hart & Ahuja, 1996). Moreover, to examine impact of the energy performance on liquidity of the firms I utilized free operating cash flows (FOCF) (Clarkson et al., 2011). Table 2. shows the summary of the CFP variables and how they were measured.

Table 2.

Summary of the CFP variables

CFP measure	Descriptive Name	Description
ROE	Return on Equity	After-tax profits divided by shareholder's equity.
ROA	Return on Assets	Net profit divided by total assets.
Tobin's q	Tobin's q	Market value divided by total assets
FOCF	Free Operating cash flows	Free operating cash flows

Notes: The balance sheet positions will be calculated on yearly average basis

To test the hypothesis the following model has been constructed. The explanation of variables included in the model is presented in table 3 below.

$$CFP_{it} = \beta_0 + \beta_1 size_{it} + \beta_2 LEV_{it} + \beta_3 B/M_{it} + \beta_4 EF_{it} + \beta_5 COV_t EF_{it} + \beta_6 WiU_t EF_{it} + a_i + \varepsilon_{it}$$

Table 3

Explanation of the variables in the model.

Variable name	Descriptive name and explanation
CFP_{it}	Corporate financial performance measure (ROE, ROS, ROA, Tobin's q or FOCF) for a company i in a period t
EF_{it}	Energy efficiency of a company i in a period t
COV_tEF_{it}	Interaction variable expressed as a product of dummy variable COV_t (COVID19 pandemic) and string variable EF_{it}. COVt is equal to 1 in the years 2020 and 2021, in the rest it takes value 0.
WiU_tEF_{it}	Interaction variable expressed as a product of dummy variable WiU_t (war in Ukraine) and string variable EF_{it}. WiU_t is equal to 1 in the year 2022, in the rest it takes value 0.
Control variables	
Lev_{it}	Leverage expressed as Debt to Equity (D/E) ratio of a company i in a period t
Size	For variable size proxy of number of employees will be used
B/M	Book to market ratio
a_i	Time-persistent individual characteristics of firm i e.g. industry is an ordinary variable where 1= basic materials, 2 = industrials, 3 = energy, and 4 = technology.
ε_{it}	Error term of the model

Table 4. presents the cross sectional data aggregated into industry and country category. Worth noticing that 73% of the companies in the sample is based in three countries: Germany, France, and Switzerland. Moreover, Figure 1. presents that almost three quarters of the data set is in two categories: industrials and technology. In the model industry has been described as an ordinary variable where 1 is basic materials, 2 - industrials, 3 - energy, and lastly 4 – technology.

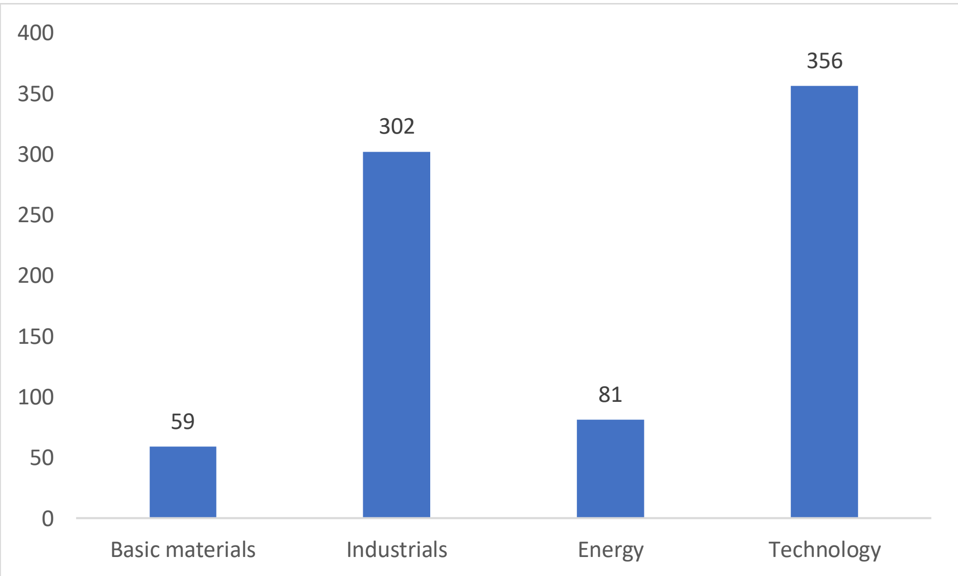
Table 4.

Cross sectional data aggregated into industry and country category.

	Basic Materials	Industrials	Technology	Energy	Total
Austria	5	8	5	3	6%
Belgium	6	3	6	2	5%
Germany	19	44	39	7	33%
Luxemburg	5	5	5	2	5%
Monaco	0	4	0	0	1%
Switzerland	7	44	8	1	18%
Netherlands	5	9	9	5	9%
France	12	34	17	7	21%
Total in %	18%	46%	27%	8%	326

Figure 1.

Number of companies in each sector - distribution in the sample regarding the ordinal explanatory variable



Note: Y axis presents number of companies

Table 5.

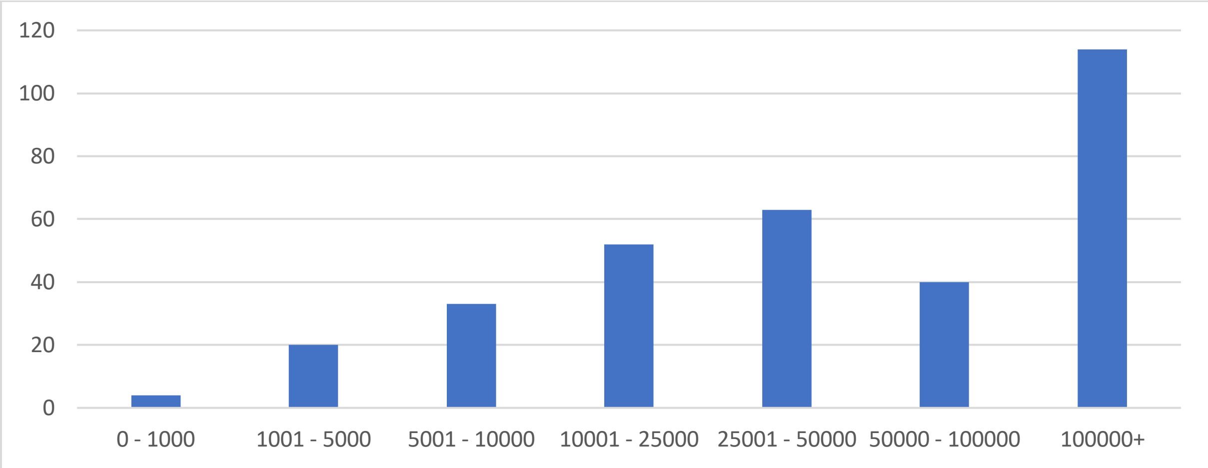
Number of observations of time series explanatory variables in each year

	2015	2016	2017	2018	2019	2020	2021	2022
Energy Efficiency	38%	41%	49%	31%	65%	56%	87%	90%
Debt to equity	94%	94%	97%	98%	98%	98%	98%	77%
Size	89%	91%	94%	95%	98%	98%	98%	96%
Book to market ratio	90%	90%	94%	95%	97%	98%	100%	79%

The sample was created by taking into account only companies which reported the total use of energy (needed to calculate energy efficiency) in at least one year between 2015 and 2022. In table 5. we can observe that number of firms in the sample which report EF was only 38% in 2015 and around 90% in 2022. It shows an upwards trend, on average it increase by 8 percentage point yearly which is almost 25 companies per annum. It may be because ecological impact of the companies is more and more important part of its valuation and the energy efficiency directly impacts carbon emissions. The lower number of observations in 2022 for the debt to equity or book to market ratio may be due to the fact that the data was collected in the beginning of 2nd quarter of 2023. Therefore most probably not all values were inputted into the Reuters EIKON database.

Figure 2

Distribution of the variable size of the companies measured in number of employees.

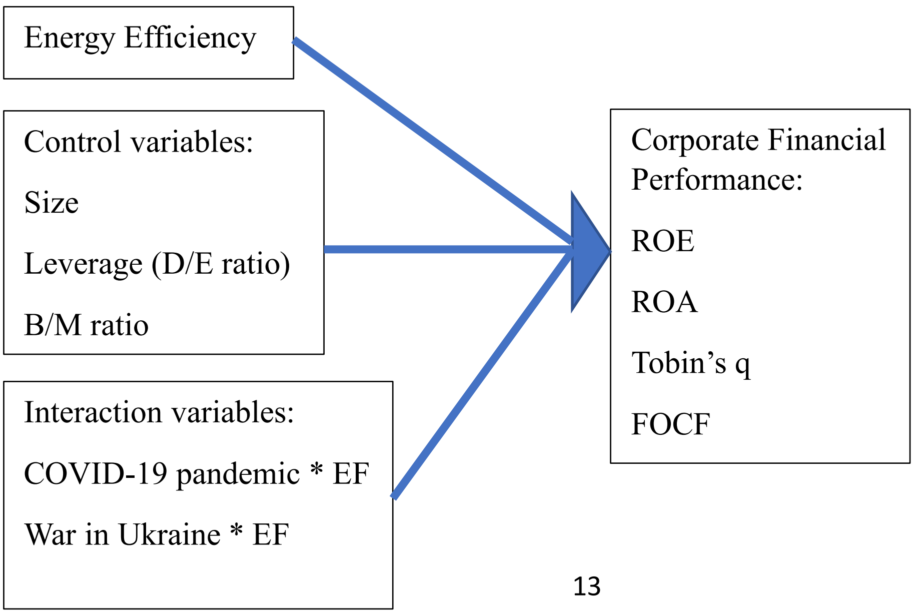


Note: Y axis presents number of companies, and X axis shows ranges of how many employees are in a given firm

Figure 2. presents the size of the companies on which the research is conducted. We can observe that the highest amount of companies exceed 100,000 number of employees followed by the range of 25,001 and 50,000. In total they are responsible for around 50% of the cross sectional observations. The lowest amount of firms in question is for the smallest ones which have less than 1000 workers.

Figure 3

Overview of the proposed model to investigate relationship between energy efficiency and corporate financial performance



To resolve the problem of losing time series dummy variables (COV and WiU) in the fixed effect models the interaction variables were introduced. The analysis will be two folded. In the first part I used regression modelling to estimate whether the relationship between the energy efficiency and the corporate financial performance exists and, if yes is it positive or negative link. Moreover, I assessed whether the COVID-19 pandemic or the war in Ukraine improve the link between EF and CFP measured in the first step.

Empirical Analysis

In this section descriptive statistics are presented. Thereafter, the results are shown and interpreted divided into 4 parts, each concerning its dependent variable (return on equity, return on assets, Tobin's q and free operating cash flows).

Table 6.

Descriptive statistics of dependent and independent variables

	Max	Min	Average	Geometric mean	Median
ROE	518.31	-625.22	-0.36		0.05
ROA	0.55	-3.29	0.04		0.04
Tobin's q	276.07	0.0001	1.72		0.79
FOCF	20268	-7395	191.92		27.02
Energy Efficiency	217.22	0.0001	4.25	0.65	0.47
Debt to equity	20388	0	110.06		56.56
Size	596270	4	23461		6040
Book to market ratio	6982	-204	4.81		0.47

Table 6. presents maximum, minimum, arithmetic average and median of the variables, besides ordinary or dummy variables. For ROA and ROE the values of the midpoint and mean are quite close to each other, with the high maximum and low minimum. The rest of the variables are influenced by the small amount of really high numbers therefore their arithmetic average is much higher than median. Using geometric mean for EF we find that it is much smaller than the arithmetic one. Since it can only be used for datasets with positive numbers,

computing it for the other variables was impossible. For debt to equity minimal value is 0 because it was assumed that some companies can finance themselves with 100% equity and therefore do not have any long term debt.

Table 7.

Correlation of the explanatory variables

	Energy Efficiency	EF*Cov19	EF * WinU	D/E	Size	B/M	Year	Industry
Energy Efficiency	1							
EF *Cov19	0.6458	1						
EF *WinU	0.1839	-0.0304	1					
D/E	0.0647	0.0310	-0.0105	1				
Size	-0.0170	-0.0386	-0.0269	0.0623	1			
B/M	-0.0092	-0.0053	-0.0043	-0.0094	-0.0166	1		
Year	-0.0190	0.1221	0.1990	0.0150	-0.1099	-0.0002	1	
Industry	-0.1872	-0.1119	-0.0841	-0.0533	-0.0196	0.0182	-0.0071	1

Thereafter, the correlation analysis was conducted and presented in Table 7. It was assumed that values higher than 0.4 mean high correlation. We can see that besides the interrelationship of the energy efficiency and the interaction variable EF * COV19 there is no problem with this association. All the values are in between 0.1839 for the EF * WinU and EF and -0.1872 for the EF and the Industry. High correlation between the energy efficiency and the interaction variables is due to the fact that part of the product is the EF therefore rise in the energy efficiency should also mean some advancement in the interaction regressors.

After more in detail description of the sample and variables the results of the research are presented. The empirical analysis was conducted using STATA 2021 software.

Table 8. presents the variance inflation factor (VIF) which shows whether there is a problem of the multicollinearity. The highest value is for the interaction variable COV*EF (2.00) and the lowest for book to market ratio (1.00) with a mean for all the regressors equal to 1.32. Based on the rule of thumb that the VIF values smaller than 4 say that there is no significant

multicollinearity between the independent variables, we can observe that no such issue arises here. Number of employees was used as the proxy for size because natural logarithm of the total assets showed high VIF value (>20).

Table 8.

Values of variance inflation factor for the independent variables.

Variable	Variance inflation factor
Energy Efficiency	1.99
War in Ukraine	1.29
WinU*EF	1.25
Covid19 pandemic	1.26
COV*EF	2.00
Size	1.02
D/E	1.01
B/M	1.00
Industry	1.05
Mean VIF	1.32

Hausman test

To conform with the previous literature on the problem in this research Hausman test will be performed to assess whether fixed effect (FE) or random effect (RE) model should be used (e.g. Fan et al., 2017; Delmas et al., 2015). These models assume heteroskedasticity and strict exogeneity. Therefore, no other statistical analysis is needed. The test considers whether the individual cross sectional characteristics are correlated with the independent variables. If null hypothesis is rejected random effect model should be used otherwise fixed effect. The statistical analysis has been conducted in STATA software.

Table 9.

Results of Hausman test.

Dependent variable in the model	Prob>chi2	Method to be used
ROE	0.1700	Fixed effect
ROA	0.0398	Fixed effect
Tobin's q	0.9943	Random effect
FOCF	0.1700	Fixed effect

Table 9. presents the results of Hausman test for all the main models. We can observe that for ROE, ROA and FOCF prob>chi2 is low. Therefore, null hypothesis is not rejected and the fixed effect model should be used. However, for Tobin's q the random effect model should be used because null hypothesis should be rejected.

13 regressions were run. The fixed effect model was used for dependent variables ROE, ROA and FOCF, and the random effect one for Tobin's q, therefore the industry variable could only be used for the latter (omission of time constant variables in FE). The results are presented as followed: ROE – table 10 , ROA – table 11, Tobin's q - table 12, and lastly FOCF – table 13. Models 1, 4, 7 and 11 are the main output. The rest are supplementary analysis. Regressions 3, 6, 10 and 13 include time trend regressor "year" which is not in scope of this research therefore it's not reported and only the effect of it on the statistical significance and coefficients of explanatory variables will be discussed. In models 2, 5, 9 and 12 was checked whether the interaction variables (EF*WinU and EF*COV) influenced the results of the models. The results will be discussed in 4 parts, one for each dependent variables.

ROE

Table 10. presents the results of regressions for the ROE dependent variable. We can see that there are positive signs for the relationship between the return on equity and the energy efficiency and the interaction regressor EF*COV19 in model 1 and 3. It can be interpreted that increase in the energy efficiency by 1 increases the ROE by 0.015 percentage point. Even stronger increase can be observed when the COVID19 pandemic happened, here return on equity grows by 0.02 p.p.. Contrary results are observed for the 2nd interaction variable

concerned around the war in Ukraine, when the Russian aggression has happened, higher energy efficiency decreases ROE. However, no statistical significance is found for these relationships therefore we can assume that these phenomes are not consistent. Model 2 and 3 tested if adding or subtracting variables from the model helps with the statistical significance. Taking out interaction variables from the model decreased p-value, however it is still high. Lastly, including in the regression time variable (model 3) decreases the statistical significance compared to the main ROE model 1.

Regarding control variables, debt to equity ratio shows negative relationship with strong statistical significance in all models (1-3). ROE can be calculated from DuPont analysis and it includes D/E ratio, therefore the low p-value is consistent with the theory. Increase in total debt in the financing of the firm by 1 p.p., all else constant, indicates a decrease of ROE by 0.03 p.p.. The negative sign can be explained by the rise in central banks interest rates in recent years which translate into higher cost of debt (Bodea & Hicks, 2015). As was shown in the descriptive analysis median for D/E ratio is rather high (56%). We can observe in table 10. that size has a positive impact on the ROE, however it is statistically insignificant. Lastly, increase in book to market ratio by 1 p.p. increases return on equity by 0.1022 p.p. in all models. Moreover, the results show that it has high statistical significance.

Tabela 10.

Results of empirical analysis for dependent variable ROE

	Model 1	Model 2	Model 3
Energy	0.0150	0.0308	0.0108
Efficiency	(0.845)	(0.667)	(0.889)
EF *Cov19	0.0225		0.0351
	(0.777)		(0.672)
EF *WinU	-0.0601		-0.0286
	(0.752)		(0.886)
D/E	-0.0325***	-0.0324***	-0.0324***
	(0.000)	(0.000)	(0.000)
Size	0.00004	0.00003	0.00004
	(0.520)	(0.527)	(0.476)
B/M	0.1022***	0.1022***	0.1022***
	(0.000)	(0.000)	(0.000)

ROA

The results of empirical analysis for the return on assets is presented in table 11. The energy efficiency and the interaction variable concerned around the COVID19 pandemic have a negative sign for all models. However, the second interaction term EF * WinU shows positive sign. Therefore, we can interpret that increase in the energy efficiency by 1 (either higher revenue by the same input of energy or same revenue with lower total energy used) decreases return on assets by 0.001 p.p.. Moreover, when in 2020 and 2021 this relationship is even stronger compared to the other years, in the research decreasing, ROA by 0.0009 p.p.. Lastly, in 2022 the Russian aggression on Ukraine offsets the negative sign of EF and even increase in EF improves return on assets by 0.0011 p.p.. First two relationships are strongly statistically significant with the p-value less than 0.05. However, for latter the probability value is equal to 0.144, therefore this effect is less consistent. In model 5. by subtracting both interaction variables we increased statistical significance of the energy efficiency. Moreover, the coefficient decreased by 0.0005. In regression 6 the time variable was added to test whether there is spurious relationship or not. We can observe that for the EF's p-value increased marginally and for the EF*COV19 it decreased by 0.003. On the other hand the second interaction variable lost its statistical significance. Therefore, I can argue that the impact of the first two variables is consistent, and the latter is not.

In terms of the control variables, debt to equity ratio shows consistent negative value (-0.0001) and strong statistical significance (p-value = 0.000) for all 3 models. However, the number of employees is not statistically significant showing barely any negative effect on ROA. Lastly book to market ratio shows strong statistical significance however the impact on the dependent variable is marginal.

Tabel 11.

Result of empirical analysis for dependent variable ROA

	Model 4	Model 5	Model 6
Energy	-0.0010***	-0.0015***	-0.0001***
Efficiency	(0.001)	(0.000)	(0.002)
EF *Cov19	-0.0009***		-0.0010***
	(0.005)		(0.002)
EF *WinU	0.0011*		0.0008
	(0.144)		(0.314)
D/E	-0.0001***	-0.0001***	-0.0001***
	(0.000)	(0.000)	(0.000)
Size	-0.00000	-0.00000	-0.00000
	(0.256)	(0.321)	(0.189)
B/M	0.0000***	0.0000***	0.0000***
	(0.007)	(0.008)	(0.007)

Tobin's q

For Tobin's q were conducted 4 models instead of 3. It is due to the fact that the random effect model was used and therefore time constant variable "industry" would not be omitted in the regression. I wanted to check its effect on the main model. All models show negative sign for the relationship between energy efficiency and Tobin's q. I can interpret it, that increase in the energy efficiency decreases by 0.0028 market value to total assets ratio. When the COVID19 pandemic and the war in Ukraine happened this relationship becomes even stronger with the additional decrease of 0.0011 and 0.0103 respectively. However, no statistically significant results have been found. All the p-values in the main model are above 0.7. Implementing "Industry" variable decreased the probability value, however the change was marginal (no more than 0.023). Moreover, implementing the time variable in model 10 helped even further but still no statistical significance has been found for any of the variables. Model 9 shows that by subtracting interaction variables EF*COV19 and EF*WinU worsens the reliability of the regressors. Therefore, we can assume that there is no consistent relationship between the energy efficiency and the Tobin's q in the period in question.

Control variables presented in the models 7 through 10 don't show any statistical significance either. Moreover, none of them have more than marginal impact on the variable. Addition of Industry shows that this is the main factor for the Tobin's q value in the model with relatively low p-value compared to the other dependent variables. When industry goes from 1 (basic materials) to 2 (industry), the effect on the dependent variable decreases by 0.6474. This applies for all 4 categories. Therefore, it means that the technology companies compared to the basic materials ones have 4 (basic materials 1 and technology is equal to 4 in ordinary variable) * (-0.6386) = -2.5544 lower Tobin's q.

Table 12.

Results of empirical analysis for dependent variable Tobin's q

	Model 7	Model 8	Model 9	Model 10
Energy	-0.0028	-0.0032	-0.0019	-0.0029
Efficiency	(0.828)	(0.805)	(0.872)	(0.822)
EF *Cov19	-0.0011	0.0014		-0.0021
	(0.933)	(0.919)		(0.878)
EF *WinU	-0.0103	-0.0111		-0.0131
	(0.748)	(0.728)		(0.696)
D/E	-0.0002	-0.0002	-0.0002	-0.0002
	(0.705)	(0.700)	(0.708)	(0.693)
Size	-0.00000	-0.00000	-0.00000	-0.00000
	(0.605)	(0.588)	(0.611)	(0.577)
B/M	-0.0000	-0.0000	-0.0000	-0.00000
	(0.945)	(0.946)	(0.946)	(0.947)
Industry		-0.6474		-0.6386
		(0.320)		(0.320)

FOCF

Table 13. presents model 11 through 13 concerning the free operating cash flows dependent variable. All regressions show negative relationship between the energy efficiency and the outcome. It means that increase in EF by 1 decreases the FOCF by 10,921 million EUR. However, when the COVID19 pandemic and the war in Ukraine have happened they offset it. In 2020 and 2021 there is an increase of 8,833 million EUR compared to other years, and in

2022 the difference is 32,361 million. All these results are statistically significant for the model 11, the p-value varies from 0.022 for the EF * WinU variable to 0.133 for the second interaction variable. Model 12 without these terms show that the EF effect on the FOCF becomes stronger by around 1,300 million EUR and its probability value decreased from 0.055 to 0.021. However, when the time trend is added to the regression (model 13) the statistical significance drops for all the terms mentioned beforehand. However, the energy efficiency is still low with the p-value equal to 0.163.

Debt to equity and book to market ratio show no significant relationship with the free operating cash flows. However, D/E variable shows 0.160 probability value for the model 13. On the other hand, size has the p-value lower than 0.15 for the models 11 and 12. We can interpret it that for every employee more FOCF increase by 0.00717 million EUR.

Table 13.

Results of empirical analysis for dependent variable FOCF

	Model 11	Model 12	Model 13
Energy	-10.9210**	-12.2963***	-7.8816
Efficiency	(0.055)	(0.021)	(0.163)
EF *Cov19	8.8325*		-0.3706
	(0.133)		(0.951)
EF *WinU	32.3607***		9.3840
	(0.022)		(0.518)
D/E	-0.2556	-0.2538	-0.3144
	(0.259)	(0.263)	(0.160)
Size	0.00717**	0.00665*	0.0040
	(0.091)	(0.117)	(0.350)
B/M	-0.0952	-0.0959	-0.0895
	(0.592)	(0.590)	(0.610)

To sum up, the negative relationship between the energy efficiency and the return on assets, and the free operating cash flows has been found. Moreover, the war in Ukraine and the COVID19 pandemic positively impacts the EF link with the ROA and the FOCF. Therefore, the first hypothesis has been rejected and the second and the third one accepted. In the discussion part possible explanations of these conclusions will be presented.

Discussion and conclusion

The empirical analysis results in this research paper are contrary to the Porter hypothesis (Porter, 1991) which states that the pro-environmental investments and management can augment productivity and competitiveness. Similar outcome of the analysis were suggested by Xie et al. (2018). They observed that there is negative relationship between the energy efficiency and the financial corporate performance, ROA and market value. Authors suggested that these outcomes are not statistically significant, however the p-value for them was 0.013 and 0.009 respectively. Therefore, with criteria used in this master thesis they would be described as persistent. Subrahmanya (2006) who conducted studies using sample of the brick clusters in India also came to the conclusion that the energy efficiency has a negative relationship with the financial performance. He observed that EF has an unfavorable impact on the productivity. The relationship may be negative due to cost to increase energy efficiency by investing in EST. Hart and Ahuja (1996) found that the effect of such investments are seen in the next 2 years. In the first year after the expenditure ROA increases and after two ROE. Therefore, reduction in energy expenses and increase in profitability of production need more time to offset CAPEX. Return on equity needs more time to adjust and reflect improvements in energy efficiency since it consists also of financing structure of the firms.

Ferriani and Gazzani (2022) analyzed whether shock in the energy market caused by the war in Ukraine created any interference in the corporate financial performance with regard to the energy efficiency in EU. They found out, that during this time the higher EF or carbon performance the bigger positive impact on CFP. These results are in line with the positive sign in FOCF and ROA with strong statistical significance, in this master thesis. Yoo et al. (2021) examined how the COVID19 pandemic impacted the financial performance of the firms with regard to the ESG score. They observed that companies with higher E-score were better off during and post pandemic period than ones which had lower. It showed in the higher stock returns and lower volatility. This is in line with the positive coefficient for the FOCF dependent variable.

To contrary conclusions came Trinks et al. (2020). They found a positive link between carbon intensity and CFP. It was argued that best practice firms are less sensitive to the carbon pricing regulations and therefore the energy prices. However, they conducted their study between 2009 and 2017 and used the directional distance function approach. Similarly, Fan et al. (2017) observed that firms with high energy efficiency have better corporate financial performance than companies with the lower one. They conducted these studies between 2010 and 2014 using a sample of Chinese entities. Moreover, both of these studies conducted research with exclusion of the major energy crises periods which are described in this paper. Implementation into a models the COVID19 pandemic or the war in Ukraine could have shown better picture of how the energy efficiency impact the corporate financial performance. Academic literature with contrary results can imply EF positive relationship with CFP depends on the various parameter (for instance period, country or model) on which the research has been made.

Time period, industries, range of countries and corporate financial performance metrics picked as input to the model are a considerable limitation of this study. Furthermore, refined econometrics models could be used to get better insight. Moreover, lag variables and investments into energy saving technologies regressor could be implemented to see whether there is a possibility that EF impacts positively financial performance in the long run. And lastly, use of countries or multinational entities (e.g. EU) policies could be also measured and implemented to see whether they also impact energy efficiency relationship with corporate financial performance.

To conclude, energy is a variable or semi-variable cost, therefore the results in this research paper show that the energy efficiency maybe not improve CFP, however it protects it from the shocks to the energy market, like ones during the COVID19 pandemic or the war in Ukraine. Increase in the unit cost for power sources show that companies which have higher energy efficiency have much higher resistance to these appreciation. On the other hand, when the prices deteriorate firms with lower EF are better off. However, more research needs to be conducted aiming to test this phenomenon to see if these results are persistent across other energy crises.

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