ENVIRONMENTAL EFFICIENCY AND MARKET VALUE: USING THE DEA METHOD TO EVALUATE PUBLIC COMPANIES FROM THE EUROPEAN UNION

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Abstract: Enterprises that reduce their consumption of raw materials and production of pollution should observe the resulting high degree of environmental efficiency, which is understood as the minimisation of energy and water consumption, carbon dioxide production and waste. High environmental efficiency should translate positively into their financial performance. Our study compares the environmental efficiency of companies listed on the regulated markets of the European Union and its impact on their market value. We use the non-parametric DEA method and the Ohlson Valuation Model to assess the impact of environmental efficiency on companies' market value. The research sample includes public companies from the 27 EU Member States listed on their respective stock exchanges during the period 2014–2023. Data come from the Refinitiv Eikon database. The research shows that while the surveyed companies cannot be considered environmentally efficient, there is a positive relationship between environmental efficiency and market value.

***Keywords*:** environmental efficiency, market value, DEA method, public companies, European Union

INTRODUCTION

Sustainable transformation is an inherent element of the modern global economy. There is a growing awareness among societies and businesses of the threats that result from the progressive degradation of the natural environment, which contributes to destructive and irreversible changes. Although rankings and criteria for assessing businesses still focus on their financial performance, environmental changes have forced the global community to question the environmental costs of the global race, which are inextricably linked to business activities. Many companies delay taking actions that are a financial burden and require a change in the way they operate. To address this, many countries have adopted regulations requiring them to publish information on their impact on the natural environment. The European Union (EU) exemplifies this with its latest Directive EU (2022 – 2022/2464/EU), which requires companies to disclose non-financial information. Currently, reports are still prepared based on the provisions contained in Directive EU (2014 – 2014/95/EU). According to the 2014 Directive, public companies have been required to provide non-financial ESG (environmental, social, and governance).

Our focus of interest is the environmental area. We hypothesise that companies that reduce their consumption of raw materials and the production of pollution will achieve high levels of environmental efficiency as a result. We understand environmental efficiency as minimising environmental costs (energy and water consumption, as well as carbon dioxide and waste production), i.e., reducing the negative impact on the environment. It is reflected in environmental metrics like the Environmental Pillar Score published by rating agencies. A high degree of environmental efficiency should translate positively into economic performance. Improving a company's environmental impact, as well as its financial results, should translate into improved stakeholder opinions and a higher market valuation.

Therefore, we have formulated the following research question:

1. Does a decrease in a company's resource consumption and production of environmental pollutants lead to higher environmental efficiency?
2. Does a company's environmental efficiency significantly increase its market value?

The study aims to compare the environmental efficiency of EU-listed companies and show how it impacts their market value from the point of view of natural resource management. How a company's environmental performance impacts its market value has not been still resolved. Previous studies

documented both positive and negative effects of environmental performance on market valuation (e.g., Elsayed and Paton, 2005; Nakaoet al., 2007; Horváthová, 2010; Albertini, 2013; Dixton-Flower et al., 2013; Trumpp and Guenther, 2015; Li et al., 2017; Manrique and Martí-Ballester, 2017). Therefore, we want to use a different methodical approach to investigate this relationship using EU listed companies.

To assess environmental efficiency, we use the non-parametric DEA (Data Envelopment Analysis) method. The analysis is carried out with efficiency measures oriented at minimising inputs and constant return to scale (CRS model). We define inputs as environmental resources consumed (energy and water) and pollutants generated (carbon dioxide and waste). We took the Environmental Pillar Score as the output. In the next stage of our research, we assess the impact of environmental efficiency on market value using a regression analysis based on the Ohlson Valuation Model (OVM). The model shows that a company's market value can be estimated based on financial and non-financial information (e.g., ESG). In our version of the OVM, we use the environmental efficiency calculated by the DEA method as an explanatory variable. This is a novelty and an innovative approach which creates a theoretical framework for assessing a company's market value through economic and environmental efficiencies using the DEA method.

The research sample includes public companies listed on the stock exchanges in the 27 EU Member States (as of May 1, 2024) that were headquartered in a given country. For the study of environmental and economic efficiencies, the Refinitiv database[1] is used, which contains financial and non-financial data (ESG). The initial research sample included 4,547 companies listed in 27 European markets during the period 2003–2023. Our final sample comprises 411 companies.

The research shows that while the surveyed companies cannot be considered environmentally efficient, there is a positive relationship between environmental efficiency and market value. Companies' environmental performance may, therefore, be an important factor for investors.

METHODOLOGY

Our research sample includes public companies listed on the stock exchanges in the 27 EU Member States (as of May 1, 2024) that were headquartered in a given country. As Refinitiv's ESG database includes companies only from 2003, the annual data from 2003–2023 were reviewed. The initial research sample included 4,547 companies listed in 27 European markets.

Firstly, we assessed the quality of environmental reporting. Unfortunately, the total number of companies reporting ESG data over different time spans was as follows: 1,215 companies reported data for at least three years, 841 for at least five years, 428 for at least ten years, and 174 for 21 years. Given the low quality of the reported data, we limited our study to the last ten years (2014–2023). We also included only those countries where the number of companies reporting non-financial data was at least ten. As a result, our research sample comprises 411 companies.

In the first stage of our analysis, we investigate the environmental efficiency of companies with the use of the DEA method. The DEA method has been used by many authors when studying environmental efficiency (Song et al., 2012; Chen et al., 2019; Hermoso-Orzáez et al., 2020; Tóth et al., 2023). Our choice of the input-oriented model with fixed effects of scale (CRS) aligns with our hypothesis about minimising four inputs (ENERGY[2], WATER[3], CO2[4], WASTE[5]) to achieve an effect in the form of E[6].

In the second stage of our analysis, the calculated DEA measures are used as variables that could influence a company's economic efficiency. We use the model presented by Ohlson (1995) and later promoted by Graham (2005) and Dechow and Schrand (2010). Following Guenster et al. (2011), Bajic and Yurtoglu (2018), and Torre et al. (2020), our study modifies the original OVM model by using the Return on Total Assets (ROTA). We also include environmental performance, calculated using the DEA method, as an explanatory variable. Similar approaches have been employed in recent ESG research (Fatemi et al., 2018; Khan, 2019; Cornell and Damodaran, 2020; Pedersen et al., 2021; Wong et al., 2021; Giannopoulos et al., 2022; Naffa and Fain, 2022).

[1] On December 1, 2023, Refinitiv's name was changed to LSEG (a name associated with the London Stock Exchange Group). Given the greater recognition of Refinitiv than LSEG, we use the name Refinitiv.
[2] Total direct and indirect energy consumption in gigajoules divided by revenues in US dollars in millions.
[3] Total water withdrawal in cubic meters divided by revenues in US dollars in millions.
[4] Total direct and indirect CO2 and CO2 equivalents emission in tonnes divided by revenues in US dollars in millions.
[5] Total non-hazardous and hazardous amounts of waste produced in tonnes divided by revenues in US dollars in millions.
[6] The environmental pillar measures a company's impact on living and non-living natural systems, including the air, land and water, as well as complete ecosystems.

As a company's market value is influenced by many additional factors, following previous research (Velte, 2017; Atan et al., 2018; Bajic and Yurtoglu, 2018; Fatemi et al., 2018; Cornell and Damodaran, 2020; Wong et al., 2021; Giannopoulos et al., 2022; Abdi et al., 2022), our model also includes the following control variables: SIZE, GDR, CR, and AT. SIZE is measured by the natural logarithm of total assets. We also use the General Debt Ratio (GDR), defined as the book value of total debt to the book value of total assets for the company's leverage. The current liquidity ratio (CR) is calculated by dividing current assets by short-term liabilities. GROW is calculated using the revenue growth rate. We also use the asset tangibility ratio (AT) as the relationship between the book value of fixed assets and the book value of total assets. A dummy variable (SECTOR) takes a value of 1 for the Financials sector and 0 for other sectors[7]. Companies from the Financials sector conduct slightly different types of business; they are subjected to additional regulations and report certain information differently. Our final version of OVM is as follows:

$$MC_{i,t} = \beta_0 + \beta_1 ROTA_{i,t} + \beta_2 EFF_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 GDR_{i,t} + \beta_5 CR_{i,t} + \beta_6 AT_{i,t} + \beta_7 GROW_{i,t} + \beta_8 SECTOR_{i,t} + \varepsilon_{i,t}.$$

All independent variables were winsorised at the top and bottom 1% using OLS panel data regression analysis[8]. Based on the results of the Hausmann test, it was considered justified to use fixed effects (FE), and they were selected for the FE model (Redundant Fixed Effects Test) using the Chi^2 statistic. For the redundant effects (RE), we used the Breusch-Pagan test using the Lagrange Multiplier.

FINDINGS

To address our research objectives, we first calculated the DEA measures[9] for 411 public companies as their indexes of environmental efficiency. Table 1 presents selected statistics of environmental efficiency results for 13 EU countries using the DEA CCR method.

Table 1. Selected statistics for environmental efficiency using the DEA method

EU Member States	N	Mean	Median	Minimum	Maximum	Std. Dev.
Austria	150	31.41	8.85	0.11	100.00	36.71
Belgium	230	28.18	9.99	0.00	100.00	35.28
Denmark	230	23.98	10.74	0.07	100.00	30.25
Finland	230	35.05	17.74	0.12	100.00	36.77
France	780	12.04	2.72	0.01	100.00	23.63
Germany	610	8.16	0.90	0.00	100.00	20.32
Greece	150	42.53	27.68	0.15	100.00	38.13
Ireland	100	55.92	58.04	0.59	100.00	37.40
Italy	310	20.37	5.61	0.00	100.00	30.93
Netherlands	250	32.74	14.14	0.03	100.00	36.69
Poland	260	38.27	25.24	0.01	100.00	35.56
Spain	360	30.38	13.11	0.04	100.00	34.88
Sweden	450	31.26	17.33	0.21	100.00	33.71

Source: own study based on Refinitiv data.

It is important to note that analysed companies are generally environmentally inefficient, with the average of the DEA measures for all entities being only 24.47. Only Ireland and Greece were slightly highly

[7] Refinitiv uses its own methodology (TRBC, The Refinitiv Business Classification) to classify these entities into one of 13 economic sectors (Basic Materials, Consumer Cyclicals, Consumer Non-Cyclicals, Energy, Financials, Healthcare, Industrials, Real Estate, Technology and Utilities). Financials includes Investment Holding Companies, Investment Banking & Investment Services, Banking Services, Insurance, and Collective Investments (TRBC Industry Group Names). https://www.lseg.com/content/dam/data-analytics/en_us/documents/methodology/lseg-esg-scores-methodology.pdf

[8] We use the EViews 10 software for all statistical and econometric analyses.

[9] We use the Performance Management Improvement Software (PIM-DEAsoft-V3.0).

efficient from the DEA perspective. Their average DEA ratios were 56.92 and 42.53, respectively. Therefore, public companies listed on the Irish Stock Exchange and the Athens Stock Exchange require few changes in inputs (ENERGY, WATER, CO2, and WASTE) to achieve output (E) from the DEA perspective. Considering the variation of environmental efficiency between countries, the lowest DEA efficiency was observed in Germany and France; the average efficiency ratios were only 8.16 and 12.04, respectively. In other countries, the calculated DEA measures are also significantly below unity (below 0.4), suggesting that they should focus on strategic decisions that improve environmental efficiency by minimising resource use and pollutant emissions.

To confirm how environmental efficiency, calculated using the DEA method, affects the market value of companies, a regression analysis was carried out. Table 2 presents the results of our regression analysis. The model fit reports an adjusted R-squared of 0.688.

Table 2. The impact of environmental efficiency (EFF) on firm market value (MC)

Unbalanced Panel (Fixed effects)		
Specification	Coefficient	p-Value
EFF	0.0011	0.017
ROTA	0.0342	0.000
SIZE	0.7945	0.000
GDR	0.0000	0.027
CR	0.0192	0.000
AT	0.0000	0.000
GROW	-0.0004	0.010
SECTOR	-1.5540	0.000
Intercept	4.0418	0.000
Hausman	23.859	0.002
Ch^2	23.954	0.004
Fixed effects	Yes	
F test	534.804	0.000
Adj-R^2	0.688	
N	4,110	

Source: authors' own study.

The results indicate that there is a positive correlation between environmental efficiency and market value, which is in line with our predictions. The coefficient on EFF is statistically significant at the 5% level. This finding is consistent with the previous studies that documented the positive effect of environmental performance (E) on companies' value (Guenster et al., 2011; Nollet et al., 2016; Bajic and Yurtoglu, 2018; Atan et al., 2018; Abdi et al., 2022). With respect to control variables, all coefficients are statistically significant and, except for GROW, generally consistent with our expectations. The increase in ROTA is positively associated with market value. The results are similar to other researchers (Guenster et al., 2011; Fatemi et al., 2018; Garcia and Orsato, 2020; Wong et al., 2021).

CONCLUSIONS

The analysis of the environmental efficiency of public companies listed on stock exchanges in the EU using the DEA method shows that they cannot be considered environmentally efficient. This finding is particularly evident in companies from countries traditionally viewed as core EU members, such as Germany and France, as well as those known for their commitment to sustainable development, such as Denmark or Sweden. The results suggest that, overall, EU companies have significant room for improvement in their environmental practices despite the numerous legal regulations and subsequent requirements adopted by the EU.

Our research has demonstrated that there is a positive relationship between environmental efficiency and market value. This means that investors may consider a company's environmental performance to be an important factor in their investment decision-making. Therefore, companies should prioritise increasing their environmental performance because it should be financially beneficial for them. Currently, the change in companies' attitudes towards disclosing environmental information and introducing pro-ecological changes mainly stems from legal EU regulations rather than a genuine belief in the profitability of such actions. The complete implementation of the EU Directive (2022) will oblige companies to undertake timely and comprehensive environmental reporting. This development will address a significant research limitation, which is the relatively small database of environmental data published by companies. All listed companies, regardless of their size, will have to present non-financial reports for 2026, i.e. full reporting will start from 2027.

The lack of due attention to a high level of environmental performance in the case of EU public companies can be explained in two ways. On the one hand, this may result from the lack of sufficient knowledge in this area. Nevertheless, it will have to be supplemented and implemented in accordance with the requirements of the EU Directive (2022). On the other hand, companies may be afraid of having to incur high costs of implementing pro-ecological solutions, which may negatively affect their financial situation in the short term and only bring the expected benefits related to investors' decisions in the long term. The latter option is worth a more detailed analysis and may become the subject of further research in the future.

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