

Sustainability to Financial Realities: A Comparative Study of Renewable Energy's Impact on Financial Performance

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Abstract—This study examines the impact of renewable energy (RE) performance on companies' financial performance, primarily focusing on RE-related sustainable development goals (SDGs) and environmental factors. We analyze a sample of 2,737 companies across 47 countries from 2009 to 2018 using panel data analysis. Our results suggest that the effect of RE performance can be understood through three phases: policies adopted, targets established, and actions implemented. Interestingly, RE policies negatively impact profitability due to the substantial costs incurred by companies. Moreover, RE-related SDGs are found to affect companies' financial performance adversely. However, environmental factors demonstrate a positive and significant impact on corporate financial performance, which is observed consistently across developed and emerging countries. Furthermore, RE performance targets and actions have a significant positive impact, specifically in developed countries. This highlights the complex relationship between RE initiatives and financial outcomes, highlighting differential effects across various stages of implementation and geographic contexts.

I. INTRODUCTION

Rapid economic growth, globalization, and digital transformation have increased the consumption of natural resources, leading to concerns for the welfare of society. The Global Footprint Network reported that humans have exceeded what Earth ecosystems can regenerate in 2019, consuming almost 1.7 of Earth [1]. Similarly, the demand for energy consumption is growing. International Energy Agency (IEA) reports that global energy-related CO₂ emissions rose by 2% due to higher energy consumption in 2018 [2]. Another serious concern is the increase in the global average temperature, mainly due to the burning of fossil fuels that intensify CO₂ emissions. According to the IEA, global emissions grew by 2.1% in 2018 [3].

Consequently, renewable energy (RE) has gained widespread coverage over the last decades due to its massive impact on the environment and investment. Since the Paris Agreement on Climate Change in 2015, the European Union (EU) has taken serial steps to reduce greenhouse gas emissions by using more RE resources. One of the EU targets for 2030 is to reach 30% energy consumption from RE [4]. Although global investment in RE has reached its peak in the last five years, the market share of developed countries has gradually dropped.

Developed countries had the upper hand on RE investments until 2014, while the balance shifted in favor of emerging countries in 2015. By 2017, emerging economies accounted for 63% of the global RE investments. The US suffered a decline of 6% due to strict regulations, while the UK, Europe, and Japan witnessed a 65%, 36%, and 28% decrease in RE, respectively, in the last couple of years [5].

Capacity investment in RE has also shown remarkable growth, reaching USD 47.5 billion in emerging countries and USD 125.8 billion in developed economies in 2018. The Middle East and Africa regions spent up to USD 16.1 billion on solar energy projects. Likewise, implementing the UN SDGs regulations related to RE investments positively impacts the economic growth of the Eurasian countries [6]. The US allocated USD 43 billion to green power plant projects, while solar energy investments in Europe rose to USD 19.2 billion and wind energy to USD 36.7 billion in 2019. RE investment increased by USD 2.6 trillion from 2010 to 2019, accounting for 45% of the world's electricity [7].

Regarding the legal framework, international policymakers make considerable efforts to enact environmental regulations. Many companies have shifted their interests to investing more in green energy, believing it is the right solution to prevent global warming and be sustainable. They realized that this approach not only boosts environmental performance (EP) but also affects financial performance [8]. Many firms such as Google, Facebook, and Apple pledged to generate 100% of their power from RE in the upcoming years. In academia, recent studies mainly focus on how companies can benefit from implementing sustainable energy systems to improve financial performance [9], [10], [11], [12], [13], [14]. These studies mostly adopted energy intensity, green innovation, and RE utilization when analyzing the relationship between energy performance and financial performance.

This study investigates how RE performance affects corporate financial performance in emerging countries after the 2008 global financial crisis. We measure the RE performance of companies by referring to the relevant sustainable development goals (SDGs) set up by the United Nations (UN) in 2015 for 2030. Among the 17 SDGs, two of them are directly related to RE. The SDG 7 guarantees access to affordable, dependable, sustainable, and clean energy. The UN expects that the share of

RE will substantially increase due to the advancements in energy efficiency and cleaner fossil fuel technologies. The SDG 12 emphasizes ensuring sustainable consumption and production. The UN anticipates that by 2030, companies will adopt sustainable practices, i.e., reducing waste and using efficient natural resources. This study also covers environmental factors from environmental, social, and governance (ESG) indicators, including resource use, emissions, and innovation, to examine their effects on financial performance.

The present study contributes to the literature three-fold. First, given the conflicting results on how RE performance affects corporate financial performance, our study provides a deeper understanding of this impact through three phases: policies adopted, targets established, and actions taken. Second, answering the previous question depends on many factors, including geographic differentiation. This study elaborates on two geographic dimensions: developed versus emerging countries. Finally, it provides valuable insights to field professionals on elevating their sustainable management capabilities by investing in UN SDGs-related RE sources to increase profitability and improve corporate reputation.

The present study differs from the previous ones by using UN RE-related SDGs and environmental ESGs to examine energy-finance interaction in developed and emerging countries after the 2008 global financial crisis. The results strongly suggest that emerging countries must learn from the journey of developed countries. Developed countries should decrease the severity of environmental policies due to excessive expenses that make companies unable to move forward while emerging countries must keep a certain level of regulation intensity since they are still in the growth stage.

The rest of the study is organized as follows: Section 2 reviews the literature and develops the hypotheses. Section 3 presents the data, methodology, and variables. Section 4 discusses the empirical findings and concludes the last section.

II. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

A. Literature Review

Scholars have conducted numerous studies to examine the relationship between environmental performance (EP) and financial performance (FP) ([15], [16], [17], [18], [19]). Some studies identified a one-way relationship, EP affecting FP [20], [21],[22], [23], [24], while others revealed a reverse relationship [25], [26]. Alternatively, Hart and Ahuja [8] suggested the existence of a so-called "virtuous circle" between these two performances, claiming that companies with abundant resources tend to improve EP, which would positively affect FP. Makni et al. [27] supported this argument by providing evidence from 329 US, European, and Asian companies. They showed that superior EP leads to improved FP that, in turn, enables reinvestments in EP.

According to Delmas and Blass [28], the EP could be divided into three parts. The first one deals with the environmental impact of energy use, emission reduction, and carbon footprint. The second part handles regulatory compliance with EP standards and policies. The third one addresses organizational processes involving environmental management

systems, from environmental requirements to auditing, reporting, and accountability. This study mainly focuses on the environmental impact of measuring EP. Most of the previous studies detected a negative relationship between EP and FP and aligned their findings with the trade-off hypothesis [29], [30], [31]. Cordeiro and Sarkis [32] acknowledged the debate over environmental actions and strategies to prevent pollution and reduce emissions and their implications on the FP. They detected a negative relationship between environmental practices and FP for a sample of 523 US firms. Filbeck and Gorman [33] examined the relationship between electric utility companies and found a negative relationship between EP and FP. Hassel et al. [34] expressed the value relevance of EP and how it treats the market value of equity and accounting earnings and presented complete support to the cost-concerned school, arguing that EP negatively influences FP. Escobar and Vredenburg [35] focused on how oil and gas companies respond to sustainable development issues and detected no superior FP between the companies that considered environmental practices and those that did not.

From another angle, Wagner and Schaltegger [36] analyzed European manufacturing companies and found that the type of industry moderates the EP-FP relationship and the sort of environmental strategies implemented by the companies. They noticed a more positive FP in companies embracing shareholders' value strategies than companies that did not. In the same context, Christoffersen et al. [37] claimed that integrating energy management systems with firm strategies would reduce energy consumption, lower utility bills, and provide a higher benefit. Kushwaha and Sharma [38] noted a strong relationship between EP and FP in a study held on the automobile industry. Ernhart and Lizal[26] revealed evidence that better EP improved FP in the Czech Republic firms. Bunse et al. [39] encouraged firms to integrate energy management paradigms into decision-making processes to promote their FP.

Many scholars also supported the "it pays hypothesis" argument, believing that involving environmental innovation in the equation of traditional trade-offs would turn the facts upside down [40],[41],[42]. Porter and Linde [43] argued that innovation is a solution for companies to ameliorate their financial resources, help them using as a competitive advantage, and thus increase financial efficiency. Hart [44] underlined three important stages of using environmental practices to increase FP: using pollution prevention strategies instead of pollution control, employing product stewardship as a focal key to reduce consumption, and utilizing clean technology as a means to improve sustainability. However, other authors did not necessarily find a superior FP in companies with better EP. Sarumpaet [45] studied Indonesian companies and revealed that EP is not significantly associated with FP. Iwata and Okada [46] evaluated the association between EP and financial stability by using waste and greenhouse gas emissions as measures of EP in Japanese companies, showing a decrease in long-term FP.

From the investment perspective, in line with stakeholder theory, investors benefit from increased returns, community members trust companies, and a green reputation might attract other customers, suppliers, and more investors [47]. Buysse and Verbeke [48] showed that stakeholders affect environmental strategies adopted by companies. Delmas and Toffel [49]

investigated the reason behind the adoption of additional environmental management practices and found that the philanthropic act of those companies has more to do with the public and institutional stakeholder pressure. In a study held for 84 companies in North America, Vachon and Klassen [50] split green practices into environmental collaborations and monitoring when dealing with customers and suppliers. Another study conducted on 26 Tunisian manufacturing companies from 1994 to 2008 found an increase of 1.5% in the productivity of industries that face stakeholder pressure regarding environmental strategies [51]. However, investors are not only looking for green growth but also seeking improvements in energy fields. Strategies that align with SDGs provide brighter opportunities for shareholders. Bergmann et al. [11] detected a strong relationship between energy efficiency and profitability in 650 manufacturing firms in Japan, Europe, and the US. Fan et al. [52] took advantage of the energy intensity and energy efficiency index for 17 Chinese companies to analyze how the FP responded to energy efficiency and found better financial outcomes in firms that used less energy. Stinchfield [53] argued that RE production and deployment resulted in greater financial benefits. Shin et al. [54] reached similar results when they analyzed the relationship between RE utilization and FP in the US's top 60 RE user firms. Businesses that consistently utilized RE in their operations revealed a higher return on investment, and Tobin's q.

However, recent studies have shown that relying only on policy incentives for effective RE implementation is insufficient. Executing RE projects to replicate financial resources will make it easier for other RE projects to be executed, particularly in emerging countries [55]. The financial ability of companies to back up the implementation of environmental strategies plays a crucial role in how the results identify the relationship between EP and FP [56]. Especially when combined with the constant efforts of policy-makers to adopt more holistic RE approaches that bring innovative strategies and applicable reforms [57]. Therefore, embracing environmental activities could be a good source of high financial gains for some companies [58].

Despite all these efforts, companies still face some environmental constraints to position themselves. Thus, the natural environment is needed as a component of the equation. Hart [59] proposed the integration of the natural environment factor into the resource-based view (RBV), calling it a natural resource-based view (NRBV). The main idea behind RBV is integrating the firm's internal capabilities [60], [61] and external factors [62], [63], [64]. NRBV focuses on creating competitive advantages through a firm relationship with environmental sustainability. Combining different key resources, the NRBV put forward three strategies to help attain a competitive advantage: pollution prevention (to minimize emissions and waste), product stewardship (to minimize the cost and environmental impact of products throughout the value chain), and sustainable development (to improve the future environmental, social, and economic position of the company).

B. Hypotheses Development

We have clustered our hypotheses into three groups based on specific Sustainable Development Goals (SDGs) and environmental factors. The first group comprises three

hypotheses derived from the SDG 7. This SDG aims to ensure access to affordable, reliable, sustainable, and modern energy services by 2030. Specifically, it encourages companies to adopt policies that improve energy efficiency, generate more RE sources, and develop innovative technologies for clean energy use. Additionally, it advocates for environmentally responsible and cost-efficient products and services. The second group includes two hypotheses derived from SDG 12 pertaining to responsible consumption and production. The third group consists of two hypotheses derived from various environmental factors. Furthermore, we have included a fourth section that addresses control variables. Thus, our hypotheses are structured as follows:

H1a: There is a positive association between policy energy efficiency and financial performance.

H1b: There is a positive association between renewable energy use and financial performance.

H1c: There is a positive association between renewable energy products and financial performance.

SDG 12 targets responsible consumption and production, aiming to achieve sustainable economic growth while reducing ecological footprints, particularly in the areas of water, energy, and food. At the firm level, this SDG advocates several key initiatives. First, companies are encouraged to prioritize actions such as recycling, reusing, and reducing total waste. Second, policies should promote the use of sustainable packaging materials. Third, environmental criteria should guide decisions to eliminate certain materials from production processes. Lastly, companies should extend these sustainability efforts to their supply chains to minimize overall environmental impact [65], [66]. Therefore, based on these objectives, we propose the following hypotheses:

H2a: There is a positive association between resource use score and financial performance.

H2b: There is a positive association between emissions score and financial performance.

Implementing an ESG strategy enables companies to assess their sustainability performance across various metrics, including resource management, emission reduction, production efficiency, and green procurement to prevent global warming. At the firm level, environmental factors scrutinize whether companies employ best management practices to mitigate environmental risks and establish targets for improving energy efficiency. Drawing upon the NRBV and stakeholder theory, we propose the following hypotheses:

H3a: There is a positive association between environment pillar score and financial performance.

H3b: There is a positive association between target energy efficiency and financial performance.

Figure 1 shows the conceptual framework.

III. DATA AND METHODOLOGY

A. Data and Sample Selection

Our study used secondary data sourced from the Thomson Reuters database (EIKON). Our sample consists of non-

financial companies listed under the Thomson Reuters Business Classification, spanning industries such as energy, healthcare, industrials, technology, telecommunications services, and utilities. We compared the performance of non- financial

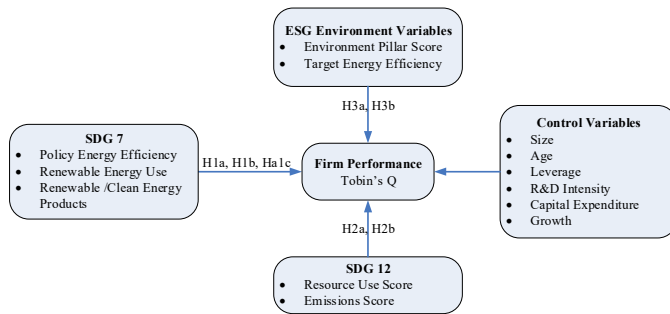


Fig. 1. Conceptual framework

companies across developed and emerging countries during the period from 2009 to 2018. Our sample encompasses 47 countries and includes 2,737 non-financial firms, resulting in 20,960 observations across 26 developed countries and 6,410 observations across 21 emerging countries. We employed the United Nations (UN) classification system to classify countries as either developed or emerging, as depicted in Figure 2.

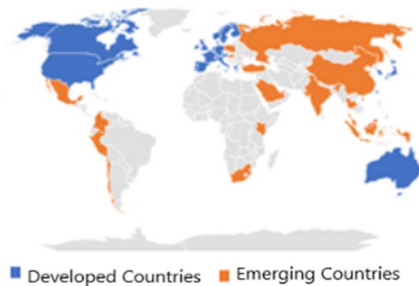


Fig. 2. Map for developed and emerging countries

We mapped our dependent variables to the UN SDGs. Initially, we identified variables aligned with SDG 7 (Affordable and Clean Energy), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). Specifically, we started with four variables under SDG 7, nine under SDG 12, and one under SDG 13. After filtering out variables with insufficient data, we narrowed it down to five SDG variables: three from SDG 7 and two from SDG 12.

Our analysis focused solely on environmental factors within the broader framework of ESG pillars. Although the EIKON database contains a comprehensive set of 121 environment variables categorized into resource use, emissions, and innovation, we selectively chose two variables related to RE. This selection aligns with our emphasis on RE-related metrics.

Lastly, we adopted Tobin's q as our dependent variable to measure the FP of companies.

B. Variables

1) Independent variables

We utilized variables aligned with SDGs 7 and 12, along with environmental variables, to assess companies' RE

initiatives. Under SDG 7, we considered the following variables: Policy energy efficiency, RE use, and RE/clean products. For SDG 12, we incorporated the resource use score and emissions score. From environmental factors, we included the environmental pillar score and target energy efficiency.

These variables collectively provide insights into companies' efforts related to RE adoption, energy efficiency policies, clean product development, resource utilization, emissions reduction, and overall environmental performance.

Policy Energy Efficiency (PEE) is a set of formal documented processes for efficient energy use. It investigates whether the company has a policy to improve its energy efficiency in terms of processes/mechanisms/procedures to efficiently improve energy use in operation.

Renewable Energy Use (REU) inspects whether the company uses RE by the amount of RE produced/purchased for its use only. It also measures the amount of waste converted to energy and used by the firm.

Renewable/Clean Energy Products (REP) analyzes whether companies use clean RE sources in the process of their products and services. It also examines if companies derive at least 25% of the power produced or revenue from clean technologies and use much of it to finance RE projects.

Resource Use Score (RUS) evaluates how the company diminishes material use, water, and energy employment. It also reflects eco-efficient and technological solutions in managing the company's supply chain.

Emissions Score (ES) assesses the company's impact on reducing environmental emissions in both the production and operational processes.

Environment Pillar Score (EPS) determines the company's impact on the ecosystem and assesses how well it uses its management practices to avoid environmental risks.

Target Energy Efficiency (TEE) inspects if the company sets targets to achieve energy efficiency.

2) Dependent variables

We use Tobin's Q as a market-based measure of the companies' FP. Tobin's Q is calculated following Lindenberg and Ross's (1981) definition by dividing the company's total market value by total assets. It reflects investor trust [68].

$$\text{Tobin's Q} = \text{Total Market Value} / \text{Total Asset Value} \quad (1)$$

3) Control variables

This study uses firm size, firm age, leverage, R&D intensity, capital expenditures, and growth as control variables.

Firm Size (Size) has a debatable impact on firm performance. Majumdar [69] and Isik and Tasgin [69] identified a positive association between size and profitability, while Hatem [70] found a negative relationship. The logarithm of total assets measures the firm size.

$$\text{Firm Size} = \ln(\text{Total Assets}) \quad (2)$$

Firm Age (Age) also has an ambiguous effect on firm performance. Few authors believe a significant positive relationship exists between firm age and profitability, while many others show that age negatively affects firm performance

[71], [72]. Firm age is measured by the logarithm of the number of years a company has been operating.

$$\text{Firm Age} = \ln(\text{Number of working years}) \quad (3)$$

According to the market timing and pecking order theory, *firm leverage (leverage)* positively affects FP. Haykir and Celik [73] found this when they studied the behavior of 48 companies over a 17-year period in Bangladesh. Firm leverage is calculated by dividing total debt by total assets.

$$\text{Firm Leverage} = \text{Total Debt} / \text{Total Assets} \quad (4)$$

R&D Intensity (RD) has a strong influence on the FP, as depicted by many studies [73], [74]. It is measured by dividing R&D investments by net sales.

$$\text{R\&D Intensity} = \text{R\&D Expenses} / \text{Total Revenue} \quad (5)$$

Capital Expenditure (CE) is a firm's funds to acquire or upgrade physical assets, i.e., property, buildings, and equipment. It may have a positive effect on FP. It is measured as in Equation 6.

$$\text{CE} = \text{Net increase in PP\&E (Property, Plant, and Equipment)} + \text{Depreciation Expense} \quad (6)$$

Growth (GR) enhances the positive relationship between energy intensity and FP [52]. We measure it using the Compounded Annual Growth Rate (CAGR) as a proxy.

C. Methodology

The study uses panel data analysis. It fits our data set since the sample comprises both cross-sectional and time-series data ([75]). We used STATA 15 to calculate the results. To test the association between RE performance FP, we run the following model:

$$\begin{aligned} FP_{it} = & \beta_0 + \beta_{1it} PEE_{1it} + \beta_{2it} REU_{2it} + \beta_{3it} REP_{3it} + \\ & \beta_{4it} RUS_{4it} + \beta_{5it} ES_{5it} + \beta_{6it} EPS_{6it} + \beta_{7it} TEE_{7it} + \\ & \beta_{8it} SIZE_{8it} + \beta_{9it} AGE_{9it} + \beta_{10it} LEV_{10it} + \beta_{11it} RD_{11it} + \\ & \beta_{12it} CE_{12it} + \beta_{13it} GR_{13it} + \mu_i + u_{it} \end{aligned} \quad (7)$$

i and t denote the i^{th} company ($i = 1 \dots 2737$) and the t^{th} year ($t = 2009 \dots 2018$), respectively.

Based on our dataset, we balanced panel data with 20,960 observations scattered across 26 developed countries and 6,420 observations dispersed over 21 emerging countries.

IV. EMPIRICAL FINDINGS

A. Descriptive statistics

Table 1 provides a summary of the descriptive statistics. The results show that 52.1% of the companies in developed countries produce and purchase RE compared to 1.2% of the companies in emerging countries. Developed countries have higher ratios of RE/clean products (15.9%), policy energy efficiency (73.8%), and energy efficiency targets of 35.4%. These ratios are relatively small in emerging countries, i.e., 6.5%, 53.4%, and 15.6%, respectively. Companies in developed countries also show high RE use, emissions scores, and environmental pillar scores, almost 1.5 times higher than in emerging markets. It seems that companies in developed countries benefit more from RE. This may be due to their vast experience and technological progress. For instance, the R&D of firms in developed countries is equal to 3.6%, whereas it is much lower in emerging countries.

TABLE I. DESCRIPTIVE STATISTICS

Variables	Developed countries		Emerging countries	
	Mean	S.D. ^a	Mean	S.D. ^a
Tobin's q	1.557	2.102	2.218	2.970
PEE	0.738	0.439	0.534	0.498
REU	0.521	0.499	0.012	0.083
REP	0.159	0.365	0.065	0.247
RUS	49.216	36.053	27.354	32.550
ES	48.313	36.236	27.152	32.463
EPS	44.229	32.382	23.47	27.611
TEE	0.354	0.478	0.156	0.363
SIZE	21.856	3.714	21.181	4.113
AGE	33.867	34.487	27.527	22.919
LEVERAGE	0.273	2.422	0.249	0.196
RD	0.036	1.590	0.004	0.083
CE	17.011	5.874	15.508	7.043
GR	0.048	0.129	0.072	0.179

^a Standard deviation

Tables 2 and 3 provide the correlation results. The coefficients do not exceed 0.7. However, variables under the SDG 7, SDG 12, and the environmental factors of ESG are

TABLE II. CORRELATION MATRIX FOR DEVELOPED COUNTRIES

Variables ^a	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Tobin's q	1													
2. PEE	-0.094*	1												
3. REU	-0.087*	0.595*	1											
4. REP	-0.121*	0.252*	0.200*	1										
5. RUS	-0.091*	0.726*	0.635*	0.256*	1									
6. ES	-0.113*	0.707*	0.625*	0.269*	0.780*	1								
7. EPS	-0.109*	0.782*	0.688*	0.379*	0.771*	0.771*	1							
8. TEE	-0.063*	0.437*	0.429*	0.193*	0.571*	0.506*	0.579*	1						
9. SIZE	-0.114*	0.232*	0.269*	0.198*	0.347*	0.338*	0.369*	0.238*	1					
10. AGE	-0.053*	0.255*	0.207*	0.127*	0.219*	0.227*	0.244*	0.177*	0.105*	1				
11. LEVERAGE	-0.016	0.002	0.015	0.005	0.014	0.013	0.001	0.001	0.015	0.004	1			
12. RD	0.019*	0.006	-0.010	-0.003	0.001	-0.005	-0.000	-0.006	-0.004	-0.007	-0.001	1		
13. CE	-0.091*	0.188*	0.193*	0.167*	0.277*	0.275*	0.293*	0.178*	0.761*	0.086*	0.006	-0.005	1	
14. GR	0.139*	0.056*	0.042*	-0.013	0.054*	0.050*	0.055*	0.038*	0.028*	0.076*	-0.003	-0.004	0.027*	1

^a *p<0.01

TABLE III. CORRELATION MATRIX FOR EMERGING COUNTRIES

Variables ^a	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Tobin's q	1													
2. PEE	-0.279*	1												
3. REU	-0.029	0.139*	1											
4. REP	-0.125*	0.247*	-0.016	1										
5. RUS	-0.251*	0.684*	0.202*	0.206*	1									
6. ES	-0.257*	0.681*	0.181*	0.230*	0.699*	1								
7. EPS	-0.258*	0.693*	0.193*	0.319*	0.746*	0.748*	1							
8. TEE	-0.136*	0.402*	0.121*	0.086*	0.629*	0.545*	0.591*	1						
9. SIZE	-0.169*	0.205*	-0.000	0.047*	0.255*	0.218*	0.218*	0.147*	1					
10. AGE	-0.122*	0.257*	0.074*	0.133*	0.297*	0.295*	0.313*	0.179*	-0.013	1				
11. LEVERAGE	-0.255*	0.105*	0.081*	0.128*	0.070*	0.096*	0.098*	0.012	0.053*	0.021	1			
12. RD	0.052*	0.015	0.001	-0.003	0.009	0.016	0.014	-0.009	-0.010	-0.021	-0.032*	1		
13. CE	-0.123*	0.161*	-0.008	0.007	0.209*	0.178*	0.177*	0.143*	0.869*	-0.021	0.018	-0.009	1	
14. GR	0.114*	-0.015	-0.006	-0.019	-0.027	-0.035*	-0.035*	0.009	-0.006	0.004	-0.100*	0	-0.003	1

^b. *p<0.01

highly correlated with each other. For instance, there is a 78% correlation between RUS and ES. However, the pairwise correlation matrices do not present a material multicollinearity problem. Notwithstanding, we also check for multicollinearity through variance inflation factors (VIF). Freund [76] suggested an acceptable cutoff of 10 in any given model. The results in Table 4 show no evidence of multicollinearity.

A. Regression results

To determine the most suitable regression model for our analysis, we conducted the Hausman test, as recommended by [75] for model selection. The Hausman test results indicated a probability value greater than 0.05 for both developed countries ($\chi^2=7.60$, $p>0.05$) and emerging countries ($\chi^2=11.91$, $p>0.05$). Consequently, we did not reject the null hypothesis, indicating that the random effects model is the most appropriate for our data. The random effects model, estimated using the generalized least squares method, inherently controls for heteroscedasticity, enhancing the robustness of our analysis. To further validate the suitability of the random effects model, we also conducted a Lagrangian Multiplier (LM) test. This test confirmed that our data aligns well with the assumptions of the random effects model over a simple ordinary least squares (OLS) regression approach. Therefore, based on the Hausman and LM test results, we proceeded with the random effects model for our regression analysis.

We ran panel data regressions separately for developed and emerging countries, using OLS, fixed effects, and random-effects models. We used random effects as a fit base model to run the regression in line with the previous tests. Table 5 displays the results.

The results reveal a significant negative relationship, contradicting H1a, in both developed ($\beta_1 = -0.134$, $p<0.01$) and emerging countries ($\beta_1 = -0.370$, $p<0.01$). This suggests that having policies aimed at improving energy efficiency adversely impacts FP. This phenomenon can be attributed to several factors: companies may implement environmental policies under public pressure, stringent regulations, management commitment, and competitive pressures, resulting in significant operational costs.

TABLE IV. VARIANCE INFLATION FACTORS (VIF)

Variables	Developed countries	Emerging countries
	VIF	VIF
EPS	7.74	8.99
RUS	5.94	7.22
ES	5.62	5.92
PEE	2.75	4.26
SIZE	2.55	4.14
CE	2.39	2.97
REU	1.97	1.74
TEE	1.57	1.36
REP	1.23	1.12
AGE	1.09	1.06
GR	1.01	1.05
LEVERAGE	1.00	1.01
RD	1.00	1.00
Mean VIF	2.76	3.21

In emerging countries, the recent formulation and implementation of RE policies over the past two decades may not yet be positively reflected in FP due to the gradual adoption and adaptation required. Conversely, in developed countries, establishing robust systems to comply with energy efficiency policies often demands substantial capital investment and rigorous operational processes.

For instance, as indicated in Table 1, developed countries allocate a significantly higher share of R&D investment (3.6%) compared to emerging countries (0.4%), aligning with previous studies [77]. However, as highlighted by Freund et al.[78] energy policies are essential for facilitating global energy investments and should ideally lead to improved energy efficiency and financial profitability when efficiently implemented.

TABLE V. REGRESSION RESULTS

Variables	Developed Countries ^a			Emerging Countries ^a		
	<i>Random effect</i>	<i>Fixed effect</i>	<i>OLS</i>	<i>Random effect</i>	<i>Fixed effect</i>	<i>OLS</i>
	<i>Tobin's q</i>	<i>Tobin's q</i>	<i>Tobin's q</i>	<i>Tobin's q</i>	<i>Tobin's q</i>	<i>Tobin's q</i>
Constant	-2.268***	-1.787***	-1.527***	-2.935***	1.238***	-1.334***
PEE (β_1)	-0.134***	-0.125***	-0.048*	-0.370***	-0.252***	-0.544***
REU (β_2)	-0.024**	-0.005	-0.044**	0.265*	0.448***	0.532***
REP (β_3)	-0.058***	-0.050***	-0.392***	-0.072**	0.019	-0.476***
RUS (β_4)	-0.002***	-0.002***	0.001**	-0.000	0.001	-0.008***
ES (β_5)	-0.003***	-0.003***	-0.005***	-0.003***	-0.001	-0.008***
EPS (β_6)	0.003***	0.004***	0.003***	0.000	0.001	0.013***
TEE (β_7)	0.017*	0.015	-0.026	0.066**	0.048	-0.025
LN-SIZE (β_8)	0.123***	0.125***	0.075***	0.183**	0.195***	0.123***
AGE (β_9)	-0.006***	-0.024***	-0.000	-0.001*	-0.061***	-0.001***
RD (β_{10})	0.004**	0.004**	0.015***	-0.156*	-0.180**	0.715***
LEVERAGE (β_{11})	-0.001	-0.001	-0.009***	-0.539***	-0.311***	-2.066***
LN-CE (β_{12})	-0.005***	-0.003***	-0.003**	-0.023***	-0.019***	-0.012***
GR (β_{13})	0.135***	0.123***	1.561***	-0.152***	-0.187***	0.746***
Observations	20,960	20,960	20,960	6,410	6,410	6,410
R-square	0.4309	0.439	0.106	0.4831	0.519	0.206

^c *p<0.1, **p<0.05, ***p<0.01

The coefficient results for REU show a positive and significant relationship ($\beta_2 = 0.265$, $p < 0.1$) in emerging countries, supporting H1b. Conversely, in developed countries, the relationship is negative and significant ($\beta_2 = -0.024$, $p < 0.05$), not supporting H1b. The observed negative relationship in developed countries can be attributed to the substantial investments required to produce or procure RE, volatile energy prices, and the ongoing maturation of renewable technologies. This context may dampen the immediate positive impact of RE adoption on FP. These findings are consistent with Baltagi and Baltagi [77], suggesting that integrating RE sources may not directly contribute to enhanced FP for companies in developed economies.

Contrary to our expectations, the coefficient for REP is consistently negative and statistically significant across all models in both developed ($\beta_3 = -0.056$, $p < 0.01$) and emerging countries ($\beta_3 = -0.072$, $p < 0.05$), contradicting with H1c. The observed negative relationship can be explained by the challenging nature of developing and adopting emerging products and technologies for clean RE. In developed countries, significant resources are often allocated to finance R&D for RE projects, aiming to achieve ambitious targets like producing 25% of power from clean sources. The rapid pace of technological advancements in developed countries creates pressure to continuously innovate and optimize solutions, which can translate into higher costs and impact profitability negatively. In emerging countries, the lack of resources to fund R&D in RE technologies often results in dependence on developed countries for technology transfer. The expense associated with adopting new technologies can strain firms' profitability in these economies. These findings highlight the complex dynamics surrounding RE adoption and its impact on FP, reflecting the distinct challenges faced by firms in developed and emerging economies.

Our expectation of a positive and significant relationship between RUS and FP (H2a) was not met, but the results are consistent with stakeholder theory. The findings indicate that improving resource efficiency may result in higher expenses, potentially impacting profitability negatively. Companies that leverage their internal capabilities to reduce resource consumption may prioritize building a strong green reputation and delivering value to shareholders and stakeholders rather than solely focusing on immediate financial gains. As a result, the results do not support H2a in either developed ($\beta_4 = -0.002$, $p < 0.01$) or emerging countries ($\beta_4 = -0.000$, $p > 0.10$). This underscores the nuanced relationship between resource efficiency and FP, highlighting the broader strategic implications of sustainability efforts beyond direct financial outcomes.

Contrary to H2b, which posited a positive relationship between ES and FP, the results show a negative and significant coefficient in both developed countries ($\beta_5 = -0.003$, $p < 0.01$) and emerging countries ($\beta_5 = -0.003$, $p < 0.01$), indicating that higher emissions scores are associated with decreased FP. This unexpected finding underscores companies' regulatory and operational challenges in managing and reducing environmental emissions. Compliance with environmental regulations and the associated costs of emission reduction efforts may exert long-term pressure on profitability. Therefore, the results do not support the notion that higher emissions scores lead to increased FP, highlighting the complexities and trade-offs inherent in balancing environmental commitments with financial outcomes.

We find strong support for H3a, which posits that the EPS significantly and positively impacts FP, particularly in developed countries ($\beta_6 = 0.003$, $p < 0.01$). In developed economies, taking proactive environmental actions translates into tangible benefits for profitability, as evidenced by the

positive coefficient. However, the influence of EPS on FP is found to be statistically insignificant in emerging countries ($\beta_6 = 0.000$, $p > 0.1$). This suggests that the relationship between environmental initiatives and FP may vary across different economic contexts. In developed countries, capitalizing on environmental opportunities and effectively managing environmental risks can lead to cost savings and enhanced profitability. The positive impact of environmental actions on financial outcomes underscores the importance of sustainability strategies in driving business success.

Our final hypothesis, H3b, posits that setting targets to achieve energy efficiency positively and significantly impacts FP. The results provide strong support for this hypothesis in both developed ($\beta_7 = 0.017$, $p < 0.1$) and emerging countries ($\beta_7 = 0.066$, $p < 0.05$). The findings indicate that establishing objectives to reduce energy consumption and improve energy efficiency attracts investor interest and enhances willingness to invest in sustainable firms. This alignment between energy efficiency goals and FP underscores the value investors place on sustainability and efficient resource management in companies. Overall, the results highlight the positive impact of energy efficiency targets on FP across developed and emerging economies, emphasizing the importance of strategic sustainability initiatives in driving investor confidence and support for sustainable businesses.

The results show that SIZE has a positive and significant influence on Tobin's q in developed ($\beta_1 = 0.123$, $p < 0.01$) and emerging countries ($\beta_1 = 0.183$, $p < 0.05$). This implies that large companies show better market performance compared to small ones. The results align with the prior studies [9], [12]. The results also show that firm age has a negative and significant relationship with FP in developed ($\beta_9 = -0.006$, $p < 0.01$) and emerging countries ($\beta_9 = -0.001$, $p < 0.1$). Even though old companies have spent significant years in the market, which has facilitated a higher market share, most of them are not quite familiar with RE and its implementation due to the hard adaptation of new technologies.

We also found that high R&D-intensive companies are more likely to achieve better FP in developed countries ($\beta_{10} = 0.004$, $p < 0.05$). This indicates that R&D activities on green products and energy efficiency reveal more benefits than costs. The results confirm the findings of [9]. However, we found opposite results in emerging countries ($\beta_{10} = -0.156$, $p < 0.1$). With the rapid technological advancements, developed countries are under pressure to keep expanding technological innovations and formulating optimized solutions. Therefore, they have already incurred some losses. In emerging countries, the lack of resources to finance R&D in RE unintentionally drives them to depend on developed countries constantly. New technologies are expensive and, thus, decrease short-term profitability.

LEVERAGE is not significant for developed countries ($\beta_{11} = -0.001$, $p > 0.10$) but negative and significant in emerging countries ($\beta_{11} = -0.539$, $p < 0.01$). This is because an increase in financial leverage means an increase in debt, which makes it harder for companies to repay it and increases business failure risk. This is in line with the findings of the previous studies [79] and [80]. CE is negative and significant in all countries ($\beta_{12} = -0.005$, $p < 0.01$ and $\beta_{12} = -0.023$, $p < 0.01$). Purchasing fixed assets and acquiring intangibles along with software developments

cost a lot. Thus, it has a negative influence on Tobin's q . Finally, GR positively and significantly impacts developed countries ($\beta_{13} = 0.135$, $p < 0.01$). This can be justified by the economic theory arguing that the liberalization of financial markets results in growth and stability in these countries. However, our results indicate a significant negative effect in emerging countries ($\beta_{13} = -0.152$, $p < 0.01$). This may be explained by high inflation rates leading to an increase in living costs, which harms the economy and, thus, decreases the profitability of companies.

V. CONCLUSIONS AND DISCUSSION

RE has emerged as a critical component of global sustainability efforts, with countries increasingly investing in renewables to combat climate change and reduce greenhouse gas emissions. These investments not only contribute to environmental goals but also stimulate economic growth by enhancing energy security, reducing costs, and stabilizing energy prices. Additionally, companies that invest in RE often benefit from improved reputations, although the direct impact on FP remains nuanced and varied.

These findings collectively emphasize the complex interplay between RE initiatives, environmental factors, and financial outcomes, underscoring the need for strategic and context-specific approaches to sustainable business practices.

A. Implications of the study

The study offers valuable insights for policymakers, particularly in developed countries, regarding managing and refining environmental and RE policies. While stringent regulations and measures are essential for promoting environmental sustainability and societal well-being, policymakers should be mindful of reaching a balance to avoid excessive expenses and burdensome costs for companies. Overregulation beyond a certain threshold could potentially undermine the profitability of businesses and impede economic growth.

In contrast, policymakers in emerging countries may benefit from maintaining or intensifying their focus on RE regulations. Given that companies in these countries are often in the growth phase continued support and encouragement from regulatory authorities could foster increased investment in RE technologies. This, in turn, would facilitate the effective implementation of energy efficiency strategies and contribute to long-term sustainable development. Therefore, regulatory authorities should strive to strike a delicate balance in setting environmental and RE policies, ensuring they are conducive to both environmental protection and economic prosperity while tailoring approaches to the unique contexts and stages of development in different countries.

Companies can enhance their RE performance to optimize the value chain, reduce carbon footprint emissions, and enhance overall effectiveness. Integrating energy efficiency technologies into quality control processes during supply chain activities can yield significant benefits. Moreover, companies should prioritize developing products and technologies that leverage RE sources across manufacturing, production, and packaging processes.

It is essential for companies not only to concentrate on RE

TABLE VI. SUMMARY OF THE HYPOTHESES

Hypothesis	Variable name	Expected sign	Developed countries ^a		Emerging countries ^a	
			Actual sign (Tobin's q)	Level of support	Actual sign (Tobin's q)	Level of support
SDG 7						
H1a: There is a positive and significant association between policy energy efficiency and firm financial performance.	PEE	(+)	(-) ^{***}	Not supported	(-) ^{***}	Not supported
H1b: There is a positive and significant association between renewable energy use and firm financial performance	REU	(+)	(-) ^{**}	Not supported	(+) [*]	Supported
H1c: There is a positive and significant association between renewable/clean energy products and firm financial performance.	REP	(+)	(-) ^{***}	Not supported	(-) ^{**}	Not supported
SDG 12						
H2a: There is a positive and significant association between resource use score and firm financial performance.	RUS	(+)	(-) ^{***}	Not supported	(-)	Not supported
H2b: There is a positive and significant association between emissions score and firm financial performance	ES	(+)	(-) ^{***}	Not supported	(-) ^{***}	Not supported
ESG Environmental variables						
H3a: There is a positive and significant association between environment pillar score and firm financial performance.	EPS	(+)	(+) ^{***}	Supported	(+)	Not Supported
H3b: There is a positive and significant association between target energy efficiency and firm financial performance.	TEE	(+)	(+) [*]	Supported	(+) ^{**}	Supported

^a *p<0.1, **p<0.05, ***p<0.01

performance within R&D activities but also to foster a RE mindset and implement sustainable strategies as integral parts of their organizational culture. By embedding RE strategies into company culture, organizations can cultivate a sustainable competitive edge and contribute positively to environmental and economic goals.

In summary, companies should proactively embrace RE initiatives throughout their operations, leveraging technology and strategic approaches to drive efficiency, reduce emissions, and establish a sustainable business model for long-term success and competitiveness.

B. Limitations of the study and future research

While this study contributes valuable insights into the relationship between RE and FP, we acknowledge several limitations that could guide future research directions. Firstly, our study primarily focused on the 7th and 12th SDGs and a limited set of environmental variables. Future research could expand the scope by incorporating additional RE variables to enrich the analyses further and explore nuanced relationships.

Secondly, the study period of 10 years and the sample of 47 countries and 563 companies may constrain the capture of broader trends and variations. Future studies could extend the timeframe and sample size to provide more comprehensive and robust conclusions.

Furthermore, an important limitation of our study is the assumption of contemporaneous effects between RE initiatives and FP within the same year. We acknowledge that this approach may overlook potential time lags in the impact of RE investments, policies, and initiatives on FP, which could

manifest over subsequent years. The absence of explicit modeling of time lags could introduce alternative explanations for observed statistical results, such as economic conditions influencing both RE investments and FP. It would also be useful to continue in this direction, accumulating more years and even more variables, including time lags testing the model's forecasting capabilities.

While our study aimed to analyze the relationship between RE initiatives and FP comprehensively, we acknowledge a potential limitation related to multiple hypothesis testing. Given the large number of data points and variables involved in our analysis, there is a risk of Type I errors, where statistically significant results may arise by chance. We did not employ a Bonferroni-style adjustment to address this issue explicitly. In future research, it would be beneficial to incorporate appropriate corrections for multiple comparisons to enhance the robustness and reliability of statistical findings

Lastly, a potential area for future research could involve narrowing the focus to a specific industry, such as the RE sector. By delving into a single industry, researchers could uncover more detailed and industry-specific insights that may not be fully captured in cross-sector analyses.

Addressing these limitations in future research endeavors would enhance the depth and applicability of findings in understanding the complex dynamics between RE initiatives, environmental factors, and FP.

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