



Utrecht University

**Impact of Environmental, Social, and Governance
(ESG) integration on the financial performance of
renewable energy companies, particularly solar
energy, in emerging countries.**

Aleksandra Tatko (8022399)

Joanna Maria Jaromin (4884663)

Jorge Bernad Hernandez (4484444)

Julia Carbone (1115790)

Lavinia Sterpellone (7437374)

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1. Introduction

ESG (Environmental, Social, and Governance) refers to a set of criteria used to evaluate the impact of a company's operations on the environment and society. Nowadays, solar energy is one of the most important in the field of renewable energies. For instance, it holds huge potential for addressing energy shortages and promoting sustainable development in these regions. Given this, the implementation of ESG practices by solar companies can significantly enhance their financial performance by encouraging sustainable growth, bringing in eco-conscious investors, and improving operational efficiency. Solar companies can mitigate risks and capitalize on the growing demand for renewable energy solutions by reducing environmental footprints, engaging with communities, and ensuring robust governance. This paper aims to reinforce the idea that the application of ESG practices can drive long-term profitability and resilience in the dynamic renewable energy market.

Emerging countries often face unique challenges, such as underdeveloped infrastructure, political and economic instability, and regulatory hurdles. Despite these difficulties, they present significant opportunities for growth, particularly in the renewable energy sector. Latest studies examining ESG ratings and financial performance in South Africa show how ESG integration can affect solar companies in an emerging market context (Chininga, Alhassan, & Zeka, 2023). Specifically, environmental initiatives enhance firms' financial bottom line and market performance, while social and governance practices do not significantly affect those measures (Chininga, Alhassan, & Zeka, 2023).

Recent studies, such as those by Zhang (2023) and Van Der Heide (2023), highlight the positive correlation between ESG practices and firm performance, primarily concentrating on developed markets and diverse industry sectors. Zhang (2023) conducted a

comprehensive analysis of ESG performance on corporate value using panel data from 2018 to 2021, finding a positive relationship between ESG performance and financial returns despite the COVID-19 pandemic. However, Zhang's analysis encompassed various industries and was primarily focused on the Chinese market, lacking specificity regarding the renewable energy sector in emerging markets. Similarly, Van Der Heide (2023) explored the impact of ESG performance on financial firm performance for companies listed on the NASDAQ, focusing on developed countries and neglecting the unique challenges and opportunities faced by renewable energy companies in emerging economies.

This study aims to bridge this gap by providing an understanding of how ESG implementation influences the financial performance of renewable energy companies, particularly solar companies, in emerging markets. By focusing on this niche area, the research can identify region-specific challenges and opportunities that may affect the relationship between ESG practices and financial outcomes. Additionally, Liu (2022) emphasized the importance of ESG practices in enhancing financial performance, particularly of renewable energy companies in emerging markets.

Moreover, the findings of this study will have practical implications for solar companies, investors, and policymakers operating in emerging markets. By identifying the ESG factors that significantly impact financial performance, solar companies can tailor their sustainability strategies to maximize economic benefits. Investors will gain insights into the value proposition of ESG-integrated solar companies, potentially leading to more informed investment decisions. Policymakers can leverage these findings to design regulations and incentives that promote ESG integration in the renewable energy sector, thereby fostering sustainable economic development in emerging countries.

Thus, it is anticipated that solar companies in emerging countries that implement ESG practices will exhibit better financial performance. Furthermore, it is expected that both the return on equity and assets will positively correlate with the financial performance of the firms.

2. Literature Review

2.1 Overview of Existing Literature

The integration of ESG (Environmental, Social, and Governance) practices has gained significant recognition for its potential to enhance financial performance, particularly in the renewable energy sector. This improvement in business operations and competitive advantage, as well as the enhancement of companies' reputations, has been well-documented. According to Friede et al. (2015), approximately 90% of the over 2000 ESG-related papers reviewed demonstrated a positive correlation between ESG and financial performance. This correlation is especially pronounced in solar energy companies, which engage in environmentally friendly activities, attracting more investment and regulatory support in emerging markets (Friede et al., 2015).

2.2 Financial performance metrics

Several frameworks have been employed to assess the impact of ESG integration on financial performance. The most common metrics include Return on Assets (ROA), Return on Equity (ROE), Tobin's Q, and stock performance. ROA and ROE have been used in all the studies that were examined for this research plan. ROA, a profitability ratio of net income to total assets, indicates that higher ROA correlates with more efficient asset use and, therefore higher ESG practices, as found in all the studies. ROE, calculated by dividing net income by shareholders' equity, is another key metric showing a positive correlation with ESG practices.

The firm's present market value can be determined using Tobin's Q, a common and extensively used market-based statistic. Tobin's Q is commonly represented as the ratio of a company's market capitalization to the entire value of its physical assets (Kim et al., 2013). It displays the corporation's physical assets' financial condition in the current market.

According to the findings of the studies used in this literature review, companies with robust ESG policies typically have higher Tobin's Q scores, which are indicative of increased investor confidence and market valuation. This implies that investors view companies with robust ESG policies as more valuable and long-lasting, which is consistent with the positive market opinion. Like Schabek (2020) Tobin's q will not be used in this study as it is not possible to calculate it for private companies.

Current literature consistently concludes that integrating ESG practices positively impacts financial performance. Schabek (2020) found that for solar power producers in emerging markets, ROA is 0.09 times higher. Public companies exhibit lower ROE, but no significant impact on ROA. Schabek's paper contributes to the existing research by analyzing novel factors that have not been previously considered in this field. Specifically, it includes an examination of wind-based power producers, although the analysis reveals no significant impact on performance; additionally, it investigates the level of company debt to assess the risk of ESG integration in indebted companies, finding that debt levels affect Return on Assets (ROA) but not Return on Equity (ROE). The study is only one of the few existing research papers that add variables omitted in other studies: solar, wind, private, and public and it also provides a comparison of financial performance of fossil fuel vs. renewable-energy-based power producers.

Sang Kim and Zichuan Li (2021) highlighted that ESG measures generate better outcomes in emerging markets, particularly in firms with weak governance. After testing several regressions Sang Kim and Zichuan Li have come to the result that among the environmental, social, and governance factors, governance has the most significant impact on firms, although it was tested on firms with weak governance; the reason for this is that firms with weak governance have more room for improvement in this type of practices and when the governance gets strengthened it can result in substantial enhancement in the performance and stability. The effect of credit risk is tested in this article as well, revealing that all of them have a significant impact. However, the effect of the environmental part is negative on credit rating, and social is the most positively impactful measure.

Naeem and Cankaya (2022) examined 192 power and energy generation firms from 2008 to 2019, finding that while ESG practices improve financial performance based on ROE and ROA regressions, they may negatively affect market value due to increased costs. They suggest that as they are energy and power generation companies, using ESG measures does not attract investors due to an increase in costs. This article has some limitations such as location and markets, which have not been considered when making the analysis. On the other hand, this research provides new value by investigating a very specific theme in the sustainable finance scope.

2.3 Theoretical Background

The Natural Resource-Based View (NRBV), as presented by Hart and Ahuja (1996), posits that by reducing pollution, firms can decrease costs and achieve higher profitability through more efficient resource use. This theory aligns with the observed financial improvements in highly polluting firms that reduce their environmental impact. The study by Hart and Ahuja

(1996) also gives insight into sustainable development, which as stated, focuses on long-term strategies to integrate ESG practices into the company's operations. The behavior of energy firms in developed countries is analyzed (Gupta, 2005), where the authors discovered a positive correlation between the energy stock return and the price of oil and other variables. Product stewardship encompasses a product's whole lifespan, from creation to disposal, and goes beyond the confines of the company. Businesses that implement product stewardship methods typically see improvements in consumer loyalty and brand reputation, which have a positive financial impact. There is evidence, yet it varies in degree, that adopting environmentally conscious activities improves financial performance (King and Lenox, 2001).

Stakeholder Theory, discussed in numerous studies including Schabek (2020), Fu and Li (2023), and Naeem and Cankaya (2022), asserts that corporations should create value for all stakeholders, not just shareholders. Therefore, the company's objective should be to create value for all stakeholders, including its customers, employees, the surrounding communities, and all other resources, rather than just maximizing financial gain for the shareholder. Ensuring the firm's sustainability is the primary goal of ESG initiatives. Investors today are more concerned with a company's potential to survive over the long term, and they place a high value on the company's social responsibility. Stakeholder theory states that a company's desire to generate sustainable wealth is fueled by its relationships with its different stakeholders. The organization would disclose information about its financial and non-financial operations to the public (Parmar et al., 2010). The faith of investors increases as a result of the disclosure of such information, which lessens knowledge asymmetry among stakeholders. Similarly, by ESG disclosure, companies increase the investors' trust in the company's long-term investment by increasing transparency and reducing information asymmetry (Cui et al., 2018). This theory is pivotal to our research as it underscores the

broader impact of ESG practices beyond mere financial performance, aligning corporate strategies with societal and environmental responsibilities, which is essential for the long-term viability of solar energy companies in emerging markets.

2.4 Conclusion

Overall, the literature has found that the integration of ESG practices is positively correlated with improved financial performance, particularly in terms of ROA, ROE, and Tobin; 's Q. By concentrating on solar energy firms in emerging markets, this research tries to close a gap in the literature and to offer substantial value. Due to the lack of data availability and data sources, an issue that has been raised by the majority of the literature, we base our research on theoretical knowledge and previous studies. This research advances sustainable investment practices and knowledge of the role environmental, social, and governance (ESG) plays in financial performance with a focus on solar energy.

3. Methodology

3.1 Study Context

This study focuses on examining the impact of Environmental, Social, and Governance (ESG) integration on the financial performance of solar companies in emerging countries. For this research, emerging countries are defined based on the classification provided by the International Monetary Fund (IMF) and include nations such as India, Brazil, South Africa, and Indonesia. The solar industry is selected due to its critical role in the transition to renewable energy, which is pivotal for sustainable development in these regions.

Due to the unavailability of financial data for a comprehensive analysis, the methodology is divided into two parts. The first part outlines the theoretical methodology that would be employed once access to all the necessary ESG data is obtained, based on

methodologies used in previous literature, such as the study by Luo et al. (2020).

Additionally, the methodology refers to insights from other relevant studies, including the impact of ESG practices on firm performance in emerging countries (Andries et al., 2022), and the effects of ESG integration in various contexts (Flammer, 2021; García et al., 2023).

The second part uses publicly available data from the World Open Data Bank on annual GDP growth and renewable energy share for the four developing countries (Brazil, South Africa, Indonesia, and India) to simulate potential results and assess the impact of ESG integration on financial performance in these emerging markets. This approach was decided upon after reviewing other literature, such as those by Muço et al. (2021), Eren et al. (2019), and Zhe et al. (2021), which indicated the effectiveness of using annual GDP growth and renewable energy share as proxies for evaluating the economic impact of ESG integration.

3.2 Research Design

The research employs a quantitative approach to provide a comprehensive analysis of how ESG integration influences the financial performance of solar companies in emerging countries. This approach allows for a clear, statistically significant understanding of the relationships between ESG scores and financial performance metrics.

The quantitative component involves collecting financial data and ESG scores for solar companies operating in selected emerging countries. The financial data will include metrics such as return on assets (ROA), which measures how efficiently a company utilizes its assets to generate profit; return on equity (ROE), which indicates how effectively a company uses shareholders' equity to generate profits; and stock price performance, which reflects market perception of a company's future profitability and overall financial health.

As the independent variable, the research will use ESG scores, including overall scores and individual components such as environmental, social, and governance. As mentioned earlier, the dependent variables in the analysis will be financial performance metrics. Additionally, the research includes control variables such as company size, age, market conditions, and economic indicators of the countries.

3.3 Proposed Analysis

The research analysis will consist of descriptive statistics, correlation analysis, and regression analysis, all conducted using statistical software such as STATA or R. Data visualization techniques will be employed to provide a clearer understanding of the relationships between the chosen variables.

1. Descriptive Statistics

Descriptive statistics will summarize the main features of the dataset, focusing on both ESG scores and financial performance metrics of solar companies in emerging countries. This analysis will calculate the mean, median, standard deviation, minimum, and maximum values for overall ESG scores and their components (environmental, social, and governance scores), as well as financial metrics like ROA, ROE, and stock price performance. Additionally, control variables such as company size, age, market conditions, and economic indicators will be included. Statistical software like STATA or R will be employed to generate these statistics and visualize the data through histograms and boxplots.

The resulting summary statistics table will provide a concise overview of the data's central tendency, dispersion, and distribution characteristics, revealing key insights into the relationships between ESG scores and financial performance. For instance, the table will show whether higher ESG scores correlate with better financial outcomes, laying the groundwork for more complex analyses like correlation and regression. This approach

ensures a robust understanding of how ESG integration impacts financial performance in the solar industry within emerging markets.

2. Correlation Analysis

Furthermore, the research will assess the relationships between ESG scores and financial performance metrics using Pearson and Spearman correlation coefficients. The Pearson correlation coefficient is a widely used statistical measure that assesses the strength and direction of the linear relationship between two continuous variables. It is particularly useful when the data is normally distributed and the relationship between variables is expected to be linear. Pearson correlation can quantify the degree to which changes in ESG scores are associated with changes in financial performance metrics such as ROA, ROE, and stock price performance. This method will help us determine if higher ESG scores correlate with better financial outcomes, providing clear, interpretable results that are essential for stakeholders and investors interested in the financial implications of ESG integration.

On the other hand, the Spearman correlation coefficient is a non-parametric measure of rank correlation, which assesses how well the relationship between two variables can be described using a monotonic function. Spearman correlation is particularly advantageous when the data does not meet the assumptions of normality or when the relationship between variables is not strictly linear. By using Spearman correlation, we can capture and quantify the strength and direction of the association between ESG scores and financial performance in a more flexible manner. Scatter plots will be used to visualize the correlation between ESG scores and financial performance metrics (ROA, ROE, stock price performance).

3. Regression Analysis

Simple Linear Regression:

$$\text{Financial Performance} = \beta_0 + \beta_1 \text{ESG Score} + \epsilon$$

Equation 3.1

The purpose of using a simple linear regression model is to analyze the direct relationship between overall ESG scores and financial performance metrics such as ROA, ROE, and stock price performance. This model allows us to isolate the effect of ESG scores on financial performance without the influence of other variables. It provides a straightforward interpretation of the relationship and helps establish a baseline understanding. Regression line plots will be created to illustrate the relationship between ESG scores and financial performance. However, it is acknowledged that the results from simple linear regression may be skewed by omitted variable bias (OVB), where other relevant factors that influence financial performance are not accounted for.

Multiple Linear Regression:

$$\text{Financial Performance} = \beta_0 + \beta_1 \text{ESG Score} + \beta_2 \text{Company Size} + \beta_3 \text{Company Age} + \beta_4 \text{Market Conditions} + \beta_5 \text{Economic Indicators} + \epsilon$$

Equation 3.2

The multiple linear regression model assesses the impact of ESG scores on financial performance while controlling for other variables such as company size, age, market conditions, and economic indicators. Including these control variables accounts for additional factors that may influence financial performance, reducing potential bias from omitted variables and providing a more accurate estimate of the effect of ESG scores. Residual plots and diagnostic plots will assess the assumptions of the regression models, ensuring the validity and reliability of the results.

Starting with the simple linear model helps in understanding the isolated effect of ESG scores and sets a clear foundation, allowing for comparison and contrast with the results of the multiple regression model, which highlights the influence of additional variables.

Bayesian Regression:

Bayesian regression incorporates prior information along with the likelihood of the observed data to produce a posterior distribution. This method integrates prior beliefs and evidence, providing a probabilistic interpretation of the regression coefficients. Bayesian regression can be particularly useful in this context as it accounts for uncertainty and can incorporate expert knowledge about the expected relationships between ESG scores and financial performance.

Using Bayesian regression involves specifying prior distributions for the regression coefficients and updating these priors with the observed data to obtain the posterior distributions. This approach provides a comprehensive framework for estimating the effect of ESG scores on financial performance, considering both the observed data and prior information.

In summary, the combination of simple and multiple linear regression models, along with the potential inclusion of Bayesian regression, offers a robust and comprehensive analysis of the relationship between ESG scores and financial performance. These methods together address potential biases, account for additional influencing factors, and provide a deeper understanding through probabilistic modeling.

3.4 Possible Results

- **Positive Relationship:**

If the regression coefficient β_1 for ESG Score is significantly positive, it indicates that higher ESG scores correlate with better financial performance. This outcome would be consistent with prior research showing that companies with robust ESG practices tend to be more efficient, attract more investors, and exhibit lower risk profiles (Friede et al., 2015; Eccles et al., 2014). Although a positive relationship between these variables is anticipated, as indicated in the literature review, it is acknowledged that the results might vary.

- Negative Relationship:

If β_1 is significantly negative, it implies that higher ESG scores might be associated with lower financial performance. This could suggest that the costs of implementing ESG practices outweigh the benefits, at least in the short term. This finding aligns with some studies indicating that the immediate costs of ESG initiatives can be substantial (Gillan et al., 2021). While this is not the expected outcome, it remains a possibility that cannot be excluded.

- No Significant Relationship:

If β_1 is not statistically significant, it suggests that ESG scores do not have a measurable impact on financial performance. This result might imply that the financial benefits of ESG practices are not immediately apparent or are offset by other factors. This outcome is supported by studies that have found no significant impact of ESG on financial performance in certain contexts (Revelli & Viviani, 2015). Despite expecting a positive correlation, the possibility of a non-significant result is recognized.

The coefficients of control variables (company size, age, market conditions, economic indicators) will provide additional insights into other factors influencing financial performance. For instance, larger companies or those in favorable market conditions might show better financial performance, independently of ESG scores. Including these control

variables helps isolate the specific impact of ESG scores, thereby enhancing the robustness of the analysis.

3.5 Model Robustness

Testing for multicollinearity, heteroscedasticity, and autocorrelation is crucial to ensure the reliability and validity of the regression results. Multicollinearity can be assessed using variance inflation factors (VIFs) to identify high correlations between independent variables that might distort the results. Heteroscedasticity, which refers to the non-constant variance of residuals, can be detected using tests such as the Breusch-Pagan test or White's test.

Addressing heteroscedasticity is important because it can lead to inefficient estimates and affect the standard errors of the coefficients.

Autocorrelation, the correlation of residuals across periods, can be checked using the Durbin-Watson test or the Ljung-Box test. Additionally, using robust standard errors can correct for any heteroscedasticity, and transformation techniques can stabilize variance. Cross-validation techniques, such as k-fold cross-validation, can be employed to assess the model's predictive performance and prevent overfitting, ensuring the model's robustness and reliability.

3.6 Proposed Example of Methodology

Based on the existing literature that examines the relationship between renewable energy usage and economic growth, this part of the research adopts a similar methodological approach. Previous studies, such as those by Muço et al. (2021), Eren et al. (2019), and Zhe et al. (2021), have demonstrated that increased renewable energy consumption is positively correlated with economic growth in various countries. These findings suggest that green energy initiatives can significantly enhance a nation's economic performance. Drawing inspiration from these studies, publicly available data on annual GDP growth and renewable

energy share is utilized to test the hypothesis regarding the impact of Environmental, Social, and Governance (ESG) integration on the financial performance of solar companies in emerging countries. By applying this methodology, the aim is to provide empirical evidence that aligns with the theoretical frameworks and results highlighted in the aforementioned research, thereby offering insights into how ESG practices can influence financial outcomes in the solar industry within these regions.

To simulate possible results, the paper uses data from the World Bank on GDP growth and renewable energy (% of total final energy consumption), between the years 2010 and 2020, for four countries: Brazil, Indonesia, South Africa, and India. This data was employed to perform an initial regression analysis in R to test the hypothesis about the positive relationship between the financial growth of solar companies and the impact of ESG integration in these four countries. This preliminary analysis also serves as an example of how the research intends to proceed once the ESG and financial data for solar companies become accessible. The following visualizations were created to simulate potential results.

The regression of GDP growth over the years 2010 to 2020, as shown in Figure 1, revealed varying trends among the countries. India exhibited the highest GDP growth, particularly noticeable from 2011 to 2016. Conversely, Brazil experienced the lowest growth, with significant fluctuations and a notable decline between 2013 and 2017, resulting in negative growth rates during these years. Both Indonesia and South Africa showed slight decreases in GDP growth over the decade. A sharp decline in GDP growth was observed across all four countries after 2019.

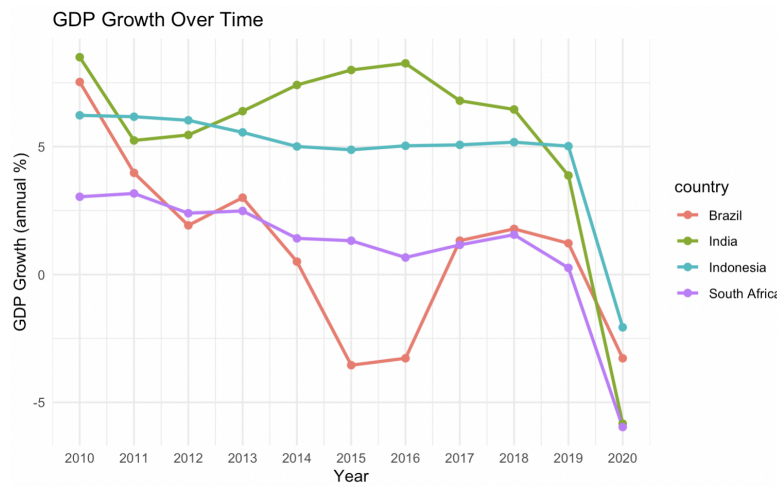


Fig. 1 GDP Growth over time in 4 developing countries.

Figure 2 shows renewable energy usage as a percentage of total energy consumption. It indicates that Brazil maintained the highest and most stable level, fluctuating around 45% throughout the period from 2010 to 2020. In contrast, South Africa consistently recorded the lowest renewable energy share, hovering around 10%. While most countries displayed relatively stable renewable energy consumption, Indonesia experienced a significant decrease from approximately 35% to about 20%.

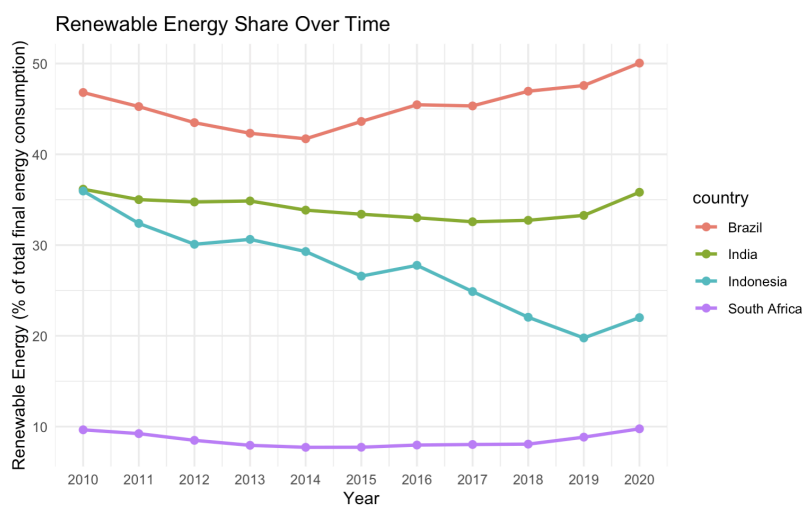


Fig. 2 Renewable Energy share over the years in 4 developing countries

In the final analysis, presented in Figure 3, the data from the previous visualizations was combined, and renewable energy share was regressed against annual GDP growth for all four countries. This visualization substantiates the hypothesis concerning the positive relationship between financial growth and ESG development in emerging markets. The trend line and the dispersion of data points suggest that higher adoption of renewable energy (a critical ESG metric) is associated with improved economic performance, as evidenced by GDP growth.

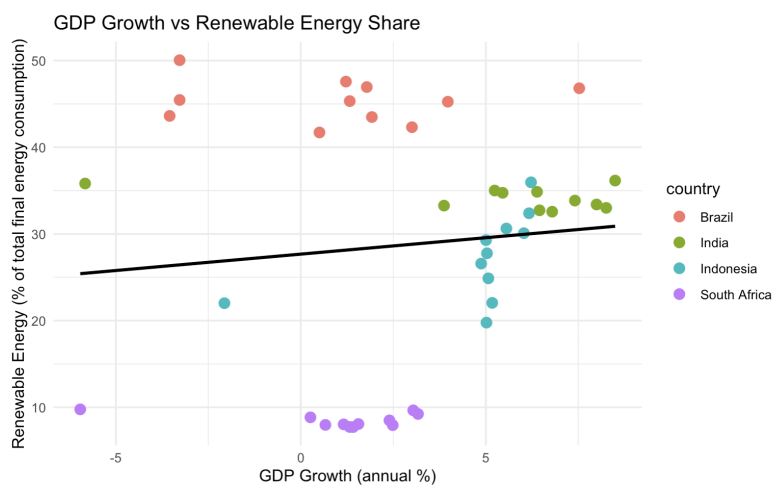


Fig. 3 Renewable Energy share and GDP growth over the years in 4 developing countries

These preliminary findings support the theoretical framework and provide a foundation for the comprehensive analysis to be conducted with detailed ESG and financial data from solar companies in emerging countries.

4. Conclusion

The study, using the available data and proposed analysis methodologies, examines how the integration of ESG activities affects the financial performance of solar companies in emerging countries such as India, Brazil, South Africa, and Indonesia. A quantitative approach has been used to analyze how ESG factors can significantly boost financial

performance metrics like Return on Assets (ROA), Return on Equity (ROE), and stock price performance. The results may confirm that companies with robust ESG practices tend to perform better financially, supporting the idea that sustainability and social responsibility are compatible with profitability. Conversely, the results might reveal significant initial costs that could reduce financial performance in the short term. Regardless of the outcome, the study provides important insights into ESG dynamics in a critical sector for sustainable development.

However, limitations include the reliance on publicly available data, which may lack the specificity needed for a comprehensive analysis of ESG integration's impact on financial performance. Additionally, the absence of detailed financial and ESG data for solar companies limits the depth of the analysis.

Given the appropriate and relevant data, it can be anticipated that the paper's hypothesis will be confirmed, as similar conclusions have been drawn in prior research, and the results are consistent with the expectations. Implementing a methodology that emphasizes GDP growth, acknowledges the potential presence of omitted variable bias (OVB). OVB occurs when a model leaves out one or more important variables, which can lead to inaccurate estimates and conclusions. Despite this limitation, this approach shows an initial step toward substantiating the hypothesis. The focus on GDP growth is strategic because it allows for the analysis of broader economic impacts and patterns that support the hypothesis. This perspective, while not exhaustive, provides a valuable starting point for further investigation.

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