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The Role of Analyst Coverage and Value-Relevance of Energy Efficiency

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Abstract

Purpose- The purpose of this study is to examine whether financial markets value a firm's specific corporate environmental performance (CEP), i.e. its energy efficiency practices. This study also investigates the mechanism through which energy efficiency is associated with firm value.

Design/methodology/approach- This study uses a sample of 324 US-listed non-financial firms during the period 2006–2019; data were accessed from Thomson Reuters Refinitiv. Employing baseline Ordinary Linear Squares (OLS) regression models, this study first estimates the association between energy efficiency and firm value. It then tests the role of analyst coverage (the number of sell-side financial analysts following the firm) in ascertaining the value relevance of energy efficiency. To ensure the robustness of the results, alternative estimations including endogeneity and sample bias correctness tests, were performed.

Findings- The study shows that energy efficiency is associated with firm value, and the role of analyst coverage as an external governance mechanism is positive and significant on the value relevance of energy efficiency. Furthermore, this study documents that the relationship is shaped by sustainability-related internal and external risks, indicating that financial analysts' role becomes more imperative when firms are subject to high scrutiny.

Originality/value- This study contributes to the literature by examining the intersections of energy efficiency, analyst coverage, and firm value. It attempts to demonstrate how and why CEP and financial performance (FP) are linked. In the context of growing environmental concerns, the pressure of climate change, and achievement of net-zero carbon emissions, this study provides valuable insights into the financial market wherein firms' environmentally responsible behaviours are value-enhancing, and governance mechanisms are promising. This study suggests that financial analysts can serve as an effective external governance mechanism.

Keywords: Analyst coverage, Corporate governance, Energy performance, Environmental performance, Financial market

1. Introduction

The International Energy Agency (IEA) believes that energy efficiency[1] is the "first fuel" for all energy transitions in the context of meeting global climate change and sustainable goals.[2] However, the *Energy Efficiency 2018* report published by the IEA shows that global primary energy intensity improvements have lessened over the last decade, indicating an increased consumption of energy per unit of production.

Because energy efficiency contributes to mitigating the shortage of fossil fuels (Mukherjee, 2008), reducing environmental emissions (Min, 2014), and increasing firm competitiveness or productivity (Filippini et al., 2020), policymakers, regulators, and citizens are increasingly concerned about energy efficiency. However, only a few studies have examined energy efficiency (Mukherjee, 2008). The study of firm-level energy efficiency is warranted not only because of the substantial demand for energy and resulting carbon emissions from the industrial sector,[3] but also because financial markets reward energy efficiency through premiums or incentives.

Prior research examining the association between CEP and FP has generally measured CEP through overall CSR scores or indexes accessed from different sources (Bhandari and Javakhadze, 2017; Buertey et al., 2019; Belu and Manescu, 2013). The overall CEP measurement score or index does not ensure that specific environmental initiatives, such as energy policies, investment in renewable technology, and reduction in carbon emissions, are associated with FP. However, stakeholders, such as investors and lenders, may be interested in knowing whether certain environmental activities are indeed value-enhancing.

To fill this gap in the literature, the current study focuses on a scarcely studied aspect of CEP, that is, energy efficiency. The two empirical questions that are examined are as follows:

Q1. Is there an association between energy efficiency and firm value?,

Q2. What is the underlying mechanism that links energy performance to firm value?

The latter question is crucial, especially due to the ongoing debate on whether and how CEP influences FP (Luo et al., 2015); this is also the main contribution of this study. Based on agency theory, this study argues that analyst coverage improves information transparency (Luo et al., 2015; Jo and Harjoto, 2014; Lee and Chung, 2019), curbs self-interest, and promotes managerial discretion (Hu et al., 2021). This is because of analysts' active interactions with firm management, frequent gathering or analysis of firm-specific information, and provision of buying and selling recommendations to clients. Accordingly, analyst coverage is expected to improve firms' environmentally responsible behaviours, which in turn have financial market implications.

This study investigates 324 US-listed non-financial firms from 2006 to 2019. Using baseline pooled OLS regression models, this study supports the hypothesis that a significant association between energy efficiency and firm value is positively moderated by analyst coverage. We suggest that analysts act as an effective external governance mechanism that contributes to incorporating a firm's energy performance into firm value. The results are robust to the endogeneity test (IV-2SLS), the sample selection (Heckman) model, and several robustness tests. This study contributes to the growing literature on CEP and FP. This study has several important practical implications. First, it studies the energy dimension of CEP which has received little attention in extant literature. By considering firms' energy efficiency, this study not only examines the value-relevance of energy performance, but also explores the crucial agency role played by analysts' coverage of the association between energy performance and FP. This study is the first of a few that link specific CEP (i.e. energy efficiency in this study) and FP to analysts' coverage.

Second, by measuring market-based financial performance, this study provides practical implications for financial markets. This contributes to understanding investors’ attention towards firms’ environmental initiatives and the potential role and use of analysts to mitigate information asymmetry. Third, the study provides an important policy suggestion that sustainability-related risks across firms and states in the US require strict scrutiny for the continued welfare of the financial market and maintenance of overall sustainability.

The remainder of this paper is organised as follows. First, the conceptual framework of the study is discussed and the hypotheses are developed. Then, the study data and research design are presented, followed by the results. Finally, the study’s findings and conclusions are presented.

2. Theoretical Background and Hypotheses Development

The literature on CEP and FP presents two main perspectives. The 'traditionalist', also referred to as the sceptical perspective, maintains that firms' environmental engagement incurs additional costs, and investment is irrelevant from an economic perspective; thus, there is a trade-off between CEP and FP (Fujii et al., 2013). This school of thought is derived from shareholder theory (Friedman, 1970), which advocates profit maximisation or improved returns to shareholders as a company's responsibility.

In contrast, the new doctrine of CEP favours the argument for socially and environmentally responsible firms. This positive perspective termed 'revisionist', argues that firms' environmental engagement could be more profitable in the long run. For example, pollution abatement costs, investment in innovation, and green technology decrease abatement costs in the long-term (Fujii et al., 2013). Firms with a CEP strategy also benefit from good reputations, which eventually contribute to higher market values than other environmentally unfriendly firms (Lee et al., 2015). This school of thought is derived from stakeholder theory (Freeman, 1984) which supports firms' responsibilities towards all its stakeholders. Studies along this school of thought provide evidence that CEP does not necessarily reduce firm competitiveness, but positively contributes to firm value and FP.

However, the relationship between CEP and FP is inconsistent (Fisher-Vanden and Thorburn, 2011). Furthermore, in the existing literature, CEP is generally measured using environmental or ESG scores/ratings/indexes. Therefore, there remains a knowledge gap that warrants an investigation of the value relevance of specific CEP activities. The study of specific CEP, such as carbon emission levels, energy intensity, green technology, eco-products, and environmental certification, involves substantial costs; thus, investors are concerned with the FP associated with such environmental investments. Studies employing some of these specific measures are on the rise. For instance, Iwata and Okada's (2011) study in Japan showed improved FP for firms that reduced greenhouse gas emissions. In contrast, Fisher-Vanden and Thorburn (2011) studied environmental initiatives (membership in the CPA's climate leaders for GHG reduction targeting) undertaken by US firms that experienced significantly negative abnormal stock returns. They argue that corporate commitments to reduce greenhouse gas emissions appear to conflict with firm value maximisation in firms with weak corporate governance, where managers face institutional pressures or use their discretionary power to overinvest in voluntary environmental initiatives. Despite studies increasing to use of such specific measures of CEP, the use of energy performance measures in the literature is visibly scarce.

Several studies have attempted to examine the association between energy performance and FP with inconsistent results. For example, in China, Fan et al. (2017) found a positive relationship between energy efficiency and accounting performance but not with market performance (Tobin's Q). Similarly, studying US-listed firms, Atif et al. (2021) found a significant positive effect of renewable energy use on accounting-related FP. However, studying Indian manufacturing firms, Sahu and Narayanan (2014) found energy efficiency to have a varying association with FP based on energy clusters. Therefore, within this narrow thread of literature, there is insufficient evidence to ascertain whether energy performance (energy efficiency or other energy-related initiatives), is associated with FP. This is important from an investor's perspective because investors may be interested in knowing if the capital invested for the attainment of energy efficiency has a premium. Therefore, this study considers an overlooked area of CEP, namely energy efficiency, and its association with firm value.

Based on CEP and FP literature and the 'revisionist' view, the first hypothesis is:

H_1: Energy efficiency is positively related to firm value.

The role of analyst coverage

Researchers have suggested examining hidden moderating or intervening variables to determine whether and how CEP affects FP. In the existing literature, several variables such as corporate innovation (Li et al., 2020), board gender diversity (Atif et al., 2021; Arayssi et al., 2016), firm growth (Fan et al., 2017), and internal corporate governance (Buertey et al., 2019), explain the link between CEP and FP. Therefore, it is important to unravel additional channels or mechanisms that affect the association between CEP and FP (Luo et al., 2015).

According to agency theory, agency conflicts between management and shareholders lead to information asymmetry and a lack of transparency. The agency problem is greater in the absence of monitoring or an information mechanism between the management and investors. In such cases, management discretion and entrenchment promote managerial self-interest and benefits; managers are motivated to fulfil their personal goals by allocating firm resources away from productivity-enhancing activities (Hu et al., 2021; Migu et al., 1974). The literature discusses two distinct ways in which managerial discretion misallocates a firm’s resources. First, they behave opportunistically and allocate resources for their own use, while misusing shareholder capital. Second, resources are allocated for high-yield purposes (Linden and Teece, 2018) without considering long-term benefits.

Corporate governance is an internal mechanism that facilitates the interests of both principals and agents. Prior studies have exploited such mechanisms to study the roles of board gender diversity, board independence, board committees, and institutional ownership (Min, 2014; Fakoya and Nakeng, 2019; Atif et al., 2021). Similarly, some external mechanisms, such as the institutional context, regulations, external assurance, public sentiment, and media exposure (Yang et al., 2021b; Serafeim, 2020; Asante-Appiah and Lambert, 2022) are also investigated in the association between CEP and FP. However, the literature in this area shows a limited consideration of external mechanisms. Therefore, this study considers analyst coverage as an external mechanism when examining the association between energy efficiency and firm value. Analyst coverage refers to the number of analysts who regularly follow a company and publish forecasts and recommendations (Hinze and Sump, 2019). As gatekeepers in the capital market, analysts integrate public and private information to perform financial forecasting for their clients, while using their information-access advantages and professional analytic skills (Lei et al., 2022). Analyst coverage appears to be an effective external mechanism to monitor firms (Hu et al., 2021; Yang et al., 2021a) and reduce information asymmetry (Naqvi et al., 2021; Luo et al., 2015; Jo and Harjoto, 2014) in financial markets. Yang et al. (2021a) forwarded two possible reasons for analyst coverage being effective as an external governance mechanism. First, firms with more analyst coverage have greater exposure. Analysts frequently follow firms, intensively assess their financial statements and filings, and probe the management during conference calls and other meetings. Thus, they uncover firms for the public and attract market attention towards them. Increased exposure and the likelihood of being caught by analysts and investors reduces corporate misconduct. Second, higher analyst coverage improves investor information quality because analysts conduct more surveys and issue more reports. Consequently, information asymmetry in financial markets is reduced.

This informational and monitoring role of analysts in the capital market thus causes stock prices to reflect underlying prices (Doukas et al., 2005; Luo et al., 2015) contributing to an efficient market. This is evident in Dhaliwal et al.'s (2012) study, where the relationship between non-financial disclosure and analysts’ forecasting accuracy was examined for 31 countries. They found that firms issuing standalone CSR reports are associated with lower analyst forecast errors. Similarly, Hinze and Sump (2019) systematically reviewed 45 papers on the intersection of CSR and financial analysts and revealed that CSR disclosure is associated with analysts’ forecast accuracy, indicating that CSR-related information is linked to the market valuation information environment. Although the literature shows that analyst coverage is significantly associated with CSR (Zhang et al., 2015; Chun and Shin, 2018; Adhikari, 2016; Hinze and Sump, 2019; Yang et al., 2021a) and FP (Doukas et al., 2005; Dhiensiri and Sayrak, 2010), studies on analysts’ roles in the association between CEP and FP are scarce. Hu et al. (2021) tested the interaction effect of CSR scores and analyst coverage on firm value. Their results showed an economically significant incremental effect on firm value. Luo et al. (2015) examined whether analysts pay attention to CSR score/information and incorporate it into their stock recommendations to general investors. They found a mediating role for analysts in connecting CSR to stock returns. Jo and Harjoto (2014) demonstrated that the interaction effect between analysts and the CSR index reduces firm risk. Note that the aforementioned studies considered overall CSR performance; thus, the current study focuses on examining the role of analyst coverage on the association between a specific CEP measure, energy efficiency, and firm value.

Following the agency theory perspective, the second study hypothesis is:

H_2: Analysts' coverage positively moderates the association between energy efficiency and firm value.

3. Data and Model

3.1 Sample and data

This study employs a sample of US firms accessed from the Thomson Reuters Refinitiv database. Refinitiv ASSET4 integrates firm-related data on a wide range of environmental, social, and governance (ESG) dimensions, collating it from publicly-available sources like annual reports, CSR reports, news sources, filings, and websites.[4] Firms included in the ASSET4 list are well recognised for their ESG performance, commitment, and effectiveness. Initially, the data included an unbalanced panel of 1060 listed public firms from 2002 to 2019. However, this study focuses on relatively more environmentally responsible firms, eliminating observations with zero environmental scores and observations without energy policy and target data.[5] Financial firms, observations with missing values for the baseline variables, and firms with less than four years of longitudinal data were further excluded. The final sample consists of 324 firms and 2,192 firm-year observations from 2007 to 2019.[6]

3.2 Empirical measures

We use a market-based FP measure, Tobin's Q (TQ), as a proxy for the dependent variable, firm value. TQ is a forward-looking measure of FP that measures the market value from an investor's perspective (Fan et al., 2017). This allowed us to measure the impact of a firm's policies and decisions, reflecting both the tangible and intangible aspects of performance. It also reflects past performance and future growth opportunities for firms, thus providing a better measurement of FP than accounting performance measures such as ROA and ROE (Li et al., 2020). TQ is the sum of market value and total assets, minus total equity divided by total assets (Atif et al., 2021; Basuroy et al., 2014). In the robustness analysis, we use market value per share (MVPS) or market price as a measure of firm value using the Ohlson price model. The financial data are derived from Refinitiv Eikon.

The independent variable, energy efficiency, is measured in line with energy intensity which is the percentage of total energy use over sales revenue (Atif et al., 2021; Fan et al., 2017) but is inversed as a proxy for energy efficiency. This means that the higher the energy intensity, the lower the energy efficiency.[7] Furthermore, in the robustness analysis, the study employs energy efficiency policy (EEP) and energy efficiency targets (EET), two binary variables, to measure the explanatory variable. Energy intensity (efficiency) data is derived from Thomson Reuters Refinitiv. The database reports firms' use of total energy for a given year which is the total direct and indirect energy consumption in the firm's operations. Similarly, EEP is an indicator variable of whether a firm has a policy to improve its energy efficiency by specifying various forms of processes, mechanisms, procedures, or systems for the efficient use of energy. Accordingly, EET indicates whether a firm sets short- or long-term targets or objectives to achieve energy efficiency in its business operations.

Analyst coverage is a moderating variable measured by the number of analysts following a firm, similar to Hu et al. (2021), Lei et al. (2022), and Zhang et al. (2015). Furthermore, a robustness analysis tests the effect of analyst coverage using two indicator variable-based sub-sample analyses: high analyst coverage and high recommendation counts. High analyst coverage equals one if the firm is followed by above industry-average analysts, and high recommendation counts equals one if analysts' buy or sell recommendation counts for the firm are above the industry-average.

We assume that firms for which analysts make more buy or sell recommendations to clients are more likely to have higher exposure and information transparency.

Following the literature, we also include several firm characteristics as control variables. Examples include firm size, leverage, profitability, volatility, and institutional holdings. Since the larger the firm, the higher the energy consumption, potentially higher environmental investment, and higher FP (Atif et al., 2021; Fan et al., 2017), firm size is controlled. Leverage may constrain firms' investments in business opportunities, including environmental innovation, and affect FP. Profitability is positively related to firm value (Campbell and Mínguez-Vera, 2007) because of profitable firms' ability to exploit business opportunities. Volatility indicates a firm's earnings or return uncertainty (Jo and Harjoto, 2014). Thus, more volatile firms are less likely to be the first choice of value investors. Finally, institutional ownership is included because of institutional investors' varying investment incentives. However, there seems to be a nonlinear relationship between institutional investors and FP (Koh, 2003; Daryaei and Fattahi, 2020). Therefore, it was controlled accordingly. The variables are defined in Table I below.

Insert Table I

3.3 Model specification

The two baseline models of the study are presented below:

$$Y_{it} = \propto + \beta_1 X_{1it} + \delta Z_{it} + \gamma + \varepsilon_{it} \quad \text{...}(1)$$

$$Y_{it} = \propto + \beta_1 X_{1it-1} + \beta_2 M_{1it} + \beta_3 X_{1it} * M_{1it} + \delta Z_{it} + \gamma + \varepsilon_{it} \quad \text{.......}(2)$$

In the first model, for firm *i* at time *t*, Y is the dependent variable firm value (TQ). The coefficient symbols β and δ, are vectors of coefficients on independent variable X (energy efficiency) and control variables Z (firm characteristics). The second model introduces the moderating variable M (analyst coverage).[8] In both models, year, industry and industry-year effects as shown by γ are included to account for time-variant and invariant effects. ε_{it} represents a random error term. This study employed the Pooled Ordinary Least Squares (OLS) regression method for the baseline models. In addition, the IV-2SLS regression method and the Heckman model were used to account for endogeneity.

4. Results and Analysis

4.1 Descriptive statistics

Insert Table II

Table II reports the descriptive statistics for the variables used in the baseline models. The values of the dependent variable TQ, range from 0.653 to 11.255, with an average value of 2.203, indicating that the sample firms are overvalued on average. The explanatory variable, energy efficiency ranges from 0 to 6.909%, with a mean of 6.666%. The mean value of analyst coverage shows that the sample firms have approximately 20 sell-side analysts on average, ranging between a minimum of one and maximum of 56 analysts. Moreover, the control variable statistics indicate that the sample firms are heterogeneous in terms of size, leverage, profitability, earnings volatility, and institutional ownership.

Insert Table III

Table III reports the correlation coefficients between the baseline variables. Pearson's pairwise correlation test shows that the coefficients were less than 0.55, suggesting no multicollinearity between the variables. The preliminary correlation analysis indicates that the coefficients for energy efficiency (0.174) and analyst coverage (0.189) are significant (at the 1% level) and positively related to TQ. Similarly, the correlation between analyst coverage and energy efficiency was significant (at the 1% level) and positive (0.073).

4.2 Regression results

Baseline regression models

Insert Table IV

Table IV reports the association between energy efficiency and firm value in Model 1 and the moderating role of analysts' coverage in Model 2. The results show that energy efficiency is positively and significantly associated with firm value. Furthermore, the interaction term in Model 2 examining analysts' coverage, seems to strengthen the existing association between energy efficiency and firm value. The beta coefficients increase from 0.0862 ($p<0.01$) to 0.1661 ($p<0.01$) in the interaction model.

4.3 IV-2SLS regression model

Insert Table V

The relationship between energy efficiency and FP is not without endogeneity. For instance, energy efficiency is endogenous and affected by many firm-level or contextual factors. Furthermore, one may argue that financially strong firms can invest more in green energy technology, which may lead to energy efficiency, a case of reverse causality. To address such issues, this study uses the IV-2SLS regression method with instruments for endogenous energy efficiency explanatory variables, in line with Bhandari and Javakhadze (2017), Sun and Yu (2015), and Tanthanongsakkun et al. (2022). The two instruments used for energy efficiency are (1) the firm's initial level of energy intensity and (2) the local (state) energy intensity. It is reasonable to argue that a firm's initial energy intensity level influences its current level. Additionally, energy intensity at the local level affects firm-level energy performance because of state green initiatives and policies in response to local energy intensity.[9] Furthermore, both instruments influence firm value only through the endogenous measures of energy performance. The Cragg-Donald Wald F-, under-identification, and Hansen J-tests also supported the relevance, strength, and exogeneity of the instruments used. Moreover, these instruments were primarily motivated by conceptual understanding and prior literature. The IV-2SLS results for the baseline models are reported in Panel A of Table V and are consistent with the baseline results.

4.4 Heckman selection model

The study sample includes firm-year observations without missing energy use data; thus, it may suffer from sample selection bias. Heckman's sample selection model considers this issue by accounting for the excluded firm-year observations that estimate the inverse Mills ratio for the selected variable, and uses it in the baseline model. Therefore, by employing the Heckman model, this study first calculates the inverse Mills ratio for the energy dummy using the baseline variables, and two additional variables to satisfy the exclusion restriction. The two additional variables are firm age and firm association with CSR initiatives (equal to one if the firm is associated with at least one of the following initiatives and zero otherwise: OECD guidelines, Global Compact, and GRI Reporting guidelines). We assume that these two variables affect a firm’s probability of disclosing its energy use data. Older firms have the capability and are under pressure to make sustainability disclosures; thus, they are more likely to report energy-use data. In addition, the association and engagement with CSR or sustainability-related initiatives increases firms’ awareness and actions towards environmental responsibilities; thus, they are more likely to engage in sustainability disclosures. Panel B of Table V reports the Heckman selection model’s second-stage results for the baseline models. These results were consistent with the main results.

4.5 Robustness tests

This study performed several additional tests to assess the robustness of the results. First, we examined the role of analyst coverage using a subsample analysis based on alternative binary measures. The full sample is divided into (1) high vs low analyst coverage subgroups and (2) high vs low analyst recommendation count subgroups. The unreported results show that the association between energy efficiency and firm value is significant and more pronounced within subgroups with higher analyst coverage and recommendations.[10]

Second, Ohlson's (1995) price model is used as an alternative measure of firm value. The model assumes that the market value of equity is a function of accounting and other non-accounting information. This study investigates the value relevance of energy efficiency in addition to other accounting variables. Unreported results show that, in addition to book value and earnings per share, energy efficiency explains the market value per share of a firm. It is stronger when firms have above-average analyst coverage in a given year.

Third, this study examines the treatment effects of two alternative energy efficiency variables: EEP and EET. First, propensity score matching using the Probit model predicts a firm's probability of EEP and EET. The model uses baseline control variables in addition to firm age as independent treatment variables. The full sample is then split into high and low analyst coverage subgroups, where high analyst coverage indicates an above-industry number of analysts following the firm. In an unreported table, the results show a consistently significant and stronger effect of analyst coverage within the subgroup that has above-industry analyst coverage.

Furthermore, the results support the hypotheses if lagged measures of the independent and moderating variables were employed.[11] In addition, the baseline results appear similar if the standard errors are clustered at the firm or state levels.

4.6 Additional analysis

This study further investigates the conditions under which investors might consider analyst coverage effective. The literature shows that firms require more scrutiny when internal and external sustainability-related risks are high, because of their negative impact on firm growth (Maung et al., 2020; Fafaliou et al., 2022; Asante-Appiah and Lambert, 2022; Huang et al., 2018). Thus, this study tested the effects of firm-level ESG risks and state-level climate risks on the interaction model.[12] For this, two indicator variables, ESGRepRisk and ClimateRisk, were created: taking a value of one for the above-sample average ESG reputation risk index and state-level temperature in a given year, respectively, and zero otherwise. Table VI shows the significant and positive role of analyst coverage in the value relevance of energy efficiency when firms are exposed to higher internal and external sustainability-related risks.[13] Moreover, it seems that external sustainability risks have a stronger influence on firms' energy performance than internal ESG risks. This finding is reasonable, given the rising number of state-level environmental initiatives or policies to counteract the firm-level implications of climate change. This finding further confirms the role of analyst coverage as an effective external governance mechanism because financial analysts are more likely to incorporate energy performance into firm value when firms are under greater scrutiny.

Insert Table VII

5. Discussion and Conclusion

Energy performance has not received enough attention in the literature; however, it is regarded as a driving force for energy security, environmental quality, and firm competitiveness (Mukherjee, 2008). Policymakers also emphasise energy efficiency as the main driver for reducing long-term gas emissions.[14] This study investigates energy efficiency in relation to the market-related performance of firms. The main contribution of this study is its exploration of the mechanism linking energy performance to firm value.

The baseline regression models show a positive and significant association between energy efficiency and firm value, which is consistent with CEP-

FP literature. Caragliu (2021) showed the positive and significant effect of an energy efficiency policy on profitability and productivity. Fan et al. (2017) found that energy efficiency can enhance accounting returns; however, its association with TQ is insignificant. Atif et al. (2021) showed a significant association between renewable energy use and TQ when firms have a higher representation of women on corporate boards. Thus, the latter study indicates the role of governance mechanisms that might be important for improving energy performance (Min, 2014; Fakoya and Nakeng, 2019; Zhang et al., 2021) or the value-relevance of energy performance.

This study investigates the role of analyst coverage, an external governance mechanism, in the association between energy efficiency and firm value. This study finds that analyst coverage positively and significantly moderates the value relevance of energy efficiency. This finding, which is consistent with agency theory, highlights the role of governance mechanisms in reducing conflicts of interest between management and investors. Analysts' informational and monitoring roles seem instrumental in improving information transparency in financial markets and curbing managerial discretion by disciplining managers (Jansen et al., 2022; Mouselli and Hussainey, 2014; Adhikari, 2016). This empirical result is consistent with that of Hu et al. (2021), who found improved firm value when analyst coverage interacts with CSR performance. Similarly, Naqvi et al. (2021), Jo and Harjoto (2014), and Luo et al. (2015) showed that analyst coverage is the mechanism for the link between CSR and FP, such as bid-ask spread, firm risk, and stock returns. Therefore, this study reveals financial analysts' crucial informational or monitoring roles in the relationship between energy efficiency and firm value. The study results are robust and account for endogeneity, selection bias, and alternative measures of the variables of interest.

This study further demonstrates that internal and external risks are likely to increase the informational and monitoring roles of analysts' coverage of energy efficiency's value relevance. This suggests that investors draw attention to governance mechanisms when firms are exposed to higher internal and external sustainability risks; this is in line with Asante-Appiah and Lambert (2022), who explored the role of external auditors in managing ESG risks and improving firm value. Such scrutiny is valuable to both investors and the environment.

Our findings have several significant implications. First, it shows that energy efficiency, as a specific measure of CEP, is value-relevant for financial market participants, indicating investors' concerns towards energy efficiency and green investments. This suggests that firms should consider achieving energy efficiency by formulating energy or carbon policies and targets. Second, analyst coverage of a firm interacts positively with its energy performance to improve firm value. Thus, firms followed by a higher number of sell-side analysts are more likely to benefit from reduced agency costs in terms of information asymmetry and managerial discretion, indicating the important informational or monitoring role played by analyst coverage. Thus, financial market participants may be interested in utilising analyst coverage as an external governance mechanism for their own benefit. Finally, the study of US firms' energy performance has important policy relevance because the US is the second largest carbon emitter in the world and faces increasing stakeholder pressure to adopt sustainability practices. Sustainability-related risks across firms and states in the US require strong scrutiny of financial market welfare and overall sustainability. Therefore, policymakers should consider employing and exploiting governance mechanisms such as analyst coverage in financial markets.

However, this study has some limitations. First, the sample consists of the ASSET4 category of only 324 US-listed non-financial firms. Future researchers may be interested in accounting for other firms if they have access to energy-related data from other sources. Second, this study uses total energy consumption to calculate the energy efficiency variable.

Additional insight will be obtained if future studies employ a different mix of energy consumption. Finally, we investigate the role of analyst coverage as an external governance mechanism. Future studies may consider exploring other external mechanisms or channels, such as media, pressure groups, and culture, which may affect the relationship between energy and financial performance.

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Table I Variables explanation

Variable ID	Measure	Definition
A: Dependent variable		
firm_value	Tobin's Q	TQ is the sum of the market capitalization plus total assets minus the book value of equity, all divided by the book value of the total assets.
B: Independent variable		
energy_efficiency	Energy efficiency/intensity	The inverse of energy intensity. Energy intensity is the percentage of energy consumption over sales revenue.
C: Moderating variable		
analysts_coverage	The number of analysts following	The total number of analysts following the company.
D: Control variables		
ESGscore firm_size leverage profitability volatility institutional_ownership	Sustainability performance Log(total assets) debt-to-equity Return on assets (ROA) Dispersion of EPS Institutional ownership	Refinitiv's ESG score ranging between 0 to 100. The natural logarithm of the book value of firm's total assets. The ratio of the firm's total debt to total equity. The percentage of a firm's net income is divided by its total assets. The standard deviation of earnings per share. The ratio of institutional shares to total shares outstanding.

Table II Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
firm_value (TQ)	2192	2.203	1.292	.653	11.255
energy_efficiency	2192	6.666	.564	0	6.909
analysts_coverage	2192	20.158	8.435	1	56
ESGScore	2193	64.102	14.796	9.5197	95.073
firm_size	2192	23.462	1.207	20.254	27.036
leverage	2192	.804	3.719	-36.222	36.583
profitability	2192	9.909	8.087	-34.839	38.199
volatility	2192	.058	.081	0	.798
institutional_ownership	2192	.754	.246	0	1.00

Please refer to Table I for variable descriptions.

Table III Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) firm_value (TQ)	1.000								
(2) energy_efficiency	0.174*	1.000							
(3) analysts_coverage	0.189*	0.073*	1.000						
(4) ESGScore	0.080*	-0.008	0.232*	1.000					
(5) firm_size	-0.178*	-0.007	0.496*	0.410*	1.000				
(6) leverage	-0.090*	-0.024	-0.025	-0.040	0.038	1.000			
(7) profitability	0.540*	0.132*	0.182*	0.120*	-0.044	-0.084*	1.000		
(8) volatility	-0.199*	-0.067*	0.013	-0.006	0.146*	-0.007	-0.182*	1.000	
(9) institutional_ownership	0.005	-0.001	-0.036	0.105*	-0.076*	0.013	-0.046	-0.059*	1.000

Table III shows the pairwise correlation between variables used in the baseline models. Please refer to Table I for variable descriptions. * p<0.01

Table IV Baseline models

VARIABLES	(1) model1 firm_value	(2) model2 firm_value
energy_efficiency	0.0862***	0.0961***
	(0.0285)	(0.0313)
analysts_coverage		0.6670***
		(0.0708)
energy_efficiency X analysts_coverage		0.1661***
		(0.0546)
ESGScore	0.0031*	0.0026
	(0.0018)	(0.0017)
firm_size	-0.2571***	-0.3754***
	(0.0262)	(0.0299)
leverage	-0.0114	-0.0108
	(0.0072)	(0.0071)
profitability	0.0760***	0.0699***
	(0.0053)	(0.0052)
volatility	-0.7824***	-0.8937***
	(0.2584)	(0.2578)
institutional_ownership	1.8996***	1.6362***
	(0.3718)	(0.3604)
$institutional\_ownership^2$	-1.9172***	-1.7287***
	(0.3332)	(0.3247)
Constant	6.1713***	9.5000***
	(0.6173)	(0.6786)
Year effects	Yes	Yes
Industry effects	Yes	Yes
Industry X year effects	Yes	Yes
Observations	2,192	2,192
R-squared	0.481	0.510

Table IV reports baseline results from the pooled OLS regression method. Model 1 shows the association between energy efficiency and firm value and Model 2 shows the effect of analysts' coverage on the association between energy efficiency and firm value. Please refer to Table I for variable descriptions. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table V Endogeneity tests

	(1) model1 firm_value	(2) model2 firm_value
PANEL A: IV-2SLS Regression Model		
energy_efficiency	0.1499***	0.1715***
	(0.0328)	(0.0370)
analysts_coverage		0.6855***
		(0.0697)
energy_efficiency X analysts_coverage		0.2152***
		(0.0617)
Constant	5.2869***	9.0891***
	(0.5927)	(0.6475)
Controls	Yes	Yes
Year effects	Yes	Yes
Industry effects	Yes	Yes
Industry X year effects	Yes	Yes
Kleibergen-Paap rk LM statistic	111.691	111.902
P-value	0.0000	0.0000
Cragg-Donald Wald F statistic	1800.805	693.179
Hansen J statistic	1.659	3.176
P-value	0.1978	0.2043
Observations	2,072	2,072
R-squared	0.330	0.371

PANEL B: Heckman Selection Model

energy_efficiency	0.0950**	0.1049***
	(0.0404)	(0.0401)
analysts_coverage		0.6747***
		(0.061)
energy_efficiency X analysts_coverage		0.1659**
		(0.0745)
Inverse Mills Ratio	-0.1993*	-0.1767*
	(0.1055)	(0.1025)
Constant	6.7494***	10.1027***
	(1.1443)	(1.1019)
Controls	Yes	Yes
Year effects	Yes	Yes
Industry effects	Yes	Yes
Industry X year effects	Yes	Yes
Observations	5,376	5,374

Table V reports IV-2SLS regression and Heckman sample selection models for testing endogeneity. Model 1 shows second-stage results for baseline model (1) examining an association between energy efficiency and firm value. Similarly, Model 2 shows second stage results for baseline model (2) that examines the effect of analysts' coverage on the association between energy efficiency and firm value. Please refer to Table I for variable descriptions. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table VI The effects of internal and external sustainability risks

	(1)	(2)
	model1	model2
VARIABLES	firm_value	firm_value
energy_efficiency	0.1063***	0.0478
	(0.0311)	(0.0335)
analysts_coverage	0.6549***	0.6329***
	(0.0707)	(0.0706)
ESGRepRisk	0.1399***	
	(0.0503)	
ClimateRisk		0.0001
		(0.0409)
energy_efficiency X analysts_coverage	0.0562	0.0562
	(0.0588)	(0.0565)
energy_efficiency X analysts_coverage X ESGRepRisk	0.3358***	
	(0.1176)	
energy_efficiency X analysts_coverage X ClimateRisk		0.5183***
		(0.1969)
Constant	10.1617***	9.5206***
	(0.7142)	(0.6634)
Controls	Yes	Yes
Year effects	Yes	Yes
Industry effects	Yes	Yes
Industry X year effects	Yes	Yes
Observations	2,192	2,192
R-squared	0.513	0.511

Table VI reports results accounting the effect of internal and external sustainability risks, ESG reputational risks and Climate risk on the Model 1 and 2, respectively. ESGRepRisk is the dummy indicating one if the firm has above-sample-average ESG reputation risks in a given year. ClimateRisk is the dummy indicating one if the firm is located at state where the annual mean temperature is above state average in a given year. Please refer to Table I for variable descriptions. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Endnotes

1 Energy efficiency in a traditional sense, refers to the level of energy intensity, which is a measure of the output produced per unit of energy. The definition follows that as energy intensity decreases, energy efficiency improves, demonstrating an inverse relationship between energy intensity and energy efficiency. Since energy efficiency is related to the efficient use of energy, it contributes to reduced energy consumption for a given level of output.

2 According to IEA, energy is responsible for about 80% of global carbon emissions, and energy efficiency improvements will contribute to more than 40% of the reduction of energy-related greenhouse gas emission over the next 20 years. See, https://www.weforum.org/agenda/2022/01/iea-energy-efficiency-worlds-first-fuel-net-zero/

3 US energy consumption data by sector shows that the transportation and industrial sectors used more than two-thirds of energy in 2021. See, https://www.eia.gov/energyexplained/us-energy-facts/

4 For more information on the Refinitiv data, see https://www.refinitiv.com/en/sustainable-finance/esg-scores#:~:text=The%20Refinitiv%20ESG%20score%20measures,company%20assessment%20and%20scoring%20process.

5 It is assumed that environmentally responsible firms should have a positive environmental score, and they should disclose whether they have energy related policies and targets. Alternatively, it can be said that the database should include firms more subject to public exposure, so missing data is unlikely.

6 The energy use data at the Refinitiv ASSET4 database is substantially missing. It could be due to under-reporting by firms, especially in the last decade when there were no or few reporting regulations and less environmental concerns. However, the study also considered observations without energy data, employing the Heckman sample selection model. The model accounted for 557 firms with 5,376 firm-year observations. The omission of the rest of the firms and observations is due to the reasons stated above, for example, missing data for other variables used in the study.

7 According to the US Department of Energy, the difference between energy efficiency and intensity is insignificant for a specific technology - one is simply the inverse of the other. The decline in energy intensity can be taken as a proxy for efficiency improvements. See, https://www.energy.gov/eere/analysis/energy-efficiency-vs-energy-intensity#:~:text=Efficiency%20and%20Intensity%20at%20the,melt%20one%20ton%20of%20steel.

8 The model uses mean-adjusted interaction variables.

9 US states have varying energy and carbon related policies implemented at different periods of time. Some states such as California, Massachusetts, New York, Vermont, Maine, among others are more proactive and have energy efficiency policies and programs to save energy, advance equity, and produce environmental and economic benefits. Thus, firms in those states are likely to have more energy efficient performance than others. Thus, the current instrument- local (state) level energy intensity can take this into account. See, energy efficiency score for the US States https://www.aceee.org/state-policy/scorecard

10 The sample split considers the industry-average analysts' coverage and industry-average analysts' recommendation counts, indicating one for above-industry average, and zero otherwise. The results are qualitatively similar if the natural logarithm of the total number of analysts' recommendation counts is used as the moderator in the interaction model.

11 Results are in line with the study hypotheses if the independent variable is replaced by the ratio of total energy to total employees, total energy to total assets, or the logarithm of total energy use.

[12] Firms' ESG risk is measured using the RepRisk Index developed by RepRisk database that captures and quantifies a firm's reputational risk exposure to ESG issues. States' climate risk is measured using the historical record of the annual mean temperature in each US state, available from WorldBank.

[13] The results are consistent if the study splits the sample based on both binary variables.

[14] Eurostat at the European Union believes that improvements in energy efficiency and energy mix are important forces for reducing total greenhouse gas emissions. See, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Climate_change_-_driving_forces