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MANAGERIAL RISK-TAKING AND THE ADOPTION OF ENERGY EFFICIENCY POLICY: IMPLICATIONS ON RESOURCE AVAILABILITY

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ABSTRACT

The principal-agent contract motivates managers to take risks to increase shareholders' returns. A key issue is whether managerial risk-taking decisions are made at the cost of sustainable practices, particularly in relation to environmental protection, which may conflict with profit-seeking activities. This study examines the impact of managerial risk-taking on firms' energy efficiency practices using a sample of 36 countries from 2006 to 2019. We further investigate how firm size, as a tangible resource, and board size, as an intangible resource, moderate this relationship. Our findings suggest that, although managers take risks to seek higher profitability from investments that may not align with environmental sustainability, intangible resources such as board size can help bridge the gap between profitability and sustainability. However, tangible resources may shift firms' focus away from sustainable practices, directing attention toward profitable investments that might not be environmentally friendly. In practice, this study highlights the importance of corporate governance, particularly board composition, which plays a key role in contributing to corporate sustainability.

Keywords: Risk-Taking, energy efficiency, resources, board size, firm size.

INTRODUCTION

With zero-carbon policies becoming a key focus in international discussions, the growing global concern over climate change and its impact on the environment has led to calls for urgent action to reduce harmful practices and cut greenhouse gas emissions (Fankhauser et al., 2021). Although the

government has the potential to play a significant role by setting sustainability practice standards to drive social development (Khin, 2020), there is a lack of government initiatives to improve corporate environmental responsibility specifically. As a result, greenwashing is detected, as seen in cases such as Volkswagen and Walmart, which falsely reported their environmental responsibilities (Davison, 2024). A problem statement is that firms pursuing profitable investments may have to go against environmental protection, and this could be due to financial and non-financial constraints (Salas et al., 2018) in order to satisfy all stakeholders.

The world today is increasingly focused on sustainability, and ESG scoring has become an important metric for evaluating ethical and responsible practices among corporations (Peterdy, 2024). Among the three pillars of ESG, the social and governance components have been the primary focus in the literature over the past decades, reflecting corporate social responsibility (CSR) and corporate governance. However, recent studies have begun to emphasise corporate environmental responsibility, with energy usage being a key topic in discussions surrounding climate change. Therefore, this study focuses on the adoption of energy efficiency policies among publicly listed firms. The decision to adopt such policies is linked to their carbon emissions, resource conservation, and the reduction of environmentally hazardous activities.

Corporations face a dilemma in balancing decisions between profitability and sustainability (Ooi et al., 2024). This is supported by the literature, which suggests that firms allocating resources to profitable projects may be less able to commit to sustainability practices (Younas & Zafar, 2019; Pradhan & Nibedita, 2019; Budiyono & Maryam, 2017). However, rather than considering overall ESG scores, which may be tactically adjusted (see Lee et al., 2023), there is a research gap in explaining whether managerial risk-taking to secure short-term profits discourages firms from adopting energy efficiency policies. The rationale behind this research gap is that managerial risk-taking often leads to investments in profitable projects that may not be environmentally friendly. Limiting investment scope to energy-efficient practices could increase the opportunity cost of investment. However, the literature lacks evidence to verify this, which is crucial for informing future policy implications.

The decision to take managerial risks and adopt energy efficiency policies can be explained by two main theories in this study, namely the agency theory and stakeholder theory. Based on the agency theory perspective posits that managers tend to prioritise short-term profitability to secure immediate bonuses and incentives. The argument aligns with the empirical findings of Gerged (2021), which demonstrate the negative impact of ownership on environmental disclosure. This is because investment in energy efficiency typically harms short-term shareholder profits (Wiseman & Gomez-Mejia, 1998), resulting in a negative impact on the managers. Oppositely, the stakeholder theory, however, aligns with the real options theory, which views corporate social responsibility (CSR) as a means of acquiring intangible resources to enhance the success of a firm's investments (Trigeorgis & Tsekrekos, 2018), such as increasing the accessibility to sustainability funding (Bouton et al., 2010), and enhancing the firm's reputation (Zhang & Ouyang, 2021).

Therefore, managers may determine the adoption of energy-efficient practices based on the firm's resource availability. This includes financial capital, technological infrastructure, and human resources essential for executing energy-saving projects. The idea of resource availability in this study is supported by resource scarcity theory, which suggests that limited resources available to individuals or groups, under certain circumstances, may lead to strategic behaviour, competition, or conflict in utilising the resources (Castrogiovanni et al., 2006). The theory basically explains that in a condition

where resources are limited, their availability becomes a potential determinant of economic productivity and survival.

Resource scarcity theory offers a framework for comprehending how scarce resources affect their availability, as well as the broader implications for social and environmental systems. Moreover, resource scarcity in firms may affect managers' decisions to allocate resources based on priority. However, firms with substantial resources are likely more capable of investing in energy-efficient technologies, while those with constrained resources may prioritise immediate, profitable initiatives over sustainability objectives. With that, this study further examines both types of resources, with pecuniary resources represented by firm size and non-pecuniary resources represented by board size, in moderating the relationship between managerial risk-taking and the adoption of energy efficiency policies.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

The classical agency theory suggests managers should take risks to maximise shareholder value (Holmström, 1979; Jensen & Murphy, 1990). In the principal-agent contract, managerial risk-taking should be rewarded. However, this has given rise to the next agency issue, where managers take risks at the expense of shareholder value without proper strategic planning. This is driven by the desire to gain benefit from the compensation scheme associated with their risk-taking (Dong et al., 2010). Another prominent theory related to managerial risk-taking is the prospect theory, which posits that managers unreluctantly take risks after assessing their own security, particularly considering the consequences of their risk-taking actions in the event of failure.

Managerial risk-taking often occurs when a firm finds no other viable alternatives. To enhance the chances of success in risk-taking endeavours, managers typically align their risk-taking with a set of follow-up strategies (Bromiley, 1991; Palmer & Wiseman, 1999). Therefore, risk-taking indicators often encompass a wide range of decisions related to strategic choices, including R&D spending, diversification, acquisitions, divestitures, and competitive actions (Hoskisson et al., 2017).

Literature has shown that managerial decisions are relevant to a firm's energy efficiency. However, the impact of managers' decisions on energy-efficient practices has been inconsistent in terms of firm performance. On one hand, Pons et al. (2013) find that energy intensity does not have a significant impact on firms' economic performance. On the other hand, Fan et al. (2017) find that energy efficiency significantly improves financial performance. Similarly, climate-friendly management practices have been shown to positively affect firm performance (Martin et al., 2012). Another strand of studies highlights the managerial fixed effects in pro-environmental practices, such as managers' awareness and sensitivity to environmental issues (Kostka et al., 2013), ambition (Rohdin et al., 2007), and commitment (Chiaroni et al., 2016).

In addition to examining the behavioural aspects of managers, one less-explored strand of studies in the literature sheds light on the resource allocation associated with managerial risk-taking. This area of research is related to measuring the probability of undertaking a risky project with allocated resources and how that probability changes as resource allocation increases (Henderson & Cockburn, 1996). Bromiley (2009) demonstrates that the probability of success increases with the availability of resources. However, the increased resource availability reduces the proportion of resources allocated to risky projects. This occurs because higher resources elevate the operational reference point, leading to

a shift in outcomes from positive to negative due to the diminishing effect of additional resources on the probability of success. Consequently, additional resources should be allocated to safe rather than risky projects.

Hile resource allocation strategy has been revealed, previous studies have rarely focused on the availability of resources for firms to engage in risk-taking while simultaneously adopting sustainability practices. A study by Drempetic et al. (2020) has shown a positive correlation between firm size and ESG scores, arguing that larger firm size generates more resources for ESG practices.

Ooi et al. (2024) show that managerial risk-taking leads to a reduction in ESG practices. This could be due to potential resource limitations to adopting sustainability practices, such as the need to pay for high upfront costs and limited access to capital (Fleiter et al., 2012). Thollander et al. (2013) highlight that financial challenges are the most significant factors slowing the shift toward energy-efficient technologies, including energy taxes, rising energy prices, and the limited availability of loans or subsidies for energy efficiency investments.

Based on the agency perspective, managers may prioritise financial stability over sustainability initiatives (Younas & Zafar, 2019). This is evidenced by the U.S. and German samples, which conclude that managerial risk-taking is negatively associated with the firm's intention to engage in sustainability initiatives (Younas & Zafar, 2018). The negative impact of managerial risk-taking on the firms' sustainability, including the adoption of energy-efficiency practices, is primarily because such risk-taking creates pressure on the firms to prioritise monetary gains for shareholders at the expense of other stakeholders' interests (John et al., 2010). Therefore, we postulate that managers tend to take risks in profitable investments that may not align with energy efficiency principles.

> *Hypothesis 1: There is a significant negative effect of managerial risk-taking on the adoption of energy efficiency policy.*

Firm Size, Managerial Risk-Taking and Energy Efficiency

Literature has revealed that firm characteristics, such as the number of employees and earnings per share, can influence a firm's decision-making (DeCanio & Watkins, 1998). With regards to the decision of managerial risk-taking, firm size, which is a direct proxy of firm resources (Barney, 1991; Drempetic et al., 2020), is found to be a significant driver (Ng et al., 2013; Bhagat et al., 2015). This could be because of firm size concerning information disclosure, whereby larger firms disclose more information (Hou & Reber, 2011; Hahn & Kühnen, 2013) because they have greater resources to disclose, and this is a reason larger firms contribute to higher ESG scores (Drempetic et al., 2020).

When it comes to decisions regarding environmental responsibility, the literature indicates that large firms and SMEs respond differently in terms of their CSR engagement (Russo & Perrini, 2010). Smaller firms tend to adopt fewer proactive environmental practices relative to their larger counterparts (Darnall et al., 2010). This is because larger firms can access greater resources, which enables them to voluntarily engage in sustainability initiatives such as CSR (Lewis, 2003) to gain additional long-term benefits that create a positive reputation (Gardberg & Fombrun, 2006).

Another strand of studies shows a significant positive relationship between firm size and managerial compensation (Kroll et al., 1990; Ryan & Wiggins, 2002). This could be due to larger-sized firms participating in higher risk-taking decisions, increasing executive compensation for managerial risk-

taking (Luo et al., 2023). A group of studies shed light on the significant relationship between firm size and risk-taking, for example, the positive link between the insurance firm size and underwriting risk (Ng et al., 2013). The positive link between firm size and risk-taking could be explained by the too-big-to-fail (TBTF) theory (Zhou, 2009). A similar concept is applied in a banking sample where larger banks operate in small capital but are involved in riskier strategies to exploit diversification advantages (Lee, 2008).

Also, larger firms are more aware of sustainability issues, such as CSR engagement (Baumann-Pauly et al., 2013). There is evidence in the literature indicating the positive relationship between firm size and CSR expenditure (e.g., Chauhan, 2014) because they are more capable and knowledgeable in managing sustainability practices, such as the environmental management system (Horisch et al., 2014). Therefore, larger firms usually possess strength in financing and have greater human capital, so it should be more convenient for them to engage in sustainability practices (Gallo & Christensen, 2011).

In the context of energy efficiency adoption, large firms generally use fuel and electricity more efficiently than smaller firms (Zhang, 2016). Similarly, based on the Community Innovation Survey for the period 2008–2011, firm size is related to energy efficiency innovation (Costa-Campi et al., 2015). Therefore, we hypothesise that larger firms have more resources to enable managers to strategise profitable projects while adopting energy efficiency policies to ensure long-term value creation.

> *Hypothesis 2: There is a significant positive moderating effect of firm size on the relationship between managerial risk-taking and the adoption of energy efficiency policy.*

Board Size, Managerial Risk-Taking and Energy Efficiency

Literature has shown empirical evidence regarding the relationship between board size and risk-taking behaviour. In the context of risk-taking, there is a study that finds that smaller boards are related to lower levels of leverage but risker investment, and they are positively related to overall future risk (Wang, 2012; Huang & Wang, 2015). The findings indicate that smaller boards tend to take riskier investment paths with limited resources to compete for a larger market share. Instead, larger boards exhibit lower return volatility and bankruptcy risk (Nakano & Nguyen, 2012). In summary, the literature gives a notion that a larger board size exhibits less risk-taking compared to a smaller board size. In general, low individualism or strong group cohesion is related to low risk-taking (Li et al., 2013; Mihet, 2013). This may be because larger boards offer better diversity, task distribution, and increased stakeholder participation (Cheng & Courtenay, 2006), thereby providing firms with sufficient resources to achieve their goals without resorting to risk-taking.

Another strand of studies shows that a larger board size leads to greater information disclosure (Upadhyay & Sriram, 2011), including environmental accounting information disclosure (Agyemang et al., 2020; Rabi, 2021; Kumari et al., 2022). This could be due to larger firms possessing greater resources shared with larger boards for providing more data for disclosure. Those results also support the findings of a positive relationship between board size and ESG performance (Aksoy et al., 2020; Husted & de Sousa-Filho, 2019). One of the reasons is that a larger board is usually associated with establishing a sustainability committee (Kumari et al., 2022) to strategise the available resources for sustainability investment and firm value improvement.

Furthermore, Atif et al. (2021) explore the impact of corporate governance (CG) attributes on renewable energy usage. By analysing a dataset of 11,677 firm-year observations from U.S. firms between 2008

and 2016, they find a positive link between board size and renewable energy usage. The result provides robust support for the hypothesis that CG attributes, particularly board size, play a potential role in promoting energy efficiency adoption. Boards with more members may have broader networks, allowing firms to leverage external partnerships and funding to support energy efficiency projects.

In summary, the literature gives a notion that a larger board size significantly reduces risk-taking while increasing sustainability engagement. Based on the findings, this study postulates that a larger board size contributes better resources and alternatives for the firms to achieve their goals with less risk-taking while being able to cater to human capital and social capital to assist the firms in engaging in sustainability practices, especially in the adoption of energy efficiency practices.

Hypothesis 3: There is a significant positive moderating effect of board size on the relationship between managerial risk-taking and the adoption of energy efficiency policy.

METHODOLOGY

The sample of this study includes publicly listed firms from 23 developed countries (Australia, Austria, Belgium, Canada, Denmark, Singapore, Finland, France, Germany, Hong Kong, Israel, Italy, Japan, Korea, Netherlands, Norway, New Zealand, Portugal, Sweden, Switzerland, the United States of America, and the United Kingdom) and 13 developing countries (Brazil, China, Egypt, Hungary, India, Indonesia, Malaysia, Philippines, Poland, Russia, South Africa, Taiwan, Thailand, Turkey). The sample period in this study begins from 2006 to 2019, aligning with the data availability in ASSET4ESG, which covers the majority of the sample. The sample size is limited by the data availability of ASSET4ESG for extracting data on energy efficiency policy and corporate governance. The other financial data are extracted from Worldscope in Datastream.

Logit regression is used for the dependent variable that is scaled using binomial data. The dependent binomial variable captures whether the firm has adopted an energy efficiency policy ($EnergyPolicy_{it}$), which is obtained from the survey by ASSET4ESG. It is defined as one if the firm *i* at year *t* adopts the energy efficiency policy. Otherwise, it is zero. The main independent variable is managerial risk-taking, which is represented by research and development-to-sales ($RiskTaking^{R\&D/Sales}{}_{it}$) and total debt-to-total asset or leverage ($RiskTaking^{Debt/Asset}{}_{it}$). These two proxies are commonly used in the literature on risk-taking, for example, Wang (2012). Also, R&D as the proxy of risk-taking is similarly adopted in Santacruz (2020) and AlHares et al. (2020). Additionally, leverage is one of the direct measures of risk-taking mentioned in Bhagat et al. (2015). R&D expenditure can represent a higher level of risk-taking than capital expenditure (Bhagat & Welch, 1995). Therefore, the two proxies of managerial risk-taking used in this study, one represented by $RiskTaking^{R\&D/Sales}{}_{it}$, indicates a high level of risk-taking, and another one, represented by $RiskTaking^{R\&D/Sales}{}_{it}$, indicates a lower level of risk-taking (Wang, 2012). Both measures of risk-taking directly reflect managerial decisions, and we argue that these proxies should be more representative of managerial risk-taking compared to measuring the performance outcome volatility as a proxy of managerial risk-taking. In addition, the generalised method of moments (GMM) approach is used to address challenges related to endogeneity and dynamic panel data models.

Equation 1 is developed to examine the relationship between managerial risk-taking and the adoption of energy efficiency policy. Following recent studies of Dao and Phan (2023), Das et al. (2023), Ooi and Hooy (2022), and Abu-Abbas et al. (2019), this study controls the effects of firm size ($FirmSize_{it}$, measured by the natural logarithm of total assets), PPE to total sales ($PPE\text{-}to\text{-}Sales_{it}$, measured by the

ratio of total PPE to total sales of firm *i* at year *t*), return on asset ($ROA_{it,}$ measured by net income divided by total assets of firm *i* at year *t*). We expect the impacts of the firm's fundamental variables. Also, we control the impact of the financial crisis, $DCrisis_{it}$, measured by a binomial variable indicating one for the year of the financial crisis, i.e., 2008 and 2009. Otherwise, it is zero.

Besides, we control the corporate governance variables, including CEO duality ($CEODuality_{it,}$ which is a binomial variable indicating one for the CEO taking the chairmanship of the board of directors of firm *i* at year *t*; otherwise, it is zero), board size ($BoardSize_{it}$, measured by the natural logarithm of a total number of board of directors of firm *i* at year *t*), independent board ($IndepBoard_{it}$, measured by the ratio of independent directors and total number of the board of directors of firm *i* at year *t*).

The $Risk\text{-}Taking_{it}$ in equation 1 would be the R&D-to-sales ($RiskTaking^{R\&D\text{-}to\text{-}Sales}{}_{it}$) and total debt over the total asset, or leverage ($RiskTaking^{Debt\text{-}to\text{-}Asset}{}_{it}$). Based on Equation 1, we expect the effects of both managerial risk-taking measures to be negative, consistent with hypothesis 1 of this study. However, as we learn from the literature that R&D expenditure is considered a higher level of managerial risk-taking, we posit that the impact of $RiskTaking^{R\&D\text{-}to\text{-}Sales}{}_{it}$ should receive a higher positive effect than $\text{RiskTaking}^{\text{Debt-}to\text{-}Asset}{}_{it}$.

$$EnergyPolicy_{it} = \alpha_{it} + Xs_{it} + Risk\text{-}Taking_{it} + \varepsilon_{it} \qquad (1)$$

Equation 2 is extended by incorporating an interaction term for further verifying the moderating effect of firm size and board size toward the relationship between $Risk\text{-}Taking_{it}$ and $EnergyPolicy_{it.}$ Firm size represents the tangible resources, and board size represents the intangible resources (such as human capital and social capital). Therefore, we have two interaction terms, namely $RiskTaking^{Debt\text{-}to\text{-}Asset}{}_{it}$ x $FirmSize_{it}$ and $RiskTaking^{R\&D\text{-}to\text{-}Sales}{}_{it}$ x $BoardSize_{it}$, to be incorporated separately in equation 2. We expect the effects of both interaction terms to be positive, based on hypotheses 2 and 3 of this study.

$$EnergyPolicy_{it} = \alpha_{it} + Xs_{it} + Risk\text{-}Taking_{it} + Interaction_{it} + \varepsilon_{it} \qquad (2)$$

RESULTS AND DISCUSSION

Our firm-level sample consists of 36 countries from developed and developing markets. Table 1 presents the distribution of $EnergyPolicy_{it}$ by countries. The distribution indicates that there are six developed countries (Austria, Denmark, Finland, France, Germany, and Portugal), and only three developing countries (Thailand, India, and South Africa) exhibit 80 per cent of the sample mean of $EnergyPolicy_{it}$ above 80 per cent. Among the developed countries, Israel exhibits the lowest average of $EnergyPolicy_{it}$, i.e., 36 per cent. However, among the developing countries, Egypt exhibits the lowest $EnergyPolicy_{it}$, 32 per cent. The majority of the countries have at least 50 per cent of the firms in our sample that adopt the energy efficiency policy.

Table 1

Energy Efficiency Policy Adoption, period 2006-2019 (by Country)

No.	Country	Percentage	No.	Country	Percentage
1	India	96	19	Brazil	71
2	Austria	92	20	China	71
3	France	88	21	Sweden	70
4	Portugal	86	22	South Korea	69
5	Finland	84	23	Indonesia	69
6	Germany	84	24	Philippines	69
7	Thailand	84	25	Taiwan	69
8	South Africa	83	26	Hong Kong	67
9	Denmark	81	27	Singapore	64
10	Belgium	79	28	Norway	62
11	Netherlands	79	29	Hungary	61
12	Turkey	78	30	Poland	59
13	UK	77	31	USA	54
14	Italy	76	32	Australia	51
15	Malaysia	76	33	New Zealand	50
16	Russia	73	34	Canada	46
17	Switzerland	72	35	Israel	36
18	Japan	71	36	Egypt	32

The percentage of firms that have adopted energy efficiency policy over the sample period is visualised in Figure 1. Prior to 2008, the percentage increased exponentially, and then it grew slowly from 2009 (63.9%) to 2019 (77.2%). The slow growth of firms adopting energy efficiency policies indicates a worrisome situation for corporate environmental responsibility.

Figure 1

Adoption of Energy Efficiency Policy by Years

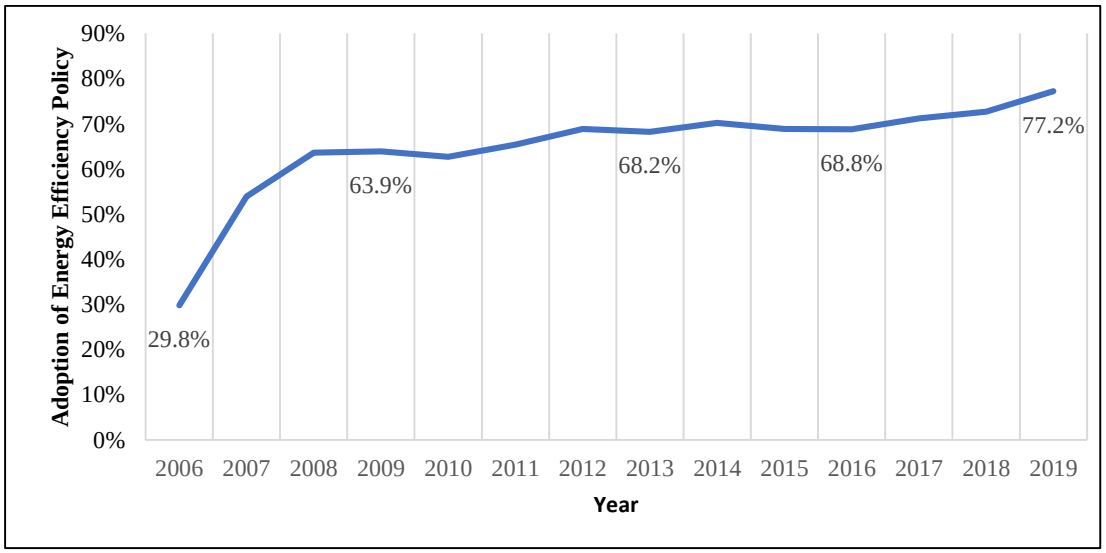


Table 2 presents the *t*-tests to compare whether there is a significant difference in managerial risk-taking between firms that adopt the energy efficiency policy and those that do not. For the group of firms adopting energy efficiency policy ($EnergyPolicy_{it} = 1$), their average $RiskTaking^{R\&D\text{-}to\text{-}Sales}_{it}$ is lower than the counterparts by 0.0388, and the difference is statistically significant at 1 per cent. This indicates that managerial risk-taking matters for firms that adopt the energy efficiency policy compared to those that do not. However, for the same group of the sample, the firms exhibit higher $RiskTaking^{Debt\text{-}to\text{-}Asset}_{it}$ compared to the counterparts in 0.0516, and the difference is significant. In sum, based on the result of Table 2, firms that adopt energy efficiency policies have lower risk-taking in decisions related to R&D, while they make riskier decisions in debt financing.

Table 2

t-Test on Managerial Risk-taking by Energy Efficiency Policy

	$RiskTaking^{R\&D\text{-}to\text{-}Sales}$		$RiskTaking^{Debt\text{-}to\text{-}Asset}$	
	Obs.	Mean	Obs.	Mean
$EnergyPolicy_{it} = 0$	15,753	0.6974	17,368	0.6495
$EnergyPolicy_{it} = 1$	19,736	0.6586	18,121	0.7011
Total	35,489		35,489	
Differences		0.0388		-0.0516
p-value		(0.0000)		(0.0000)

Notes. $EnergyPolicy_{it}$ is a dummy variable which is equal to one if the firm *I* has adopted an energy efficiency policy at year *t*, otherwise zero.

Table 3 presents the descriptive statistics of the variables. The energy efficiency represented by $EnergyPolicy_{it}$ has a mean value of 0.68, along with a value of its standard deviation of 0.47. This indicates that 68 per cent of the total observations have adopted an energy efficiency policy. For managerial risk-taking, the first proxy is the $RiskTaking^{R\&D\text{-}to\text{-}Sales}_{it}$, which has a mean of 0.99 and a standard deviation of 1.10. The variable has a minimum of zero because one of the sample observations does not have any R&D expenditure. The highest value of the variable is 12.91, which is far from the mean. It shows a diversified data distribution of our sample for generating a robust inference. The second proxy of managerial risk-taking, $RiskTaking^{Debt\text{-}to\text{-}Asset}_{it}$, has a mean of 0.18. Also, the variable has a minimum of zero because one of the sample observations does not take debt as its source of financing.

The other firm fundamental variables, such as $FirmSize_{it}$, have a mean value of 14.59, and their standard deviation shows a value of 2.03. The smallest value of the $FirmSize_{it}$ is 0.69. Besides, the average of ROA_{it} is 0.05, compared with the maximum of 0.44. This indicates that the majority of the firm performance is low, and only a small group of the sample exhibits outstanding performance. The average liquidity of the sample falls around 2.05, with a standard deviation of 2.22.

For corporate governance, $CEODuality_{it}$ has a value of the mean of 0.39, indicating that about 39 per cent of the total observations exhibit CEO duality, where the percentage is consistent with the literature (e.g. Nguyen and Nguyen, 2023). Besides, $BoardSize_{it}$ has a mean value of 10.44, and the minimum and maximum values are 0.01 and 0.35, respectively. In addition, the $IndepBoard_{it}$ has a mean value of 56.17, which indicates that the majority of the firms in the sample have adopted more than 50 per cent of the independent board of directors.

Table 3

Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
$EnergyPolicy_{it}$	0.68	0.47	0.00	1.00
$RiskTaking^{R\&D\text{-}to\text{-}Sales}{}_{it}$	0.18	1.10	0.00	12.91
$RiskTaking^{Debt\text{-}to\text{-}Asset}{}_{it}$	0.99	0.66	0.00	3.50
$FirmSize_{it}$	14.59	2.03	0.69	23.80
$PPE\text{-}to\text{-}Sales_{it}$	0.81	1.77	0.00	15.88
ROA_{it}	0.05	0.12	-0.77	0.44
$CurrentRatio_{it}$	2.05	2.22	0.20	20.50
$DCrisis_{it}$	0.14	0.35	0.00	1.00
$CEODuality_{it}$	0.82	0.39	0.00	1.00
$BoardSize_{it}$	0.10	0.04	0.01	0.35
$IndepBoard_{it}$	0.56	0.27	0.00	1.00

Table 4 presents the results of the correlation analysis. The coefficients of correlation among the variables are fairly low, with an average of below 0.5. The correlation between $FirmSize_{it}$ and $RiskTaking^{R\&D\text{-}to\text{-}Sales}{}_{it}$ is negative, at -0.03, but the correlation between $FirmSize_{it}$ and $RiskTaking^{Debt\text{-}to\text{-}Asset}{}_{it}$ is positive, at 0.08. This may give a notion that larger-sized firms tend to take more risks through greater debt financing while they are less participating in R&D. Consistently, Luo et al. (2023) have discovered that firm size is positively associated with corporate risk-taking. Instead, smaller firms tend to make riskier decisions in R&D. We observe that both measures of managerial risk-taking show a negative correlation with ROA_{it}, which gives an interesting point of view by suggesting that firms with better performance take lower risk. The correlation result aligns with the principle of managerial risk-taking, where poor-performing firms have no alternative but to take risks to achieve higher. In addition, the researcher also ran a multicollinearity test based on the Variance Inflation Factors (VIFs), and found that the VIFs of all variables are less than 10.

Table 4

Correlation Analysis

	1	2	3	4	5	6	7	8	9	10	11
$EnergyPolicy_{it}$	1.00										
$FirmSize_{it}$	0.34	1.00									
$PPE\text{-}to\text{-}Sales_{it}$	-0.03	0.10	1.00								
ROA_{it}	0.11	0.03	-0.15	1.00							
$CurrentRatio_{it}$	-0.20	-0.29	0.03	-0.03	1.00						
$DCrisis_{it}$	-0.04	0.04	0.01	0.00	-0.03	1.00					
$CEODuality_{it}$	-0.12	0.07	0.05	-0.01	0.07	0.02	1.00				
$BoardSize_{it}$	0.22	0.41	0.02	-0.01	-0.19	0.01	0.03	1.00			
$IndepBoard_{it}$	-0.03	0.10	-0.05	0.08	0.04	0.02	-0.07	-0.26	1.00		
$RiskTaking^{R\&D\text{-}to\text{-}Sales}{}_{it}$	-0.13	-0.16	0.13	-0.39	0.28	-0.02	0.02	-0.08	0.05	1.00	
$RiskTaking^{Debt\text{-}to\text{-}Asset}{}_{it}$	0.05	0.13	0.04	-0.14	-0.25	-0.02	0.03	0.02	0.04	-0.04	1.00

Table 5 presents the results of logit regression and GMM as the alternative analysis for examining the impact of managerial risk-taking on energy efficiency policy adoption. According to the logit regression results, the effects of the control variables are consistently significant. For example, $FirmSize_{it}$ shows a significant positive effect on $EnergyPolicy_{it}$ (coeff = 1.7090, p-value = 0.0000; coeff = 1.4480; p-value = 0.0000). The significant positive effects are also found in ROA_{it} and $DCrisis_{it}$. However, $CurrentRatio_{it}$ shows a significant negative effect on $EnergyPolicy_{it}$ (coeff = -0.1725, p-value = 0.0051; coeff = -0.1616, p-value = 0.0001). Only the effect of $PPE\text{-}to\text{-}Sales_{it}$ is not consistent across the two regressions, where one shows a significant positive effect (coeff = 0.1745, p-value = 0.0466) and another one shows a significant negative effect (coeff = -0.1747, p-value = 0.0035).

For the corporate governance variables, the effect of $CEODuality_{it}$ is not significantly related to $EnergyPolicy_{it}$. $BoardSize_{it}$ shows a significant negative effect on $EnergyPolicy_{it}$ (coeff = 0.0550, p-value = 0.0100), but the significant effect is only shown in the result of column 2. The result suggests that larger boards lead to a reduction in the adoption of energy efficiency policies. This is supported by the literature, which suggests that larger boards often face communication challenges in reaching a consensus. This is especially relevant in decisions related to energy efficiency investments because such decisions involve short-term profits against long-term value, which can create conflicting goals for shareholders. Instead, a high number of $IndepBoard_{it}$ tends to promote energy efficiency policy, as shown by a positive effect on $EnergyPolicy_{it}$. This is aligned with the findings of Ramly and Nordin (2018) and Younas et al. (2019), who shed light on the role of independent directors in monitoring managers from taking unhealthy, risky investments for the purpose of gaining risk-taking incentives. The role of independent directors in promoting energy efficiency policy adoption is consistent with their responsibility to promote sustainability for long-term value.

The two proxies of managerial risk-taking, which are $RiskTaking^{R\&D\text{-}to\text{-}Sales}{}_{it}$ and $RiskTaking^{Debt\text{-}to\text{-}Asset}{}_{it}$, respectively, show a significant negative impact on $EnergyPolicy_{it}$ (coeff = -1.0215, p-value = 0.0000; coeff = -0.2792, p-value = 0.0000, respectively) on energy policy. The results indicate that increasing managerial risk-taking leads to a decrease in the adoption of energy efficiency policy. The results suggest to us that hypothesis 1 is accepted. Our results are supported by Pradhan and Nibedita (2019), Budiyono and Maryam (2017), and Dyduch and Krasodomska (2017) because they show that firms taking high leverage would pay attention to monitoring their capital while reducing unrelated costs. The managers involved in risk-taking may prioritise immediate financial benefits (Dalci, 2018), probably for reporting purposes, to increase the confidence of the shareholders. In general, resource scarcity forces firms to choose a narrow range of investments that fit their goals the most at the expense of the other stakeholders' welfare. Even Gerged (2021) demonstrates that ownership is negatively related to corporate environmental disclosure; therefore, this study suggests that some shareholders prioritise short-term profits over long-term sustainability, and managers face shareholders' pressure in their decision-making (Wiseman & Gomez-Mejia, 1998).

Table 5

Managerial Risk-Taking Effect on Energy Efficiency Policy

	Logit Regression		GMM	
	(1)	(2)	(3)	(4)
$FirmSize_{it}$	1.7090***	1.4480***	0.0022***	0.0025***
	(0.0000)	(0.0000)	(0.0099)	(0.0011)
$PPE\text{-}to\text{-}Sales_{it}$	0.1745**	-0.1747***	-0.0014	-0.0040***
	(0.0466)	(0.0035)	(0.6751)	(0.0032)
ROA_{it}	0.0268***	0.0198***	0.0011***	0.0010***
	(0.0009)	(0.0003)	(0.0001)	(0.0000)
$CurrentRatio_{it}$	-0.1725***	-0.1616***	-0.0076***	-0.0057***
	(0.0051)	(0.0001)	(0.0000)	(0.0000)
$DCrisis_{it}$	4.5815***	4.6846***	-0.0174**	-0.0083
	(0.0000)	(0.0000)	(0.0355)	(0.2291)
$CEODuality_{it}$	-0.2274	0.0690	-0.0039	-0.0053
	(0.5132)	(0.7518)	(0.3966)	(0.1943)
$BoardSize_{it}$	0.0373	0.0550***	0.0013**	0.0012**
	(0.2360)	(0.0100)	(0.0340)	(0.0162)
$IndepBoard_{it}$	-0.0154***	-0.0038	0.0001	0.0001*
	(0.0021)	(0.2386)	(0.4994)	(0.0853)
$RiskTaking^{R\&D\text{-}to\text{-}Sales}{}_{it}$	-0.6577**		-0.0042**	
	(0.0264)		(0.0403)	
$RiskTaking^{Debt\text{-}to\text{-}Asset}{}_{it}$		-0.2187**		0.0058
		(0.0274)		(0.9437)
Constant	3.0928***	2.9711***	0.1555***	0.1341***
	(0.0000)	(0.0000)	0.0000	(0.0000)
Year Effect	Yes	Yes	Yes	Yes
Country Effect	Yes	Yes	Yes	Yes
Industry Effect	Yes	Yes		
Pseudo-R^2	0.1631	0.1210		
AR(1)			0.000	0.000
AR(2)			0.925	0.073
Hansen Test			0.752	0.775
Obs.	12,701	23,382	13,459	24,390

*Note*s. The dependent variable is $EnergyPolicy_{it}$. *, ** and *** represent the level of significance at 10%, 5% and 1%, respectively.

To address the endogeneity issue, we re-ran the regressions using the generalised method of moments (GMM). Based on the GMM results, the managerial risk-taking proxy, $RiskTaking^{R\&D\text{-}to\text{-}Sales}{}_{it}$, consistently shows a significant negative effect on $EnergyPolicy_{it}$ (coeff = -0.0042, p-value = 0.0403), and the major control variables show unchanged sign and significance.

Table 6 presents the moderating effect of $BoardSize_{it}$. This study finds that $BoardSize_{it}$ has a significant positive influence on the relationship between $RiskTaking^{R\&D\text{-}to\text{-}Sales}{}_{it}$ and $EnergyPolicy_{it}$ (coeff = 0.4403, p-value = 0.0540). However, the moderating effect of $BoardSize_{it}$ on the relationship between $RiskTaking^{Debt\text{-}to\text{-}Asset}{}_{it}$ and $EnergyPolicy_{it}$ is not statistically significant (coeff = 0.0349, p-value =

0.2405). The results demonstrate that larger boards effectively balance high levels of managerial risk-taking through R&D expenditure and the adoption of energy efficiency policies (see Figure 2). However, risk-taking through increased debt may impose additional financial constraints on firms, therefore hindering their ability to engage in sustainability practices. In sum, this study shows that the value of a larger board size significantly contributes to innovation in R&D rather than financial management, which could be driven by diversified board interlocks (Helmers et al., 2017).

Table 6

The Moderating Effect of Board Size on the Relationship between Managerial Risk-taking and the Energy Efficiency Policy Adoption

Logit Regression	(1)	(2)
$FirmSize_{it}$	1.7018***	1.4442***
	(0.0000)	(0.0000)
$PPE\text{-}to\text{-}Sales_{it}$	0.1669*	-0.1740***
	(0.0580)	(0.0037)
ROA_{it}	0.0273***	0.0199***
	(0.0007)	(0.0003)
$CurrentRatio_{it}$	-0.1714***	-0.1611***
	(0.0056)	(0.0001)
$DCrisis_{it}$	4.5532***	4.6801***
	(0.0000)	(0.0000)
$CEODuality_{it}$	-0.2140	0.0680
	(0.5386)	(0.7554)
$BoardSize_{it}$	0.0213	0.0193
	(0.5137)	(0.6032)
$IndepBoard_{it}$	-0.0152***	-0.0038
	(0.0023)	(0.2505)
$RiskTaking^{R\&D\text{-}to\text{-}Sales}{}_{it}$	-4.3759**	
	(0.0294)	
$RiskTaking^{R\&D\text{-}to\text{-}Sales}{}_{it}$ x $BoardSize_{it}$	0.4403*	
	(0.0540)	
$RiskTaking^{Debt\text{-}to\text{-}Asset}{}_{it}$		-0.5330*
		(0.0622)
$RiskTaking^{Debt\text{-}to\text{-}Asset}{}_{it}$ x $BoardSize_{it}$		0.0349
		(0.2405)
Constant	3.0898***	2.9706***
	(0.0000)	(0.0000)
Year Effect	Yes	Yes
Country Effect	Yes	Yes
Industry Effect	Yes	Yes
Pseudo-R^2	0.1644	0.1213
Obs.	12,701	23,382

Notes. Dependent variable is $EnergyPolicy_{it}$. *, ** and *** represent the level of significance at 10%, 5% and 1%, respectively.

These results are also consistent with Kumari et al. (2022) and Rabi (2021), which show a positive relationship between board size and sustainability practices, along with improved environmental

accounting information disclosure (Agyemang et al., 2020). In fact, a larger board should have more diversified human capital and social capital that can contribute to handling complicated issues (Ooi et al., 2015), such as strategising CSR activities to enhance the success of managerial risk-taking, as argued by the real options theory.

Figure 2 is tabulated from Table 6 of the regression model and presents the moderating effect of board size on the relationship between managerial risk-taking and the adoption of energy efficiency policy. At the same level of risk-taking, board size affects a higher level of energy efficiency policy adoption. This moderating effect notifies that larger boards effectively balance high levels of managerial risk-taking through R&D expenditure and the adoption of energy efficiency policies.

Figure 2

Moderating Effect of Board Size on Relationship between Managerial Risk-taking and Energy Efficiency Policy Adoption

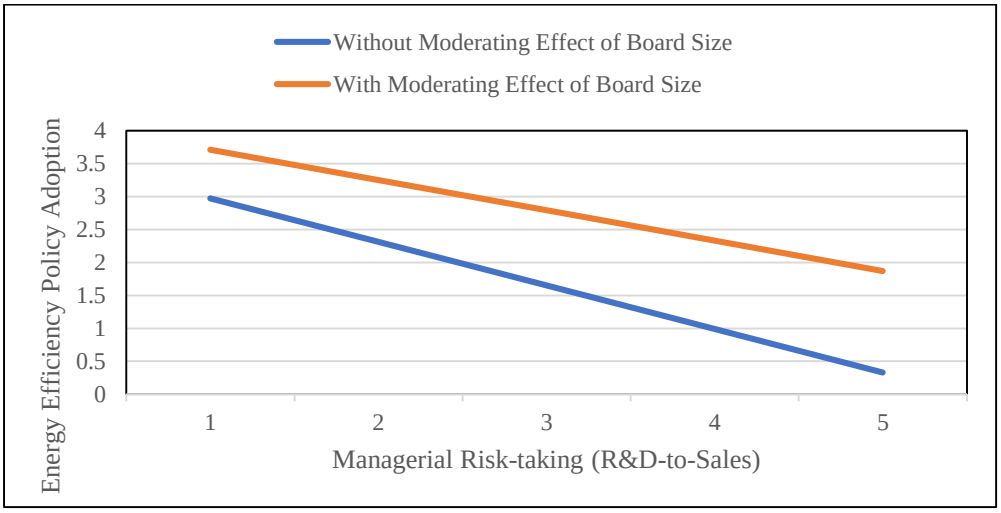


Table 7 presents the moderating effects of $FirmSize_{it}$ in this study. The results show that $FirmSize_{it}$ negatively moderates the relationship between $RiskTaking^{R\&D\text{-}to\text{-}Sales}{}_{it}$ and $EnergyPolicy_{it}$, and the moderating effect is statistically significant at a 1 per cent level of significance (coeff = -0.7353, p-value = 0.0635). Similarly, the moderating effect of $FirmSize_{it}$ on the relationship between $RiskTaking^{Debt\text{-}to\text{-}Asset}{}_{it}$ and $EnergyPolicy_{it}$ is significantly negative (coeff = -0.3418, p-value = 0.0000).

Table 7

The Moderating Effect of Firm Size on the Relationship between Managerial Risk-taking and the Energy Efficiency Policy Adoption

Logit Regression	(1)	(2)
$FirmSize_{it}$	0.9798***	1.2169***
	(0.0000)	(0.0000)
$PPE\text{-}to\text{-}Sales_{it}$	0.1982**	-0.1163**
	(0.0190)	(0.0342)
ROA_{it}	0.0329***	0.0241***
	(0.0000)	(0.0000)

(continued)

Logit Regression	(1)	(2)
$CurrentRatio_{it}$	-0.2258***	-0.1852***
	(0.0001)	(0.0000)
$DCrisis_{it}$	4.7472***	4.8780***
	(0.0000)	(0.0000)
$CEODuality_{it}$	-0.0066	0.1794
	(0.9846)	(0.4114)
$BoardSize_{it}$	0.1232***	0.1326***
	(0.0001)	(0.0000)
$IndepBoard_{it}$	-0.0079	0.0008
	(0.1092)	(0.8063)
$RiskTaking^{R\&D\text{-}to\text{-}Sales}{}_{it}$	-0.5778**	
	(0.0464)	
$RiskTaking^{R\&D\text{-}to\text{-}Sales}{}_{it}$ x $FirmSize_{it}$	-0.7353*	
	(0.0635)	
$RiskTaking^{Debt\text{-}to\text{-}Asset}{}_{it}$		0.1830*
		(0.0987)
$RiskTaking^{Debt\text{-}to\text{-}Asset}{}_{it}$ x $FirmSize_{it}$		-0.3418***
		(0.0000)
Constant	3.1811***	3.0662***
	(0.0000)	(0.0000)
Year Effect	Yes	Yes
Country Effect	Yes	Yes
Industry Effect	Yes	Yes
Pseudo-R^2	0.1635	0.1259
Obs.	12,705	23,390

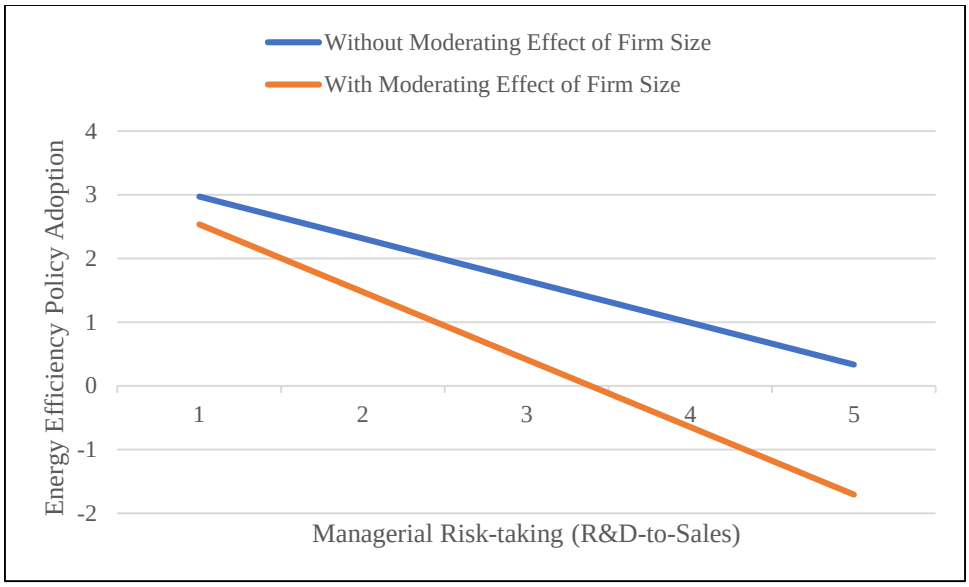
*Note*s. Dependent variable is $EnergyPolicy_{it}$. *, ** and *** represent the level of significance at 10%, 5% and 1%, respectively.

The results contradict Hypothesis 3 of this study, which originally suggested that larger firm size possesses advantages in resource allocation to formulate their risk-taking and sustainability strategies. However, the opposite results may indicate that firm size is used to explain competitiveness rather than resource availability. In this context, smaller firms tend to actively engage in sustainability practices to attract market attention when lagging behind larger firms in financing (see Figure 3). Therefore, smaller firms find alternatives to attract market attention through their compliance with the current global expectations, such as engaging in energy efficiency practices. Our justification aligns with the voluntary disclosure theory rooted in economics (Hummel & Schlick, 2016), suggesting that smaller firms may gain a competitive edge through their strong commitment to environmental responsibility, thereby positioning it as an alternative means of showcasing their performance excellence in competition with larger counterparts.

Figure 3 is tabulated from Table 7 of the regression model and illustrates the moderating effect of firm size on the relationship between managerial risk-taking and the adoption of energy efficiency policies. At equivalent levels of risk-taking, smaller firms are more inclined to adopt energy efficiency policies, while larger firms tend to prioritise financial stability and maximising shareholder value. This suggests that larger firms focus more on maintaining their financial position, which may limit their investment in energy-efficient practices.

Figure 3

Moderating Effect of Smaller Firm Size on the Relationship between Managerial Risk-taking and Energy Efficiency Policy Adoption



In comparison to smaller firms, larger firms might be reluctant to align with global expectations, especially when such alignment requires investments that may only yield value in the long run. Instead, larger firms continue to compete through risk-taking because of their financial strengths. Therefore, our study adds to the mixed findings in the literature, which show positive (Hernández et al., 2020), negative (Lepoutre & Heene, 2006), and insignificant impacts (Sulastri et al., 2023) of firm size on sustainability practices.

CONCLUSION AND LIMITATIONS OF THE STUDY

The study addresses a gap in the existing literature where previous studies related to energy topics have mostly elaborated at the aggregate level, such as focusing on socioeconomic determinants of efficient energy usage adoption. This study highlights the dilemma faced by firms in choosing to maximise profits or sacrifice a portion of their profits for long-term sustainable investment. Findings show a negative relationship between managerial risk-taking and energy efficiency policy adoption, suggesting that the pursuit of profit comes at the expense of other stakeholders' well-being. This is justified by resource scarcity, and therefore, we further explore the moderating role of board size and firm size on the relationship. The former acts as a proxy of intangible resources, and the latter acts as a proxy of tangible resources. With that, we find that board size contributes to the high level of managerial risk-taking via R&D as well as the adoption of energy efficiency policy. Meanwhile, firm size does not corroborate the resource scarcity theory. Instead, it explains how smaller firms compete by aligning with global sustainability expectations.

This study offers two significant contributions. First, it addresses a gap in the existing literature. Previous studies related to energy topics have predominantly operated at the aggregate level (Iraganaboina & Eluru, 2021; Merlin & Chen, 2021; Pita et al., 2020), focusing on socioeconomic determinants of efficient energy usage adoption (e.g., Oluoch et al., 2021; Kumaran et al., 2020; Sharif

et al., 2019; Chen, 2018). Firm-level studies, on the other hand, have predominantly focused on the effects of corporate environmental responsibility on firm outcomes, particularly financial performance (Li et al., 2020; Zhang & Ouyang, 2021). Another strand of studies explores the determinants of corporate environmental responsibility, with corporate governance being one common determinant (Gerged, 2021; Lagasio & Cucari, 2019). Within this strand of corporate governance studies, this study contributes by examining managerial risk-taking, a component of corporate governance, within the context of agency theory responding to stakeholder theory.

Second, this study highlights the significance of firm resources in navigating the dilemma between pursuing short-term profits and long-term sustainability. It emphasises the role of non-financial resources, which can often be more critical than financial resources in this context, especially when it comes to adopting efficient energy usage practices that require specialised expertise (Cantore, 2016). While the literature has previously underscored the importance of innovation in achieving corporate environmental responsibility, innovation itself can be driven by the abundance of non-financial resources that often stem from the composition of the board of directors (Guo et al., 2020). Therefore, we contribute by highlighting the nuanced relationship between resource availability and sustainability practices within the corporate landscape.

Within the area of sustainability practice, future research may conduct further study and analysis by utilising other potential variables affecting energy efficiency adoption that are not included in this study, such as firm leadership, firm profitability, or corporate culture.

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REFERENCES

Abu-Abbas, B. M., Alhmoud, T., & Algazo, F. A. (2019). Financial leverage and firm performance: evidence from Amman stock exchange. *European Journal of Comparative Economics*, *16*(2), 207-237.

Adomako, S., Abdelgawad, S. G., Ahsan, M., Amankwah-Amoah, J., & Liedong, T. A. (2023). Nonmarket strategy in emerging markets: The link between SMEs' corporate political activity, corporate social responsibility, and firm competitiveness. *Journal of Business Research*, *160*.

Agyemang, A. O., Yusheng, K., Ayamba, E. C., Twum, A. K., Chengpeng, Z., & Shaibu, A. (2020). Impact of board characteristics on environmental disclosures for listed mining companies in China. *Environmental Science and Pollution Research*, *27*(17), 21188-21201.

Aksoy, M., Yilmaz, M. K., Tatoglu, E., & Basar, M. (2020). Antecedents of corporate sustainability performance in Turkey: The effects of ownership structure and board attributes on non-financial companies. *Journal of Cleaner Production*, *276*, 1-11.

AlHares, A., Elamer, A.A., Alshbili, I. & Moustafa, M. W. (2020). Board structure and corporate R&D intensity: Evidence from Forbes Global 2000. *International Journal of Accounting & Information Management*, *28*(3), 445-463.

Atif, M., Hossain, M., Alam, M. S., & Goergen, M. (2021). Does board gender diversity affect renewable energy consumption? *Journal of Corporate Finance*, *66*(February), 1-29.101665. https://doi.org/10.1016/j.jcorpfin.2020.101665

Barney, J. (1991). Special theory forum the resource-based model of the firm: Origins, implications and prospects. *Journal of Management*, *17*(1), 97-98.

Baumann-Pauly, D., Wickert, C., Spence, L. J., & Scherer, A. G. (2013). Organizing corporate social responsibility in small and large firms: Size matters. *Journal of Business Ethics*, *115*(4), 693-705.

Bhagat, S., Bolton, B., & Lu, J. (2015). Size, leverage, and risk-taking of financial institutions. *Journal of Banking & Finance*, *59*, 520-537.

Bhagat, S., & Welch, I. (1995). Corporate research and development investments international comparisons. *Journal of Accounting and Economics*, *19*, 443–470.

Bouton, S., Creyts, J., Kiely, T., Livingston, J., & Naucler, T. (2010). *Energy efficiency: A compelling global resources*. McKinsey & Company.

Bromiley, P. (1991). Testing a causal model of corporate risk taking and performance. *The Academy of Management Journal*, *34*(1), 37–59.

Bromiley, P. (2009). A prospect theory model of resource allocation. *Decision Analysis*, *6*(3), 124-138.

Budiyono, B., & Maryam, D. (2017). Disclosure of corporate social responsibility (CSR) through company characteristics at company listed on LQ45 Indonesia Stock Exchange (IDX). *International Journal of Economics, Business and Accounting Research (IJEBAR), 1*(2), 21-33.

Bunse, K., Vodicka, M., Schönsleben, P., Brülhart, M., & Ernst, F. O. (2011). Integrating energy efficiency performance in production management – gap analysis between industrial needs and scientific literature. *Journal of Cleaner Production*, *19*, 667–679.

Cantore, N. (2016). Factors affecting the adoption of energy efficiency in the manufacturing sector of developing countries. *Energy Efficiency, 19*(4), 960-976. https://doi.org/10.1108/IJESM-06-2024-0022

Castrogiovanni, G. J., Combs, J. G., & Justis, R. T. (2006). Resource scarcity and agency theory predictions concerning the continued use of franchising in multi-outlet networks. *Journal of Small Business Management*, *44*(1), 27–44.

Chauhan, S. (2014). A relational study of firm's characteristics and CSR expenditure. *Procedia Economics and Finance*, *11*, 23-32.

Chen, Y. (2018). Factors influencing renewable energy consumption in China: An empirical analysis based on provincial panel data. *Journal of Cleaner Production, 174*, 605-625.

Cheng, E. C. M., & Courtenay, S. M. (2006). Board composition, regulatory regime and voluntary disclosure. *The International Journal of Accounting*, *41*(3), 262-289.

Chiaroni, D., Chiesa, V., Franzò, S., Frattini, F., & Manfredi, V. (2016). Overcoming internal barriers to industrial energy efficiency through energy audit: A case study of a large manufacturing company in the home appliances industry. *Clean Technologies and Environmental Policy*, *19*(4), 1-16.

Costa-Campi, M. T., García-Quevedo, J., & Segarra, A. (2015). Energy efficiency determinants: An empirical analysis of Spanish innovative firms. *Energy Policy*, *83*, 229-239.

Dalci, I. (2018). Impact of financial leverage on profitability of listed manufacturing firms in China. *Pacific Accounting Review*, *30*(4), 410-432. https://doi.org/10.1108/PAR-01-2018-0008

Dao, T. T. B., & Phan, M. C. (2023). Stakeholder theory, risk-taking and firm performance. *Corporate Governance*. https://doi.org/10.1108/CG-09-2022-0366

Darnall, N., Henriques, I., & Sadorsky, P. (2010). Adopting proactive environmental strategy: The influence of stakeholders and firm size. *Journal of Management Studies, 47*(6), 1072–1094.

Das, K. P., Mukhopadhyay, S., & Suar, D. (2023). Enablers of workforce agility, firm performance, and corporate reputation. *Asia Pacific Management Review*, *28*(1), 33-44.

Davison, T. (2024). *Greenwashing examples: A summary of the nine biggest fines*. CleanHub: https://blog.cleanhub.com/greenwashing-examples.

De Freitas Netto, S. V., Sobral, M. F. F., Ribeiro, A. R. B., & da Luz Soares, G. R. (2020). Concepts and forms of greenwashing: A systematic review. *Environ Sci Eur*, *32*(19). https://doi.org/10.1186/s12302-020-0300-3

DeCanio, S., & Watkins, W. E. (1998). Information processing and organizational structure. *Journal of Economic Behavior & Organization*, *36*(3), 275-294.

Dong, Z., Wang, C., & Xie, F. (2010). Do executive stock options induce excessive risk taking? *Journal of Banking and Finance*, *34*, 2518-2529.

Drempetic, S., Klein, C., & Zwergel, B. (2020). The influence of firm size on the ESG score: Corporate sustainability ratings under review. *Journal of Business Ethics*, *167*, 333–360.

Dyduch, J., & Krasodomska, J. (2017). Determinants of corporate social responsibility disclosure: An empirical study of polish listed companies. *Sustainability, 9*(11). https://doi.org/10.3390/su9111934

Fan, L. W., Pan, S. J., Liu, G. Q., & Zhou, P. (2017). Does energy efficiency affect financial performance? Evidence from Chinese energy-intensive firms. *Journal of Cleaner Production, 151,* 53-59. https://doi.org/10.1016/j.jclepro.2017.03.044

Fankhauser et al. (2021). The meaning of net zero and how to get it right. *Nature Climate Change*, *12,* 15-21.

Fleiter, T., Schleich, J., & Ravivanpong, P. (2012). Adoption of energy-efficiency measures in SMEs – an empirical analysis based on energy audit data from Germany. *Energy Policy*, *51*, 863–875.

Gallo, P. J., & Christensen, L. J. (2011). Firm size matters: An empirical investigation of organizational size and ownership on sustainability-related behaviors. *Business & Society*, *50*(2), 315–349.

Gardberg, N. A., & Fombrun, C. J. (2006). Corporate citizenship: Creating intangible assets across institutional environments. *Academy of Management Review, 31*(2), 329–346.

Gerged, A. M. (2021). Factors affecting corporate environmental disclosure in emerging markets: The role of corporate governance structures. *Business Strategy and the Environmental*, *30*(1), 609-629.

Guo, Y., Wang, L., & Yang, Q. (2020). Do corporate environmental ethics influence firms' green practice? The mediating role of green innovation and the moderating role of personal ties. *Journal of Cleaner Production*, *266*.

Hahn, R., & Kühnen, M. (2013). Determinants of sustainability reporting: A review of results, trends, theory, and opportunities in an expanding field of research. *Journal of Cleaner Production, 59,* 5–21.

Helmers, E., & Martin, W. (2017). Advances and critical aspects in the life-cycle assessment of battery electric cars. *Energy and Emission Control Technologies*, *5*, 1-18. http://dx.doi.org/10.2147/EECT.S60408

Hayenhjelm, M. (2006). Out of the Ashes: Hope and vulnerability as explanatory factors in individual risk taking. *Journal of Risk Research, 9*(3), 189–204.

Henderson, R., & Cockburn, I. (1996). Scale, scope, and spillovers: The determinants of research productivity in drug discovery. *The RAND Journal of Economics*, *27*(1), 32–59.

Hernández, J. P. S.-I., Yañez-Araque, B., & Moreno-García, J. (2020). Moderating effect of firm size on the influence of corporate social responsibility in the economic performance of micro-, small- and medium-sized enterprises. *Technological Forecasting and Social Change*, *151*.

Hitt, M. A., Bierman, L., Shimizu, K., & Kochhar, R. (2001). Direct and moderating effects of human capital on strategy and performance in professional service firms: A resource-based perspective. *Academy of Management Journal*, *44*(1), 13-28.

Holmström, B. (1979). Moral hazard and observability. *The Bell Journal of Economics*, *10*(1), 74-91.

Hörisch, J., Freeman, R. E., & Schaltegger, S. (2014). Applying stakeholder theory in sustainability management: Links, similarities, dissimilarities, and a conceptual framework. *Organization & Environment*, *27*(4), 328–346.

Hörisch, J., Johnson, M., & Schaltegger, S. (2015). Implementation of sustainability management and company size. *Business Strategy and the Environment*, *24*(8), 765–779.

Hoskisson, R. E., Chirico, F., Zyung, J. D., & Gambeta, E. (2017). Managerial risk taking: A multi-theoretical review and future research agenda. *Journal of Management*, *43*(1), 137-169.

Hou, J., & Reber, B. H. (2011). Dimensions of disclosures: Corporate social responsibility (CSR) reporting by media companies. *Public Relations Review, 37*(2), 166–168.

Huang, Y. S., & Wang, C.-J. (2015). Corporate governance and risk-taking of Chinese firms: The role of board size. *International Review of Economics & Finance*, *37*, 96-113.

Hummel, K., & Schlick, C. (2016). The relationship between sustainability performance and sustainability disclosure–reconciling voluntary disclosure theory and legitimacy theory. *Journal of Accounting and Public Policy*, *35*(5), 455-476.

Husted, B. W., & de Sousa-Filho, J. M. (2019). Board structure and environmental, social, and governance disclosure in Latin America. *Journal of Business Research*, *102*, 220-227.

Iraganaboina, N. C., & Eluru, N. (2021). An examination of factors affecting residential energy consumption using a multiple discrete continuous approach. *Energy & Buildings*, *240,* 1-11. https://doi.org/10.1016/j.enbuild.2021.110934

Jensen, M. C., & Murphy, K. J. (1990). Performance pay and top-management incentives. *Journal of Political Economy*, *98*(2), 225-264.

John, K., Freund, S., Nguyen, D., & Vasudevan, G. K. (2010). Investor protection and cross-border acquisitions of private and public targets. *Journal of Corporate Finance*, *16*(3), 259-275.

Khin, D. (2020). Supporting national transition in Myanmar through corporate social responsibility. *Journal of International Studies*, *9*, 99-112.

Kostka, G., Moslener, U., & Andreas, J. (2013). Barriers to increasing energy efficiency: Evidence from small-and medium-sized enterprises in China. *Journal of Cleaner Production*, *57*, 59-68.

Kroll, M., Simmons, S. A., & Wright, P. (1990). Determinants of chief executive officer compensation following major acquisitions. *Journal of Business Research*, *20*(4), 349-366.

Kumaran, V. V., Ridzuan, A. R., Khan, F. U., Abdullah, H., & Mohamad, Z. Z. (2020). An empirical analysis of factors affecting renewable energy consumption in Association of Southeast Asian nations-4 countries. *International Journal of Energy Economics and Policy, 10*(2), 48-56. https://doi.org/10.32479/ijeep.8142

Kumari, P. R., Makhija, H., Sharma, D., & Behl, A. (2022). Board characteristics and environmental disclosures: Evidence from sensitive and non-sensitive industries of India. *International Journal of Managerial Finance*, *18*(4), 677-700.

Lagasio, V., & Cucari, N. (2019). Corporate governance and environmental social governance disclosure: A meta-analytical review. *Business Strategy and the Environmental*, *26*(4), 701-711.

Lee, S. W. (2008). Asset size, risk taking and profitability in Korean banking industry. *Bank and Bank Systems*, *3*(4), 50-54.

Lee, M. T., Raschke, R. L., & Krishen, A. S. (2023). Understanding ESG scores and firm performance: Are high-performing firms E, S, and G-balanced? *Technological Forecasting and Social Change*, *195*.

Lepoutre, J., & Heene, A. (2006). Investigating the impact of firm size on small business social responsibility: A critical review. *Journal of Business Ethics*, *67*, 257–273.

Lewis, S. (2003). Reputation and corporate responsibility. *Journal of Communication Management, 7*(4), 356–366.

Li, K., Griffin, D., Yue, H., & Zhao, L. (2013). How does culture influence corporate risk-taking? *Journal of Corporate Finance*, *23*, 1-22.

Li, Z., Liao, G., & Albitar, K. (2020). Does corporate environmental responsibility engagement affect firm value? The mediating role of corporate innovation. *Business Strategy and the Environment*, *29*(3), 1045-1055.

Locket, A., Thompson, S., & Morgenstern, U. (2009). The development of the resource-based view of them firm: A critical appraisal. *International Journal of Management Reviews*, *11*(1), 9-28.

Luo, L.-M., Lee, H.-T, Chiu, C.-C., & Lee, C.-W. (2023). The relations of corporate risk, operating efficiency, and firm size to managerial compensation: Evidence from Taiwan stock market-listed companies. *Asia Pacific Management Review*, *28*(2), 194-203.

Martin, R., Muûls, M., de Preux, L. B., & Wagner, U. J. (2012). Anatomy of a paradox: Management practices, organizational structure and energy efficiency. *Journal of Environmental Economics and Management*, *63*(2), 208-223.

Merlin, M. L., & Chen, Y. (2021). Analysis of the factors affecting electricity consumption in DR Congo using fully modified ordinary least square (FMOLS), dynamic ordinary least square (DOLS) and canonical cointegrating regression (CCR) estimation approach. *Energy*, *232*, 1-11. https://doi.org/10.1016/j.energy.2021.121025

Mihet, R. (2013). Effects of culture on firm risk-taking: A cross-country and cross-industry analysis. *Journal of Cultural Economics*, *37*, 109-151.

Nakano, M., & Nguyen, P. (2012). Board size and corporate risk taking: Further evidence from Japan. *Corporate Governance: An International Review*, *20*(4), 369-387.

Ng, H. T., Lee, C. L., & Ismail, H. (2013). Firm size and risk taking in Malaysia's insurance industry. *Journal of Risk Finance*, *14*(4), 378-391.

Nguyen, L. T., & Nguyen, P. T. (2023). The board profiles that promote environmental, social, and governance disclosure–Evidence from S&P 500 firms. *Finance Research Letters*, *55*.

Oluoch, S., Lal, P., & Susaeta, A. (2021). Investigating factors affecting renewable energy consumption: A panel data analysis in Sub Saharan Africa. *Environmental Challenges*, *4,* 1-10. https://doi.org/10.1016/j.envc.2021.100092

Ooi, C.-A., & Hooy, C.-W. (2022). Muslim CEOs, risk-taking and firm performance. *Pacific-Basin Finance Journal*, *74*. https://doi.org/10.1016/j.pacfin.2022.101818

Ooi, C.-A., Hooy, C.-W., & Som, A. P. M. (2015). Diversity in human and social capital: Empirical evidence from Asian tourism firms in corporate board composition. *Tourism Management*, *48*, 139-153.

Ooi, C.-A., Lu, M. P., & Zulkafli, A. H. (2024). Corporate risk-taking, economic policy uncertainty and ESG performance: International evidence. *Business Strategy and Development*, *7*(4). https://doi.org/10.1002/bsd2.70028.

Palmer, T. B., & Wiseman, R. M. (1999). Decoupling risk taking from income stream uncertainty: A holistic model of risk. *Strategic Management Journal*, *20*(11), 1037-1062.

Penrose, E. T. (1959). *The theory of the growth of the firm*. Sharpe.

Peteraf, M. A. (1993). The cornerstones of competitive advantage: A resource-based view. *Strategic Management Journal*, *14*(3), 179-191.

Peterdy, K. (2024). *ESG (Environmental, Social, & Governance)*. CFI. https://corporatefinanceinstitute.com/resources/esg/esg-environmental-social-governance/

Pita, P., Winyuchakrit, P., & Limmeechokchai, B. (2020). Analysis of factors affecting energy consumption and CO2 emissions in Thailand's road passenger transport. *Heliyon*, *6*(10), 1-15. https://doi.org/10.1016/j.heliyon.2020.e05112

Pons, M., Bikfalvi, A., Llach, J., & Palcic, I. (2013). Exploring the impact of energy efficiency technologies on manufacturing firm performance. *Journal of Cleaner Production*, *52*, 134–144.

Pradhan, A. K., & Nibedita, B. (2019). The determinants of corporate social responsibility: Evidence from Indian firms. *Global Business Review, 22*(3), 753–766. https://doi.org/10.1177/097215 0918814318

Rabi, A. M. (2021). Board characteristics and environmental disclosure: Evidence from Jordan. *International Journal of Business and Management*, *14*(2), 1-57.

Racela, O. C., & Thoumrungroje, A. (2020). Enhancing export performance through proactive export market development capabilities and ICT utilization. *Journal of Global Marketing*, *33*(1), 46-63.

Rohdin, P., Thollander, P., & Solding, P. (2007). Barriers to and drivers for energy efficiency in the Swedish foundry industry. *Energy Policy*, *35*(1), 672-677.

Roxas, H. B., & Chadee, D. (2011). A resource-based view of small export firms' social capital in a Southeasst Asian country. *Asian Academy of Management Journal*, *16*(2), 1-28.

Russo, A., & Perrini, F. (2010). Investigating stakeholder theory and social capital: CSR in large firms and SMEs. *Journal of Business Ethics, 91*(2), 207–221.

Ryan, H. E., & Wiggins, R. A. (2002). The interactions between R&D investment decisions and compensation policy. *Financial Management*, *31*(1), 5-29.

Sabherwal, R., Sabherwal, S., Havaknor, T., & Steelman, Z. (2019). How does strategic alignment affect firm performance? The roles of information technology investment and environmental uncertainty. *MIS Quarterly*, *43*(2), 453-474.

Salas, E., Reyes, D. L., & McDaniel, S. H. (2018). The science of teamwork: Progress, reflections, and the road ahead. *American Psychologist*, *73*(4), 593-600.

Santacruz, L. (2020). Measures of firm risk-taking: Revisiting Bowman's paradox. *Managerial Finance*, *46*(3), 421-434.

Sharif, A., Raza, S. A., Ozturk, I., & Afshan, S. (2019). The dynamic relationship of renewable and nonrenewable energy consumption with carbon emission: A global study with the application of heterogeneous panel estimations. *Renewable Energy, 133*, 685-691.

Stevenson, E. (2018). 2003-2008 Oil price shock: Changing effects of oil shocks on the economy. *The Libraries Student Research Prize*, *14*.

Sulastri, Arivetullatif, & Multama, I. (2023). The impact profitability, leverage and firm size on disclousure of corporate social responsibility. *Jurnal Informatika Ekonomi Bisnis*, *5*(1), 247-253.

Thollander, P., Backlund, S., Trianni, A., & Cagno, E. (2013). Beyond barriers–A case study on driving forces for improved energy efficiency in the foundry industries in Finland, France, Germany, Italy, Poland, Spain, and Sweden. *Applied Energy*, *111*. 636–643.

Trigeorgis, L., & Tsekrekos, A. E. (2018). Real options in operations research: A review. *European Journal of Operational Research*, *270*(1), 1-24.

Tsai, H.-F., & Luan, C.-J. (2016). What makes firms embrace risks? A risk-taking capability perspective. BRQ Business Research Quarterly, 19(3), 219-231.

Upadhyay, A., & Sriram, R. (2011). Board size, corporate information environment and cost of capital. *Journal of Business Finance and Accounting*, *38*(9-10), 1238-1261.

Wang, C.-J. (2012). Board size and firm risk-taking. *Review of Quantitative Finance and Accounting*, *38*, 519–542.

Wiseman, R. M., & Gomez-Mejia, L. R. (1998). A behavioral agency model of managerial risk taking. *Academy of Management Review*, *23*(1), 133-153.

Younas, Z. I., & Zafar, A. (2019). Corporate risk taking and sustainability: A case of listed firms from USA and Germany. *Journal of Global Responsibility, 10*(1), 1-15. https://doi.org/10.1108/JGR-07-2018-0027

Zhang, Q., Oo, B. L., & Lim, B. T. H. (2022). Linking corporate social responsibility (CSR) practices and organizational performance in the construction industry: A resource collaboration network. *Resources, Conservation and Recycling*, *179*.

Zhang, S. (2016). *Energy efficiency and firm performance*: *Evidence from Swedish industry* [Unpublished doctoral dissertation]. Swedish University of Agricultural Sciences.

Zhang, Y., & Ouyang, Z. (2021). Doing well by doing good: How corporate environmental responsibility influences corporate financial performance. *Corporate Social Responsibility and Environmental Management*, *28*(1), 54-63.

Zhou, C. (2009). *Are banks too big to fail?* DNB Working Papers, Netherlands Central Bank.

Zinn, J. O. (2019). The meaning of risk-taking – key concepts and dimensions. *Journal of Risk Research*, *22*(1), 1-15.