Exploring the Effect of Enterprise Risk Management for ESG Risks Towards Green Growth

Abstract

Purpose: Despite the growing emphasis on sustainability and the need to manage environmental, social, and governance (ESG) risks, the direct relationship between enterprise risk management (ERM) and green growth (GG) has not been investigated. This study seeks to fill this gap by examining the effect of ERM on the GG of oil and gas (O&G) companies in Malaysia.

Design/Methodology/Approach: The study used panel data regression models to analyze panel data from 2012 to 2021. For computing GG, we adapted the Organization for Economic Cooperation and Development's (OECD) GG framework. ERM is computed using COSO and WBCSD guidelines for ESG-related risks. Weighted content analysis is used to measure ERM and GG.

Findings: The findings derived from the content and descriptive statistics analysis indicate a consistent and ongoing rise in the adoption of ERM practices over time. However, some companies are still in the initial stages of incorporating ERM to address ESG risks. The study's findings unequivocally establish a substantial and positive relationship between ERM and GG. ERM drives GG by significantly influencing its environmental and resource productivity dimensions. The study further reveals that the impact of ERM on economic opportunities and policy responses, as well as the natural asset base, is statistically significant, albeit with relatively lower coefficient values.

Originality: To the best of the authors' knowledge, this is the first study examining ERM's effect on GG. The study adds to the existing literature by focusing on ERM's role in a company's GG. It clarifies ERM's significant effect on diminishing emerging ESG risks and advancing GG.

Practical implications: To enhance the legitimacy of organizations and foster positive stakeholder relationships, regulators, governments, and policymakers should actively promote the adoption of ERM standards that specifically address ESG risks, as outlined by COSO and WBCSD. This strategic alignment with risk management practices will ultimately contribute to improving green growth for organizations.

Keywords: Enterprise risk management, green growth, environmental performance, stakeholder theory

Article classification: Research paper

1. Introduction

Since the 21st century, shifts in climate change, rising globalization, and environmental degradation have increased stakeholders' concerns regarding corporate activities that lead to notable environmental, social, and governance (ESG) risks (Sharma and Kumar, 2023). These human-generated risks and depletion of resources are the main issues facing the contemporary world today (Vlek and Keren, 1992; Shah *et al.*, 2022b). The growing curiosity of investors and global awareness regarding ESG risks are compelling firms to focus on managing these risks. Moreover, stakeholders expect the businesses to prioritize these fronts and implement appropriate mitigation measures (Aydoğmuş *et al.*, 2022). Consequently, organizations employ enterprise risk management (ERM) frameworks to cope with ESG risks. The Committee of Sponsoring Organizations of the Treadway Commission (COSO, 2013, p. 4) defines ERM as *"the culture, capabilities, and practices, integrated with strategy-setting and its performance, that organizations rely on to manage risk in creating, preserving, and realizing value"* (COSO, 2013). Sarkis (2006) suggests that companies adopt ERM to address emerging perils and core management concerns. Rating agencies are now considering ERM in the rating process as an indicator of good management (Hoyt and Liebenberg, 2011). Thus, organizations are increasingly favoring ERM programs and establishing ERM units to overcome emerging challenges (Kuo *et al.*, 2021). Furthermore, regulators and governance bodies are motivating firms to enhance their risk-control systems by adopting a holistic risk management approach (Chairani and Siregar, 2021).

The Global Risk Report (2022) by the World Economic Forum brought attention to the potential hindrance of ESG risk factors on both businesses' financial and non-financial performance. The report revealed a continued prevalence of dominant ESG risks, encompassing natural disasters, water scarcity, climate change, health and safety concerns, labor-management issues, demographic risks, financial instability, and tax transparency, which are projected to persist until 2030. These risks are interconnected and could lead firms to financial and non-financial losses (Soomro and Lai, 2017; Chairani and Siregar, 2021). Enterprises are therefore encouraged to implement ERM to manage ESG perils (Shah *et al.*, 2022b) and enhance green growth (GG) (Lai *et al.*, 2021).

ERM enhances an organization's ability to navigate uncertainties and achieve its objectives by effectively managing emerging risks (Shad *et al.*, 2019). Besides, ERM helps allocate resources based on a company's risk profile. Scholars have examined ERM's influence on firm performance from different perspectives. Indeed, studies have examined the effect of ERM on financial performance in developed and developing economies (McShane *et al.*, 2011; Shad and Lai, 2015; Lai and Shad, 2017; Anton, 2018; Anton and Nucu, 2020; Chairani and Siregar, 2021); however, there is a dearth of studies relating it to GG (Lai *et al.*, 2021). Although the effects of ERM and the board risk committee on environmental performance have been documented (Al-Nimer *et al.*, 2021; Villiers *et al.*, 2022), their effect on GG remains under-investigated (Dobler *et al.*, 2014). This study attempts to fill this research gap by empirically investigating the impact of ERM on a firm's GG. This study may clarify ERM's role in GG to the benefit of academics, practitioners and policymakers.

GG is an emerging concept that was developed as a response to environmental degradation and climate change. It drew significant attention after evolving as a central theme at the Rio Conference on Sustainable Development in 2012 (Hickel and Kallis, 2020). According to Antal and Van Den Bergh (2016), GG entails attaining environmental and financial goals by decoupling ecological pressures from the aggregate output at an adequate rate. It resembles a "win-win situation" because it enhances enterprises' ecological as well as economic performance. For instance, organizations use greener resources to generate less pollution, and the reduced waste products can minimize the cost of capital and provide tax incentives (Sharfman and Fernando, 2008). Tax benefits can be obtained by properly disposing of the product; for example, returning a lead battery for recycling instead of sending it to a landfill (Porter and van der Linde, 1995). It captures sustainable development perspectives, suggesting that organizations can increase economic performance and protect the environment through technological innovation, institutional adaptation, and super-industrialization (Picou and Marshall, 2002). Economic growth depends on the utilization of natural resources; it leads to resource depletion and is recognized as unsustainable (Fernandes *et al.*, 2021). Therefore, economies may employ green products or processes to increase their GG and preserve their resources without compromising the natural environment.

The susceptibility of Malaysia to various ESG risks, including "human-made environmental damage, employment-livelihood crisis, prolonged economic stagnation, depletion of strategic resources, and debt crisis" has been highlighted by the World Economic Forum (GRR, 2022). Like other countries, Malaysia struggles to balance economic growth and GG (Mahdi et al., 2023). As a result, Malaysia significantly contributes to climate change and environmental degradation (Guo *et al.*, 2020). This study focuses on the Malaysian oil and gas (O&G) industry, which is vulnerable to both financial and non-financial risks (Shad *et al.*, 2020). O&G activities leading to ESG issues have been criticized for its production processes, which have negative social and environmental impacts. Although technological advancements have improved the O&G production process, operational loopholes continue to harm society and the environment on a large scale (Johnston *et al.*, 2019). This has a long-term impact on air, soil, water, and public health, ultimately leading to lower GG. (Mahmood *et al.*, 2020). Given these factors, we propose ERM as a tool to help O&G companies manage risks and improve GG.

This study offers a pioneering examination of the influence of ERM on GG, providing a comprehensive assessment. Employing a multi-theoretical framework, it aims to make a valuable contribution to the existing literature on ERM and its implications for GG. This study contributes to the existing literature in several ways. Firstly, we address a significant gap in the literature by examining the impact of ERM solely focused on ESG risks on firms' GG. Previous studies primarily focused on the impact of ERM on financial performance, except for Lai *et al.* (2021), who conceptualized the nexus between ERM, sustainability practices, and GG. However, more conceptualization is needed, necessitating further attention to the impact of ERM on GG. Our findings support the hypothesis that ERM enhances GG by effectively managing ESG risks. Secondly, our study expands our understanding of the nature and impact of GG by explicitly quantifying the effects of ERM across its three dimensions: environmental and resource productivity (ERP), economic opportunities and policy responses (EOPR), and natural asset base (NAB). This empirical analysis enhances our knowledge and insights into the interplay between ERM and the various dimensions of GG. The findings of our study demonstrate a substantial impact of ERM on the dimensions of GG. Notably, the coefficient values indicate that ERM exerts a particularly strong influence on ERP compared to EOPR and NAB. These findings provide empirical evidence on how investors perceive the complex relationship between GG and ERM when an enterprise depicts positive GG with high emissions or vice versa. Thirdly, Shah *et al.* (2022b) produced a novel ERM index for addressing ESG risks. We adapt and empirically validate their index about a firm’s GG. Fourthly, based on the Organization for Economic Co-operation and Development’s (OECD) guidelines, the study offers a self-made index for the computation of GG at the firm level. Lastly, the study integrates legitimacy, ecological modernization, and stakeholder theories to demonstrate the intertwined relationship between ERM and GG.

The remainder of the paper is organized as follows. Section 2 presents the literature review, theoretical discussion, and hypothesis postulation. Section 3 describes the methodology, model specification, and measurement of variables. Results are summarized in Section 4, including those of descriptive statistics, correlation analysis, regression analysis, robustness tests and heterogeneity analysis. Finally, Section 5 discusses the conclusion and provides implications and future directions.

2. Literature review and hypothesis development

2.1 ERM

ERM is a strategic process that enables organizations to manage risks and seize opportunities aligned with their strategic objectives (Lai and Shad, 2017). The adoption of ERM strengthens risk governance and assists management in identifying and addressing risks across the entire organization (Malik *et al.*, 2020). It is considered a strategic approach that evaluates risks and opportunities while aligning ESG perspectives with a company's overall strategy (Manab and Aziz, 2019). The implementation of ERM facilitates effective risk management within predetermined risk appetite limits, leading to improved firm performance (Adam *et al.*, 2021). Additionally, ERM acts as a valuable tool for management, enabling them to identify and prioritize risks effectively. Simultaneously, it assists corporations in developing and implementing strategies that protect them from a range of risks, including those related to safety, environment, reputation, compliance, society, community, and the economy (Fraser *et al.*, 2022). Manab and Aziz (2019) indicate that ERM aids firms by accurately estimating the probability of future threats and increases its capacity to enhance performance. Companies that effectively implement ERM can not only protect the environment but also maximize their GG potential (Kuo *et al.*, 2021).

Recognizing the significant impact of ESG risks on businesses and the subsequent high operational costs involved (Kuo *et al.*, 2021), it becomes crucial to incorporate ESG aspects within the ERM framework, particularly in the energy sector. This sector, being globally integrated and risk-sensitive, necessitates a comprehensive approach to address ESG risks (Jonek-Kowalska, 2019). By implementing ERM with a specific focus on ecological risks, organizations can establish a harmonious relationship between economic development and environmental performance (Picou and Marshall, 2002). In line with this, Valinejad and Rahmani (2018) emphasize the importance of integrating ERM to effectively promote sustainable development and address ESG risks. This proactive approach allows companies to mitigate the potential negative impacts on sustainability and align their operations with responsible and ethical practices. Moreover, Sarkis (2006) suggests that organizations should adopt ERM as a strategic approach to minimize environmental impacts and enhance their GG initiatives. By doing so, companies can optimize their environmental performance while pursuing sustainable and responsible business practices.

2.2 GG

In light of the economic downturn and ecological degradation, businesses are reevaluating their development strategies, while policymakers actively promote GG to simultaneously boost economic performance and safeguard the environment from contamination and jeopardy. Failure to consider GG could result in detrimental consequences such as increased carbon emissions, pollution, biodiversity loss, and water scarcity (Ogola, 2022). Although GG gained prominence in the 2010s, it still remains an area of ongoing research, especially at the organizational level. Its significance heightened with the introduction of the United Nations' SDGs, emphasizing the transformation of financial growth into GG. Despite, GG is primarily studied at the macro- level. Companies' contributions toward GG at the micro- level have not been adequately studied (Heindl and Löschel, 2015; Tunji-Olayeni *et al.*, 2018; Lai *et al.*, 2021).

Hajar *et al.* (2020) (p.1) define GG as "a low-carbon, climate-compatible development centered around growing the economy while improving the wellbeing of the society, the environment, and the ecosystem." Furthermore, the OECD (p.9) advocates GG as a concept "fostering economic growth and development while ensuring that the natural assets continue to provide the resources and environmental services on which our well-being relies. To do this, it must catalyze investment and innovation which will underpin sustained growth and give rise to new economic opportunities" (OECD, 2011).

The continuance of business operations for the sake of economic growth is a severe threat to GG (OECD, 2011). Consequently, organizations adopt practices that not only fulfill their financial growth objectives but also align with environmental protection and the sustainable utilization of resources. In this regard, ERM and sustainability frameworks are the dominant tools leading companies toward GG (Lai *et al.*, 2021). Many organizations have implemented ERM to address ecological issues and prioritize GG as a core management concern (Sarkis, 2006). ERM, particularly when designed to specifically address ESG risks, has the potential to reduce the likelihood of systematic risks and contribute to a firm's GG (COSO and WBCSD, 2018). Additionally, it protects businesses from financial risks and operational catastrophes that harm society and the environment (Shah *et al.*, 2022b).

2.3 Theoretical framework and hypothesis development

Due to the complex and multifaceted nature of ESG risks, as well as the limited empirical research on the connection between ERM and GG, no single theoretical framework can comprehensively elucidate the impact of ERM on firm GG. Considering this, our study takes a multi-theoretical approach to construct our arguments by incorporating various perspectives. Specifically, we leverage legitimacy theory, ecological modernization theory, and stakeholder theory to provide a comprehensive analysis of the relationship between ERM and GG.

In accordance with legitimacy theory, business organizations need to adhere to practices that meet the expectations of both stakeholders and institutions to maintain their credibility. Consequently, companies implicated in ecological degradation are expected to undertake legitimate actions (Wellalage and Kumar, 2021). In the context of ERM and GG, organizations that effectively manage ESG risks through comprehensive risk management practices are likely to enhance their legitimacy and reputation among stakeholders. Thus, companies may adopt ERM to achieve legitimacy and enhance GG (Aziz *et al.*, 2015). This can help to prevent negative impacts on the environment, align the organization with societal demand for environmentally friendly practices and products, and enhance the organization's legitimacy in the eyes of stakeholders. Enhanced legitimacy, in turn, can lead to a range of positive outcomes for organizations, including easy access to the capital market, increased customer loyalty, and enhanced stakeholder trust. These benefits create a conducive environment for organizations to pursue GG initiatives and capitalize on emerging opportunities in the sustainable marketplace. Therefore, adopting and implementing ERM practices to maintain legitimacy can serve as a viable approach to enhance GG.

Ecological modernization theory, which emerged in response to the environmental degradation resulting from inadequate ecological management, provides a theoretical framework to understand the relationship between ERM and GG. This theory recognizes the need for risk management practices to mitigate negative ecological externalities and emphasizes the trade-off between economic and environmental performance (Cohen, 1997; Cohen, 1998). Organizations facing emerging perils can establish amicable connections between financial performance and GG by implementing risk management practices (Picou and Marshall, 2002). Besides, the avoidance of ERM will pose a challenge to the firm's GG due to the interconnected characteristics of risks. Thus, ERM implementation could assist organizations in managing risks (Chairani and Siregar, 2021) and increasing GG (Raharjo and Hasnawati, 2022). Through the lens of ecological modernization theory, it can be predicted that ERM implementation will contribute to the enhancement of GG by effectively managing and mitigating the ESG risks that pose challenges to sustainable development.

Additionally, stakeholder theory propagates to establish good relationships with broad stakeholders. Freeman asserts that organizations are responsible for maintaining relations with stakeholders, including government, society, environmentalists, agencies, and consumers (Jarboui *et al.*, 2022). These stakeholders, driven by their diverse interests, demand improved GG from businesses (Villiers *et al.*, 2022). As GG becomes increasingly linked to financial outcomes, shareholders also recognize the importance of integrating environmental considerations into their investment decisions. One of the approaches to meet stakeholders' demands for enhanced GG is to overcome ESG risks. This can be achieved with the implementation of ERM. Thus, the theory provides a base for ERM implementation to manage ESG risks that impede firms' GG. Dobler *et al.* (2014) mention that ERM engagement is beneficial for a firm's economic prosperity and GG. Similarly, Cai *et al.* (2016) recommend that businesses pursue risk management practices to reduce firm risk and increase GG. Shad *et al.* (2019) highlights the role of ERM in addressing the concerns of stakeholders, strengthening the risk control environment, and leading to more GG (Lai *et al.*, 2021). In this context, organizations should emphasize ERM to manage ESG risks and foster GG, which is essential for the community's wellbeing and sustainable development. Thus, the lens of stakeholder theory underscores the cruciality of ERM implementation in fostering positive relationships with stakeholders, managing ESG risks, and enhancing GG.

Previous literature has theorized a positive relationship between ERM and GG (Lai *et al.*, 2021; Raharjo and Hasnawati, 2022). This positive effect has been established because ESG risks can be effectively managed through ERM implementation (Al-Nimer *et al.*, 2021). Settembre-Blundo *et al.* (2021) explain that ERM reduces the probability of risks that are detrimental to society and the environment. Thus, the execution of ERM is imperative for diagnosing and better understanding emerging risks (Kas'yanov *et al.*, 2018). According to Settembre-Blundo *et al.* (2021), ERM minimizes ecological criticalities and improves GG. A related study argues that ERM implementation is advantageous to enhance GG (Sarkis, 2006). Renowned practitioners have urged ERM implementation as a proactive approach to managing financial and ESG risks (COSO and WBCSD, 2018) and increasing a firm's GG. Villiers *et al.* (2022) suggest that ERM procedures effectively manage ecological risks and increase the firm's GG. Given the aforementioned theoretical and empirical discussion on the usefulness of ERM and its relationship with GG and its dimensions, we test the following hypotheses:

Hypothesis (H_1): *ERM has a significant positive impact on GG.*

Hypothesis (H_2): *ERM has a significant positive impact on ERP.*

Hypothesis (H_3): *ERM has a significant positive impact on EOPR.*

Hypothesis (H_4): *ERM has a significant positive impact on NAB.*

3. Methodology

3.1 Research Sample

Notably, the O&G industry is the riskiest in terms of exacerbating the natural environment (Shah *et al.*, 2022b). Its operations have both positive and negative effects on the economic and environmental performance, thereby posing considerable risks to stakeholders. Particularly, this study focuses on the Malaysian O&G industry due to its prominent global position, being the world's third-largest exporter of liquefied natural gas and the second-largest O&G producer in Southeast Asia (Shad *et al.*, 2020). Beyond its core business, this industry strengthens environmental regulations and frameworks by advocating for green technologies and conservation practices essential for advancing the sustainability agenda. Hence, this study targeted publicly listed Malaysian O&G companies. We used census sampling to analyze all 30 firms listed on Bursa Malaysia. Census sampling eliminates ambiguity and errors in data, as it considers each element of the population for analysis (Singh and Masuku, 2014). The data collection period spanned ten years, from 2012 to 2021. We chose 2012 as the starting year for our study because this was the year when publicly listed companies in Malaysia were required to implement risk management practices to mitigate sustainability-related risks, as outlined in the Malaysian Code of Corporate Governance (Aziz *et al.*, 2015). Annual and sustainability reports were the primary sources of data for our study.

3.2 Variables' Measurement

3.2.1 Independent Variable. In our study, the independent variable is ERM implementation. Prior studies have applied various methods to measure ERM. For instance, Shad *et al.* (2022) source annual reports and perform content analysis using five levels to determine a company's ERM implementation. Beasley *et al.* (2005) measure ERM using survey-based methods. Moreover, some studies have produced ERM indexes (Gordon *et al.*, 2009; Monda and Giorgino, 2013). For instance, Shah *et al.* (2022b) proposed an ERM index by integrating ESG elements into the risk governance framework based on the recommendations given by COSO and World Business Council for Sustainable Development (WBCSD). Our study follows the same ESG risk management guidelines and adapts Shah *et al.* (2022b) ERM measurement.

The guidelines by COSO and WBCSD (2018) focus on ESG risks and opportunities for mainstream businesses and other organizations worldwide. The main purpose is to improve organizations' resilience as they increasingly confront the prevalence and severity of ESG risks, ranging from climate change to product safety recalls. Prior studies have highly recommended content analysis. According to Landrum and Ohsowski (2018), (p. 5), content analysis is "a type of textual analysis that studies the messages or characteristics of a text to interpret meaning." This technique is significant in measuring and analyzing an entity's position and trends in disclosure (Guthrie *et al.*, 2004). Indeed, numerous studies have favored the weighted content analysis technique (Shad *et al.*, 2019; Hamad *et al.*, 2020; Hamad *et al.*, 2022) because researchers can easily quantify the meaning of certain words or concepts. Similar to Shad *et al.* (2022), this study also explores textual words using keywords and converts them into quantitative data.

In the weighted content analysis, each dimensional element is coded with scores of "0" or "1." If the element of ERM is neither practiced nor reported in a company's annual reports, it is coded with a score of "0." If a company disclosed information on the elements of ERM, it was scored as "1." After coding the elements, the scores given (X) to the elements are summed up and divided by the total number of elements (N) to obtain the level of ERM. Mathematically, the ERM value is identified by the following equation:

$$\mathrm{ERM} = \frac{\sum \mathrm{X}}{\mathrm{N}}$$

where,
X = score of 0 or 1 as mentioned above.
N = the total score of ERM element disclosed (i.e., 38)

The ERM value ranges between 0 and 1. The value of 0 indicates a null ERM while the value of 1 indicates a full ERM. The elements of ERM are given in the Appendix section.

3.2.2 Dependent variable. The dependent variable is GG. The OECD (2017) has presented a comprehensive framework for GG, consisting of five interconnected dimensions: (1) "environmental and resource productivity," (2) "natural asset base," (3) "environmental dimension of quality of life," (4) "economic opportunities and policy responses," and (5) "socio-economic context." However, this framework is primarily designed for assessing GG at the macro-level and may not be directly applicable for measuring GG at the firm-level, as the elements of GG are often not reported by individual companies. To examine GG at the firm level, we have developed an index based on the guidelines provided by the OECD. We have extracted the relevant elements from dimensions 1 and 3 of the OECD framework and combined them into a single dimension called "environmental and resource productivity" (ERP). We have excluded the fifth dimension of the OECD framework, as its elements such as population age, life expectancy at birth, and real GDP per capita, are not directly applicable to GG at the firm level. Hence, our proposed GG index comprises three dimensions: (1) environmental and resource productivity (ERP), (2) economic opportunities and policy responses (EOPR), and (3) natural asset base (NAB). We have transformed the relevant GG indicators into firm-level practices, which are included in the GG index. Table I provides the relevant details**.**

Insert Table I

The elements included in the GG index share similarities with the concept of "networking" as they are interconnected. These GG elements should encompass economic, social, and ecological aspects since company operations are intertwined with these issues. Therefore, we have merged these indicators to provide a comprehensive perspective of GG, which reflects both financial and social benefits.

The first dimension, ERP, consists of six essential elements that offer a comprehensive understanding of GG. The first five elements (reducing CO2 emissions, designing green products, consuming renewable energies, eco-innovation, and recycling waste) showcase the company's environmental conservation efforts. These indicators measure how efficiently economic activities, including production and consumption, utilize energy, natural resources, and environmental services. The sixth element (health and safety) is linked to the social aspect, highlighting the organization's commitment to supporting the well-being of its employees. This indicator illustrates the connection between the environmental risks, the overall quality of life, and well-being of individuals or workers.

The second dimension, EOPR, comprises six elements that capture the financial expenditures and benefits associated with GG. Companies that invest in research and development, knowledge-sharing sessions, environmental protection, innovation practices, and register environmental-related patents are likely to enhance their GG. Additionally, a reduction in environment-related taxes signifies a proactive approach to GG. These indicators focus on measuring the economic benefits that come with GG, such as markets for environmentally friendly products and the employment opportunities companies create. Firms track policy actions taken to facilitate the transition towards GG and eliminate obstacles, such as environmental taxes, and innovation policies. Moreover, companies use these indicators to evaluate how effective the policies are in promoting GG.

The third dimension, NAB, includes three crucial elements: water recycling, forestation/plantation, and biodiversity. These indicators in NAB show if the "natural asset base" is being maintained within sustainable limits in terms of quantity, quality, and value. Their main purpose is to identify risks to future growth that may come from a decreasing or damaged natural asset base. To assess progress in this area, companies can monitor the number of natural resources and other environmental assets, as well as the provision of environmental services. Companies heavily rely on NAB to foster GG. The extraction and utilization of resources, such as oil and gas, can impact the well-being of mammals and aquatic vertebrates. Therefore, adhering to the elements of NAB can contribute to the enhancement of GG. Adopting a proactive approach toward NAB can guide firms toward achieving GG.

The relevance of the aforementioned dimensions and elements to the GG index has been validated by industry and academic experts. Literature suggests employing three to ten experts to validate the proposed index or questionnaires (Rubio *et al.*, 2003). However, the exact number of experts depends on the researchers (Rubio *et al.*, 2003). In this study, two industry experts from the O&G industry and two academic experts are employed to validate the GG index. The two industry experts are General Managers in their respective organizations. The academic experts include a Professor and an Associate Professor from the related field. The four experts reviewed and validated the dimensions and elements of the GG index and provided suggestions to ensure the reflection of GG at the firm level. Finally, the GG index retained three dimensions and 15 elements.

GG is computed using a weighted content analysis of its annual report. The three coding options of “2,” “1,” and “0” are used to measure GG. A score of “2” is assigned to an element of GG if it is fully disclosed in detail with figures, tables, or numbers; a score of “1” is assigned if the element of GG is generally disclosed without details; a score of “0” is assigned if the element of GG has not been disclosed in the report. The content analysis was conducted using a coding technique with the options “2”, “1” and “0,” and this method has been used in previous studies (Shad *et al.*, 2020; Hamad *et al.*, 2022). The GG score of a company is computed using ratio of total score of elements disclosed (X) over the maximum score of disclosed items (N). Mathematically, the value of GG is obtained using the following equation:

$$\text{Green Growth (GG)} = \frac{\Sigma X}{N}$$

where,
X = score of 2, 1 or 0 as mentioned above.
N = the total score of GG element disclosed (i.e., 30)

Content analysis has gained prominence in academia but has a subjectivity bias, which can occur in data collection and coding. To overcome such limitations and ensure the coding reliability, we followed Hamad *et al.* (2023) and collected data by two authors. After individually reading each report, both authors extracted and coded the data. The scores are compared to check for significant differences and adjustments are made accordingly. Later, we followed Gunawan *et al.* (2020) and reviewed the data by two more researchers. They randomly picked 10 years of data from three companies (10 percent of our firm-year observations) and searched the elements in the annual reports. Both techniques ensure the coding reliability applied to extract information from the annual reports (Gunawan *et al.*, 2020; Hamad *et al.*, 2023). To guarantee the reliability of the coding technique, we conduct an inter-rater reliability test, “Krippendorff's alpha,” as an additional measure. The coefficient values of 0.907 and 0.937 confirm the inter-rater reliability and consistency of the ERM and GG scores, respectively. The high coefficient demonstrates that the scores are highly consistent and trustworthy.

3.2.3 Control variables. Although the effect of control variables remains constant in the regression analysis, including them in the model is important for minimal confounding and extraneous impact of other variables. Without control variables, the results might be skewed and unfair and indicate experimental manipulation. Based on the previous literature on ERM and ecological performance, this study uses the following five control variables: return on asset (ROA) (Anton, 2018; Shad *et al.*, 2022), firm size (Chairani and Siregar, 2021), firm age (Shad *et al.*, 2022), sustainability committee, and leverage (Nguyen and Vo, 2020). ROA can be an influential factor in GG (Walls *et al.*, 2012) because companies with enhanced profitability might have a high capacity to bear costs associated with environmental practices that improve GG (Orazalin and Mahmood, 2021). ROA is computed as net income divided by total assets. Firm size is controlled because larger businesses typically recognize environmental challenges as a top management priority and more successfully implement environmental protection practices to foster GG (Walls *et al.*, 2012). It is measured as the natural log of total assets (FSIZE). It is imperative to control firm age because older firms are highlighted more in media for ecological degradation. Thus, they are concerned with enhancing GG to reflect a good corporate image (Orazalin *et al.*, 2019). Firm age is the natural log of the number of years since the firm was established (FAGE).

Additionally, sustainability governance plays an important role in contributing to the sustainable development of a firm. It includes a sustainability committee that assists the organization in managing ESG risks and improving firm's GG (Villiers *et al.*, 2022); therefore, we control for its effect. The sustainability committee (SC) is a dummy variable, given a value of "1" when it is available in the firm and "0" otherwise. Finally, leverage is controlled because firms with high leverage value might be less interested in GG. The effect of leverage was controlled in the previous studies (Walls *et al.*, 2012; Orazalin and Mahmood, 2021) to examine GG. It is computed as total debt over total assets (LEV).

3.3 Model specification

Stakeholders expect adequate contributions toward GG from companies. Various firm factors can be used to enhance GG, including ERM. Researchers have amply studied GG as a dependent variable (Guo *et al.*, 2020; Hajar *et al.*, 2020; Hickel and Kallis, 2020; Rauf *et al.*, 2020; Fernandes *et al.*, 2021). Furthermore, ERM has been examined as an explanatory variable (Shad *et al.*, 2022). Based on the aforementioned studies, we develop the following models.

$$GG_{it} = \beta_0 + \beta_1 ERM_{it} + \beta_2 FAGE_{it} + \beta_3 LEV_{it} + \beta_4 FSIZE_{it} + \beta_5 SC_{it} + \beta_6 ROA_{it} + U_{it} \quad \text{(Model 1)}$$

$$ERP_{it} = \beta_0 + \beta_1 ERM_{it} + \beta_2 FAGE_{it} + \beta_3 LEV_{it} + \beta_4 FSIZE_{it} + \beta_5 SC_{it} + \beta_6 ROA_{it} + U_{it} \quad \text{(Model 2)}$$

$$EOPR_{it} = \beta_0 + \beta_1 ERM_{it} + \beta_2 FAGE_{it} + \beta_3 LEV_{it} + \beta_4 FSIZE_{it} + \beta_5 SC_{it} + \beta_6 ROA_{it} + U_{it} \quad \text{(Model 3)}$$

$$NAB_{it} = \beta_0 + \beta_1 ERM_{it} + \beta_2 FAGE_{it} + \beta_3 LEV_{it} + \beta_4 FSIZE_{it} + \beta_5 SC_{it} + \beta_6 ROA_{it} + U_{it} \quad \text{(Model 4)}$$

In these models, individual firm and time are denoted with *i* and *t*, respectively. Firm *i*'s GG (GG_{it}) is the dependent variable and ERM (ERM_{it}) is the independent variable. To examine ERM's effect on the sole dimension of GG, we develop three models labelled 2, 3, and 4, where ERP_{it},

$EOPR_{it}$, and NAB_{it} are the dependent variables of firm *i*, respectively. The control variables include firm age ($FAGE_{it}$), leverage (LEV_{it}), firm size ($FSIZE_{it}$), sustainability committee (SC_{it}), and return on asset (ROA_{it}). β_0, β_1, β_2, β_3, β_4, β_5, and β_6 are the parameters and U_{it} is the error term.

3.4 Estimation Methodology

The most common assumptions of panel data include data stationarity, multicollinearity, autocorrelation, heteroscedasticity, and endogeneity. Hence, prior to regression analysis, diagnosing the data to test these assumptions is important.

Table II presents the unit root test to check the stationarity of the data. The probability for each variable is zero, indicating that all the variables are stationary at the first level.

Insert Table II

Table III presents the outcome of the variance inflation factor (VIF), Durbin-Watson (DW) and Breusch -Pagan tests to show whether multicollinearity, autocorrelation, and heteroskedasticity exist. As the centered VIF values are less than six, we conclude that our panel is free of multicollinearity (Shahzad *et al.*, 2023). Furthermore, we applied DW to check the autocorrelation in the regression model. The range of DW is from 0 to 4. A DW value below or above 2 indicates positive and negative autocorrelation, respectively. The accepted range of DW is 1.5 to 2.5. Our data suffer from positive autocorrelation because the DW value is below 1.5. To deal with model misspecification issues caused by autocorrelation, Granger and Newbold (1974) (p. 117) recommend to “either include a lagged dependent variable or take first differences of the variables involved in the equation or to assume a simple first-order autoregressive form for the residual of the equation.” Hence, in this study, the issue of autocorrelation is resolved by taking lagged independent variables. The assumption of heteroskedasticity is checked using the Breusch-Pagan test. The probability of each model is lower than 5%; this shows that our regression models are exposed to heteroskedasticity. This issue is resolved using the White (1980) robust estimator. Prior studies have used a similar method to deal with heteroskedasticity (Shahzad *et al.*, 2023; Shah *et al.*, 2024).

Insert Table III

Endogeneity refers to a condition where the predictor variable correlates with the residuals. Regression models with endogeneity issues provide inconsistent estimates, potentially leading to incorrect theoretical interpretations and erroneous coefficient signs. Ullah *et al.* (2018) advocate the absence of a direct statistical test for endogeneity detection because the residuals in endogeneity bias are imperceptible. Therefore, researchers are unsure whether the issue of the correlation between residuals and predictor variables can be completely resolved (Roberts and Whited, 2013). However, endogeneity can be dealt with two-stage least-squares (2SLS) regression models (Shahzad *et al.*, 2023). Thus, we applied 2SLS to overcome endogeneity issues.

Moreover, we applied the Hausman test to select between the fixed effect model (FEM) and random effect model (REM). Shah *et al.* (2022a) argue that the FEM applies when the error terms and explanatory variables are interrelated. The REM is used when no relationship exists between the residuals and explanatory variables (Shah *et al.*, 2018; Tahir *et al.*, 2018). Hence, this study uses FEM based on the outcome of the Hausman test (probability less than 5%).

4. Results and discussions

4.1 Descriptive statistics

Table IV presents the variables and briefly explains the descriptive statistics of 300 observations spanning ten years (2012–2021). The mean value of ERM implementation in Malaysian O&G firms is 30.16% with a standard deviation of 0.1438. The minimum value of zero means that some firms have not yet implemented ERM to overcome their ESG risks. GG has an aggregate value of 40.20% with a standard deviation of 0.1549. This shows that the O&G firms are good contributors of GG. Among the dimensions of GG, ERP has the highest mean value (47.41%), followed by EOPR (38.58%) and NAB (29.53%). This indicates that ERP contributes the most toward the GG of Malaysian O&G firms, compared to EOPR and NAB. The natural log is taken for firm age and size. The reported mean values of FAGE and FSIZE are 1.33 and 6.11 with standard deviations of 0.2816 and 0.5754, respectively. On average, the leverage value of O&G companies is 0.3027 with a standard deviation of 0.2063. Regarding the ROA, the results indicate a mean of 0.0206 with a standard deviation of 0.1565. Moreover, it is given that 77.66% of the sample firms have sustainability committees.

Insert Table IV

4.2 Pearson correlation analysis

The correlation among the dependent, independent, and control variables is analyzed using Pearson correlation. The results are presented in Table V. The correlation analysis shows that the dependent and independent variables are positively correlated. ERM demonstrates a significant correlation with GG and its sub-dimensions ERP, EOPR, and NAB, suggesting that the GG of companies is positively associated with ERM. Regarding control variables, FSIZE, FAGE and SC demonstrate a significant positive correlation with GG, EOPR, ERP, and NAB. Conversely, LEV and ROA are negatively correlated with GG, ERP, EOPR, and NAB.

Insert Table V

4.3 Regression results and discussion

This study investigates the relationship between ERM and GG, as well as how ERM influences the dimensions of GG. Hence, ERM, GG, EOPR, ERP, and NAB are the variables of interest. The regression analysis is conducted using three different approaches: pooled OLS, GLS, and 2SLS. The results obtained using pooled OLS are reported in the first four columns of Table VI. The findings show that ERM influences GG and its three dimensions EOPR, ERP, and NAB at a standard level. The control variable FSIZE demonstrates a significant relationship with GG, ERP and NAB. Furthermore, FAGE has a positive impact on EOPR. LEV is negatively related to ERP and NAB. Given that pooled OLS analysis ignores the individual specific effects and violates the panel data basic assumptions like heteroscedasticity, autocorrelation, and expected endogeneity, thereby these results are not reliable. Additionally, we run the Breusch–Pagan LM test on the random-effects models (REM). The results of this test showed a significant p-value, indicating that the REM is more appropriate than the OLS model.

Therefore, to avoid the statistical issues of panel data, we apply GLS on Models 1, 2, 3, and 4. The results of the GLS estimation are reported in the last four columns of Table VI. The decision to choose between FEM GLS and REM GLS is based on the p-value of the Hausman test. A P-value of less than 5% suggests that FEM GLS should be applied (Shah *et al.*, 2022a). The GLS analysis shows that the impact of ERM on GG (column 5) is positive and statistically significant. This implies that if organizations implement ERM, their GG will increase by 62.70%. The finding is consistent with the conceptualized study of Lai *et al.* (2021) and related theories, such as the legitimacy, ecological modernization and stakeholder theories. Thus, the findings validate H1 which posits that ERM increases the GG of the firm. To better understand which dimension of GG is the most influenced by the implementation of ERM, we separately run regression on Models 2, 3, and 4. The results show that ERM significantly positively impacts ERP (column 6), EOPR (column 7), and NAB (column 8) at the standard level. These results validate H2, H3 and H4. However, a significant difference is seen in terms of the coefficient values.

Specifically, ERM implementation increases GG by contributing 17.36% to ERP, 4.37% to EOPR, and 6.16% to NAB. Based on our analysis, we contend that an increase in GG is caused by a transmission of ERP, EOPR and NAB. The control variable FAGE negatively impacts ERP (column 6), EOPR (column 7), and NAB (column 8). Similarly, LEV has a negative significant effect on ERP (column 6) at the standard level. Furthermore, the results show that the impact of FSIZE is negative on the overall GG (column 5). Conversely, SC has a positive effect on ERP and no significant effect of ROA is observed on firms' GG. The observed R-squared value is 0.7238 for Model 1 (column 5), 0.7814 for Model 2 (column 6), 0.8832 for Model 3 (column 7), and 0.8960 for Model 4 (column 8). Therefore, the models have significantly explained the variability in the target variables. The GLS regression analysis has enhanced the R-squared values when compared to the pooled OLS analysis.

Our results are consistent with the legitimacy, ecological modernization, and stakeholder theories and the alluded concept of Lai *et al.* (2021). However, the findings are inconsistent with those of Sarkis (2006), who examined the negative effect of ERM on environmental performance. Sarkis (2006) argued that the negative result is caused by the late implementation of ERM practices. The ecological modernization theory argues that organizations can achieve sustainable development by protecting the environment and fostering economic growth. This equilibrium is possible when business firms implement ERM to proactively deal with operations that influence the triple bottom line of an organization (Kachynska *et al.*, 2022).

Moreover, legitimacy and stakeholder theories underline the interest of all stakeholders that can be ensured through ERM implementation. Raharjo and Hasnawati (2022) state that ERM aligns organizational practices with strategy and aligns its operations with ecological laws and regulations, which increases the firms' GG. According to Kachynska *et al.* (2022), organizations can build a good relationship with stakeholders through ERM implementation that mitigates ecological risks and increases GG. Diakaki *et al.* (2006) propose that a firm can increase GG by reducing ecological degradation through risk management. Our findings are consistent with the aforementioned studies that ERM increases firms' GG.

Insert Table VI

4.4 Robustness testing

In empirical studies, we cannot rely only on the initial investigations. It is crucial to perform robustness tests and confirm the sensitivity of the original findings. This study performs robustness checks in three ways, as shown in Table VII. First, we changed the estimation technique and conducted a 2SLS analysis. The 2SLS analysis is preferred to ensure that the results would be free of endogeneity issues. Second, we changed our dependent variable and proxied it with ecological performance; that is, environmental sustainability performance. Previous studies have used environmental performance as a proxy for GG (Saufi *et al.*, 2016; Capozza and Samson, 2019). Third, we separately run the regression analysis without considering the effect of control variables. Subsequently, the outcomes of our interest variables remain the same in terms of the significance level and coefficient signs, as the original results reported in Table VI.

Insert Table VII

4.5 Heterogeneity Analysis

In addition to the baseline regression analysis, this study performs heterogeneity analyses to explore the variation in the impact of ERM on a firm's GG across different factors. These factors include the presence or absence of a sustainability committee, firm size (categorized as large if total assets exceed the sample mean), and different time frames (before COVID-19 and after COVID-19). The results presented in Table VIII indicate that ERM significantly enhances GG when a sustainability committee (SC) is present on the board. Conversely, ERM has no significant impact on GG in the absence of SC leading to insignificant coefficients. The results indicate that enterprises with SC significantly implement ERM for ESG risks and uplift GG. According to Shah *et al.* (2021), companies with SC, also known as green committees, possess greater capabilities to handle sustainability risks. Their strategic insights into risk management contribute to the overall GG of the enterprise. This argument is further supported by Burke *et al.* (2019), who highlight the role of SC in identifying sustainability-related opportunities. Similarly, Biswas *et al.* (2018) assert that SC plays a vital role in improving firms' environmental performance, thereby enhancing GG. Previous studies by Li *et al.* (2023) and Burke *et al.* (2019) have emphasized the significance of considering SC as a heterogeneous factor in the context of GG.

Moreover, columns 3 and 4 of Table VIII present the effect of ERM on GG for large-size and small-size firms. The positive impact of ERM on GG is more pronounced for larger firms. A one-unit increase in ERM level led to a 0.094-unit improvement in GG for larger firms, while the effect is statistically insignificant for smaller firms. Stakeholder and resource-based view (RBV) theories are essential to explain this disparity. Larger firms face greater public scrutiny due to the excess use of natural resources and causing damage to the environment. As per stakeholder theory, such firms experience heightened pressure from suppliers, customers and regulators and the media coverage compels them to prioritize both environmental preservation and economic growth. In this purview, the strong base of ERM implementation assists large firms in addressing emerging sustainability challenges that not only contribute to enhanced GG but also strengthen stakeholder relationships. As per RBV theory, larger firms, due to their greater resources and capabilities, are better positioned to implement robust ERM practices effectively. Subsequently, the seamless integration of ERM into business operations assists larger firms in managing ESG risks, leading to a more substantial positive impact on GG. In comparison, smaller firms face resource constraints and limited organizational capacity. Thus, implementing ERM practices becomes challenging for smaller firms. Consequently, smaller firms with confined capabilities are highly exposed to ESG risks that hinder their GG. Furthermore, the difference in outcomes regarding the impact of ERM on GG for larger and smaller firms could be influenced by market dynamics and competition. In the contemporary world, enterprises overcome ESG risks as it facilitates easy access to capital markets at lower interest rates. In such a way, larger firms with stronger market competitiveness and bargaining power may invest more in risk management as a strategic differentiator to maintain their market position and reputation. This ultimately results in the form of improved GG because of managing ESG risks through ERM implementation. In contrast, smaller firms may prioritize short-term financial objectives and survival, thereby placing less emphasis on ERM and its potential impact on GG.

Moreover, the analysis of heterogeneity highlights the influence of various timeframes (before and after COVID-19) on the nexus between ERM and GG. To delve deeper into this aspect, we conducted subsample analysis, as shown in columns 5 and 6 of Table VIII. The findings indicate that ERM significantly impacts GG in both periods. The rationale for the significant impact of ERM on GG both before and after COVID-19 could be due to enterprises' large focus on ESG risk management to maintain organizational resilience and competitiveness. ERM may have been recognized as a critical tool for navigating uncertainties and mitigating risks, regardless of the specific challenges that originated due to COVID-19. Companies with robust ERM frameworks are better positioned to adapt to the changing circumstances and capitalize on emerging opportunities, leading to sustained positive effects on GG.

Insert Table VIII

5. Conclusion

Prior studies, such as Fernandes *et al.* (2021), Hickel and Kallis (2020), Guo *et al.* (2020), and Capozza and Samson (2019), examine various factors that ease the drive toward non-financial performance, such as GG. Among the factors, ERM is dominant, contributing to a firm’s GG. This study investigates the impact of ERM on the GG of Malaysian O&G companies. The analysis period is constrained to ten years, from 2012 to 2021. Given that the study uses balanced panel data, pooled OLS and GLS estimation techniques are employed.

Furthermore, the robustness of the findings is checked using 2SLS. The results of the study reveal a significantly positive association between ERM and a firm’s GG. The current empirical evidence cements the concept of Lai *et al.* (2021), suggesting that ERM implementation reduces sustainability-related risks and ultimately advances a firm’s GG. The integration of ERM in a company’s operations is found to minimize ESG risks and increase GG. The perspectives of ecological modernization and stakeholder theories align with our finding that proposes ERM as a management tool to enhance a firm’s GG.

This study provides new insights into the relationship between ERM and GG and offers several management implications. If companies want to significantly contribute to a country’s GG, we suggest that managers and policymakers integrate the ESG risk factors into the ERM framework.

For managers, GG policies should be included in the risk management agenda. Particularly for O&G companies with enormous carbon emissions and lower GG, engagement in ERM implementation will enhance GG and benefit all stakeholders while providing protection for long-term investors. Based on the outcome of the study, regulators are advised to formulate guidelines for the enhancement of GG in the code of corporate governance to encourage the companies toward it. Moreover, regulators should focus on the establishment of a robust ERM framework to manage ecological, social, and governance risks in a holistic manner.

The study extends the risk management literature by considering COSO and WBCSD (2018) ERM for ESG risks and examining its impact on the GG. We developed an index to measure GG that provides a base for future researchers to compute GG at the firm-level. This index can also be used by different stakeholders (companies and managers) to assess the progress of their GG. Our study demonstrates that organizations tend to emphasize ERM to mitigate ESG risks and foster GG. The O&G firms that cause ecological degradation can sustain their sustainable development by engaging in ERM activities. This study contributes to legitimacy, ecological modernization, and stakeholder theories by relating them with the empirical analyses of ERM and GG.

The existing study has limitations that can be addressed in future research studies. Firstly, the sample is confined to the O&G sector in Malaysia, potentially limiting the generalizability of the findings to the global O&G industries. Hence, future studies should gather data from diverse markets to improve insights and broaden implications. Secondly, this study used content analysis to compute ERM and GG. This method carries some limitations, such as subjectivity bias which could be in data collection, coding and measuring. Nevertheless, we tried to mitigate this issue by double coding process. Moreover, we suggest future studies utilize primary data to examine potential differences in outcomes. We encourage future researchers to test the proposed GG index across various industries/countries. Lastly, academicians are urged to probe the relationships among firm-level factors, such as corporate governance, sustainability practices, and sustainability committees with GG.

Table I Measurement Index for the Green Growth

Dimension (D)	No	Proxy Elements
Dimension 1 Environmental and Resource Productivity (ERP)	GG-1	Reduction in company’s greenhouse gas emissions.
	GG-2	Company’s engagement in designing products to reduce energy consumption.
	GG-3	Company’s engagement in the utilization of renewable energy sources instead of conventional energy sources
	GG-4	Company’s engagement in eco-innovation
	GG-5	Company’s engagement in the recycling of waste and reuse materials
	GG-6	Company’s engagement in improving employees’ health and safety

Dimension 2 Economic Opportunities & Policy Responses (EOPR)	GG-7	Company's investment in R & D related to the environment
	GG-8	The company registers environmental-related patent applications under Patent Cooperation Treaty.
	GG-9	Company's investment in environmental protection
	GG-10	Company's investment in environmental innovation practices.
	GG-11	Reduction in the company's environmental-related taxes
	GG-12	Company's engagement in training and knowledge sessions related to the environment
Dimension 3 Natural Asset Base (NAB)	GG-13	Company's engagement in the recycling of water
	GG-14	Company's engagement in forestation/plantation
	GG-15	Company's engagement in biodiversity and ecosystem practices

Source: Authors own work

Table II: Unit Root Test

No	Variable	Test	Statistics	P-Value	Result
1	GG	Levin-Lin-Chu unit root test	-16.40	0.00	Panels are stationary
2	ERM		-2.33	0.00	Panels are stationary
3	ERP		-16.20	0.00	Panels are stationary
4	EOPR		-6.42	0.00	Panels are stationary
5	NAB		-4.78	0.00	Panels are stationary
6	FAGE		-50.29	0.00	Panels are stationary
7	LEV		-3.37	0.00	Panels are stationary
8	FSIZE		-5.049	0.00	Panels are stationary
9	SC		-5.66	0.00	Panels are stationary
10	ROA		-4.99	0.00	Panels are stationary

Source: Authors own work

Table III: Diagnostic Testing for Multicollinearity, Autocorrelation, and Heteroskedasticity					
Variance Inflation Factor (VIF)		Models	Durbin-Watson	Breusch Pagan Test	
Variables	ERM		Stats.	Chi2	Prob.
ERM	1.14	Model 1	1.4307	35.06	0.00
FAGE	1.06	Model 2	1.2004	23.03	0.00
LEV	1.10	Model 3	1.3671	64.30	0.00
FSIZE	1.19	Model 4	1.4177	4.77	0.00
SC	1.05				
ROA	1.21				

Source: Authors own work

Table IV: Descriptive statistics					
Variables	Obs.	Mean	Maximum	Minimum	Std. Dev.
ERM	300	0.3016	0.4754	0.00	0.1438
GG	300	0.4020	0.8333	0.00	0.1549
EOPR	300	0.3858	0.8333	0.00	0.1373
ERP	300	0.4741	1.00	0.00	0.1916
NAB	300	0.2953	0.8333	0.00	0.1912
FAGE	300	1.33	1.78	0.00	0.2816
LEV	300	0.3027	1.18	0.0001	0.2063
FSIZE	300	6.11	7.57	3.84	0.5754
SC	300	0.7766	1	0	0.4171
ROA	300	0.0206	0.8206	-1.46	0.1565

Source: Authors own work

Table V Pearson correlation analysis										
	1	2	3	4	5	6	7	8	9	10
GG (1)	1.000									
ERM (2)	0.509[a]	1.000								
EOPR (3)	0.914[a]	0.400[a]	1.000							
ERP (4)	0.966[a]	0.530[a]	0.843[a]	1.000						
NAB (5)	0.794[a]	0.421[a]	0.571[a]	0.692[a]	1.000					
FAGE (6)	0.133[b]	0.039	0.132[b]	0.103[b]	0.414[b]	1.000				
LEV (7)	-0.005	0.112[c]	0.073	-0.040	-0.040	-0.102[c]	1.000			
FSIZE (8)	0.240[a]	0.194[a]	0.142[b]	0.247[a]	0.270[a]	0.166[a]	0.165[a]	1.000		
SC (9)	0.024	0.082	0.037	0.063	0.024	-0.090	0.027	0.101[c]	1.000	
ROA (10)	-0.062	-0.230[a]	-0.028	-0.069	-0.072	0.075	-0.185[a]	0.200[a]	0.136[b]	1.000
[a, b,] and [c] show significance levels at 1%, 5%, and 10%.										

Source: Authors own work

Table VI Regression analysis

	Pooled OLS				GLS Fixed Effect Model			
	Model 1 GG	Model 2 ERP	Model 3 EOPR	Model 4 NAB	Model 1 GG	Model 2 ERP	Model 3 EOPR	Model 4 NAB
ERM	0.5265[a] (0.0564)	0.6738[a] (0.0685)	0.3886[a] (0.0537)	0.5077[a] (0.0731)	0.6270[a] (0.0442)	0.1736[a] (0.0456)	0.0437[a] (0.0152)	0.0616[a] (0.0229)
FAGE	0.0438 (0.0278)	0.0309 (0.0337)	0.0507[c] (0.0264)	0.0558 (0.0360)	-0.1344[a] (0.0493)	-0.0512[a] (0.0164)	-0.0387[c] (0.0200)	-0.0283[b] (0.0133)
LEV	-0.0554 (0.0387)	-0.1141[b] (0.0470)	0.0319 (0.0368)	-0.1128[b] (0.0501)	-0.0480 (0.0337)	-0.0686[a] (0.0258)	0.0063 (0.0106)	0.0191 (0.0210)
FSIZE	0.0393[a] (0.0144)	0.0545[a] (0.0175)	0.0076 (0.0137)	0.0724[a] (0.0187)	-0.0841[a] (0.0188)	0.0127 (0.0209)	0.0111 (0.0084)	0.0235 (0.0179)
SC	-0.0081 (0.0186)	0.0068 (0.0226)	-0.0250 (0.0177)	-0.0045 (0.0242)	-0.0007 (0.0125)	0.0202[c] (0.0112)	0.0045 (0.0036)	0.0012 (0.0047)
ROA	0.0039 (0.0535)	-0.0176 (0.0649)	0.0618 (0.0509)	-0.0685 (0.0693)	0.0181 (0.0135)	-0.0018 (0.0092)	0.0036 (0.0049)	0.0019 (0.0074)
R^2	0.2941	0.3202	0.1858	0.2379	0.7238	0.7814	0.8832	0.8960
Adj R^2	0.2797	0.3062	0.1692	0.2223	0.6872	0.7477	0.8652	0.8799
F-statistic	20.35	23.00	11.15	15.25	19.77	23.14	48.92	55.79
Prob (F-statistic)	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000
Hausman Test	–	–	–	–	Chi- Sq: 28.04 Prob. (0.001)	Chi- Sq: 24.90 Prob. (0.003)	Chi- Sq: 27.33 Prob. (0.001)	Chi- Sq: 15.93 Prob. (0.007)
Durbin-Watson stat.	0.4307	0.5004	0.3671	0.4177	2.081	2.077	2.089	2.263

Note: The dependent variable is "green growth (GG), environmental and resource productivity (ERP), economic opportunities and policy responses (EOPR), and natural asset base (NAB)." Enterprise risk management (ERM) is the independent variable. Firm age (FAGE), leverage (LEV), firm size (FSIZE), sustainability committee (SC), and return on asset (ROA) are control variables. The standard errors are in the parenthesis. [a, b] and [c] show significant levels at 1%, 5%, and 10% respectively.

Source: Authors own work

Table VII Robustness testing			
	GG (2SLS)	ESP (FE)	GG (FE)
ERM	0.4876[a] (0.0530)	0.9357[a] (0.0334)	0.6140[a] (0.0495)
FAGE	-0.1327[a] (0.0262)	-0.0445 (0.0716)	–
LEV	-0.0485[b] (0.0191)	-0.0400 (0.0266)	–
FIZE	0.0827[a] (0.190)	0.0523[a] (0.0160)	–
SC	0.0033 (0.0096)	0.0267[b] (0.0116)	–
ROA	0.0099 (0.0117)	0.0183 (0.0243)	–
R^2	0.6896	0.8605	0.7116
Adj R^2	0.6432	0.8420	0.6795
F-test	14.85	46.54	22.13
Prob (F-statistic)	0.000	0.000	0.000
Hausman- Test	–	Chi-Sq: 18.52 Prob: (0.001)	Chi-Sq: 11.88 Prob: (0.001)

Note: The dependent variable is green growth (GG), and environmental sustainability performance.” Enterprise risk management (ERM) is the independent variable. Firm age (FAGE), leverage (LEV), firm size (FSIZE), sustainability committee (SC) and return on asset (ROA) are control variables. The standard errors are in the parenthesis. [a] and [b] show significant levels at 1% and 5%, respectively. The probability of the Hausman test less than 5 % indicates a fixed-effect estimation model.

Source: Authors own work

Table VIII Heterogeneity analysis						
	Sustainability Committee	No Sustainability Committee	Large Size Firms	Small Size Firms	Before Covid-19	After Covid-19
ERM	0.5235[a] (0.1289)	0.0945 (0.0602)	0.5842[a] (0.0700)	0.6799 (0.5579)	0.5571[a] (0.0594)	0.7089[a] (0.2331)
Control Variables	YES	YES	YES	YES	YES	YES
constant	0.1216 (0.2133)	-0.3371 (0.2141)	-0.1251 (0.1516)	-0.2808 (0.3383)	0.0738 (0.1108)	0.2157 (0.1165)
N	100	200	140	160	240	60
R^2	0.4383	0.8005	0.7676	0.6654	0.6984	0.3314
Adj R^2	0.4085	0.7732	0.7308	0.6144	0.6466	0.2557
The standard errors are in the parenthesis. [a] show significant levels at 1%, respectively.						

Source: Authors own work

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Appendix – I ERM Index

Dimensions (D)	No	Proxy Elements
Dimension 1 (D1) Governance and culture for ESG-related risks	ERM-1	Information on a charter of the board for ESG-related risks?
	ERM-2	Information on board's approval for integrating ESG risks into the organization's mission and vision?
	ERM-3	Information on board's training and educational programs on ESG-related risks?
	ERM-4	Information on formation of board committee for ESG-related risks?
	ERM-5	Information on communication between board committees on ESG-related risks?
	ERM-6	Information on knowledge and awareness sessions to management on ESG risks?
	ERM-7	Information on reporting of ESG-related risks?
Dimension 2 (D2) Strategy and objective-setting for ESG-related risks	ERM-8	Information on the business model for ESG-related risks?
	ERM-9	Information on the SWOT analysis of ESG-related risks?
	ERM-10	Information on organization's risk appetite for ESG-related risks?
	ERM-11	Information on linking ESG-related risks to shareholder value creation?
Dimension 3 (D3) Performance for ESG-related risks	ERM-12	Information on identification of carbon emissions risk?
	ERM-13	Information on identification of biodiversity risk?
	ERM-14	Information on identification of other toxic emissions and waste material risk?
	ERM-15	Information on identification of compliance risk?
	ERM-16	Information on identification of health and safety risk?
	ERM-17	Information on identification of reputational risk?
	ERM-18	Information on identification of cyber security risk?
	ERM-19	Information on identification of financial risk?
	ERM-20	Information on assessment of carbon footprint risk?
	ERM-21	Information on assessment of compliance with governance codes?
	ERM-22	Information on assessment of product quality risk?
	ERM-23	Information on assessment of health and safety risks?
	ERM-24	Information on assessment of fraudulent risk?
	ERM-25	Information on assessment of reputational risk?
	ERM-26	Information on response to credit risk?
	ERM-27	Information on response to market risk?
	ERM-28	Information on response to liquidity risk?
	ERM-29	Information on response to foreign exchange risk?
	ERM-30	Information on response to data security risk?

Dimension 4 (D-4) Review and revision for ESG-related risks	ERM-31	Information on changes in internal and external environment affecting the organization's risk profile?
	ERM-32	Information on revision of strategies related to ESG risks?
	ERM-33	Information on due diligence of ESG-related risk management process?
	ERM-34	Information on revision of risk management processes and capabilities to enhance the management of ESG-related risks?
Dimension 5 (D-5) Information, Communication, and Reporting for ESG-related risks	ERM-35	Information on reporting of ESG risk to the board of directors and management?
	ERM-36	Information on communication of ESG risks to shareholders in annual general meetings?
	ERM-37	Information on disclosure of ESG-related risks to all stakeholder groups?
	ERM-38	Information on disclosure of board's approval in annual reports on data of ESG-related risk?

Source: Adapted from Shah et al. (2022b)