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Innovate or perish: can green entrepreneurial orientation foster green innovation by leveraging green manufacturing practices under different levels of green technology turbulence?

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Abstract

Purpose – While the significance of green entrepreneurial orientation (GEO) has been acknowledged, it is still not fully understood how GEO influences green innovation (GI). Depending on the natural resource-based view (NRBV), the practice-based view (PBV) and contingency theory (CT), the authors explore how GEO affects GI via green manufacturing practices (GMPs) and the moderating role of green technology turbulence (GTT).
Design/methodology/approach – Using the data gathered from large firms in Yemen, the suggested model was tested through hierarchical regression analysis using the PROCESS Macro in SPSS.
Findings – The empirical results reveal that GEO is positively related to GMP, which in turn is positively related to GI. Importantly, GMP mediates the link between GEO and GI. The results also demonstrate that GTT positively moderates the GEO-GI link.
Originality/value – This study makes a valuable contribution to the existing literature on sustainability and holds significant importance for managers seeking to enhance their understanding of utilizing GEO for fostering GI.

Keywords Green entrepreneurial orientation, Green manufacturing practices, Green technology turbulence, Green innovation

Paper type Research paper

Quick value overview

Interesting because – Manufacturers face challenges in achieving a balance between preserving the environment and sustainable consumption. Green innovation (GI) provides a potential solution. Previous studies have determined many precedents for companies but have focused mostly on external factors that influence GI. These factors do not provide a complete picture and it is apparent that internal factors such as green entrepreneurial orientation (GEO) play an important role. The study shows that the ability to achieve GI through green entrepreneurial activities may depend upon the capacity of managers to align their operations strategies effectively.

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Theoretical value – Previous research has studied the relationship between GEO and GI but it has shown inconsistent findings. This study found that while GEO contributes to GI, there are two other variables that play an important role. First, GEO is an antecedent to the adoption of green manufacturing practices (GMPs) which in turn influences GI. Second, green technology turbulence (GTT) is an uncertain and unpredictable external environment factor that moderates the relationship between GEO and GI.

Practical value – Enterprises must use GEO and integrate it into their strategy to improve GI. Furthermore, companies need to continue to invest in GMP because this contributes to translating green entrepreneurship-oriented firms' efforts into GI. Managers should be aware that the positive effect of GEO on GI depends on GTT and that disregarding GTT may lessen its effect. Therefore, managers should prioritize examining their firms' technology environment while adopting GEO to improve GI.

1. Introduction

In today's business environment, firms face challenges in achieving a balance between preserving the environment and sustainable consumption not only in developed countries but even in developing and less-developed countries (LDCs). Yemen is no exception, as Yemeni manufacturing firms encounter stiff competition as a result of globalization (Battour *et al.*, 2021). Besides, the current pollution in Yemen caused by the energy sector, manufacturing industries, and the conflict is leading to economic, environmental and social consequences (Al-Wesabi *et al.*, 2022). Manufacturers now recognize the need to find solutions that reconcile sustainability goals (Shehzad *et al.*, 2023). One effective approach is to enhance green innovation (GI) potential within the firms (Al-Swidi *et al.*, 2022; Huang and Li, 2017). By fostering GI, firms can fulfill their social responsibilities, attain economic success, while preserving the environment. GI refers to "a process that contributes to the creation of new production and technologies with the aim of reducing environmental risks, like pollution and negative consequences of resource exploitation" (Takalo and Tooranloo, 2021, p. 3).

Given the growing importance of GI, previous studies have determined many precedents for companies actively engaging in GI (Al-Swidi *et al.*, 2022; Song *et al.*, 2020). Most studies have investigated the external factors that influence GI, such as the technical level of the industry (Singh *et al.*, 2015), social expectations (Bossle *et al.*, 2016), competition pressures (Pondeville *et al.*, 2013) and consumer pressures (Al-Swidi *et al.*, 2022). Nevertheless, these factors do not constitute the primary motivations for firms to embrace GI, nor do they explain their early behavior toward such practices (Zhou *et al.*, 2020). Merely attributing the adoption of GI in enterprises to external factors is insufficient (Guo *et al.*, 2020). Therefore, it has become necessary to explore internal factors. Among these internal factors, research indicates that green entrepreneurial orientation (GEO) plays an essential role in improving GI (e.g. Muangmee *et al.*, 2021). From a natural resource-based view (NRBV), GEO represents a strategic resource that is combined with corporate culture and a dynamic capability that helps it in identifying, capturing and maintaining ecological initiatives over time (Makhloufi *et al.*, 2022); which enhances the dynamism of the corporate GI process (Silajdžić *et al.*, 2015). GEO is defined as a proactive strategic inclination at the firm level, focusing on identifying and seizing eco-friendly business opportunities (Covin and Slevin, 1989). GEO has the ability to motivate enterprises to embrace green practices willingly and proactively. Nevertheless, this attractive factor stands in stark contrast to the external driving factors of stakeholder pressure and government regulations. Furthermore, the concept of green entrepreneurship is not as advanced in LDCs, such as Yemen, as entrepreneurs tend to prioritize making profits, following a more traditional approach. Factors such as social responsibility, environmental protection, eco-friendly innovations and the pursuit of sustainability are not given much importance by these business leaders, who instead prioritize quick outcomes (Batrancea *et al.*, 2021). Despite the importance of GEO to ensuring corporate

sustainability (Vasilescu *et al.*, 2023), its coverage in academic literature has been limited. There exists a considerable gap in this area, particularly in terms of understanding its role and position within emerging economies (Demirel and Kesidou, 2019).

While GEO and GI are closely linked, it is important to note that companies with GEO may not necessarily achieve successful GI (Arzubiaga *et al.*, 2018; Guo *et al.*, 2020). This is primarily due to the greater complexity and higher demands associated with GI compared to public innovation (De Marchi, 2012). From this perspective, attaining GI necessitates the adoption of relevant environmental practices (Al-Hakimi *et al.*, 2022), which are achieved for organizations with different resources and capabilities. As such, green manufacturing practices (GMPs), drawing on the practice-based view (PBV), can contribute to reducing clean manufacturing costs and minimizing pollutant emissions, ultimately enhancing the firm's GI (Huang and Li, 2017). Hence, we argue that GMP may bridge the link between GEO and GI. In accordance with Al-Hakimi *et al.* (2022, p. 1), GMP is defined as "cost-efficient and unified methods utilized to reduce or eliminate all waste streams related to the design, manufacturing, and disposal of waste products and materials". A firm that adopts environmental practices, such as GMP, achieves a competitive advantage and, consequently, enhances its sustainable performance (Acquah *et al.*, 2021; Al-Swidi *et al.*, 2023). Essentially, GMP aids in reducing the environmental impact of manufacturing processes, all while maintaining product quality, reliability and cost-effectiveness (Ghadimi *et al.*, 2021). Previous studies emphasize the importance of GMP in improving sustainability through different innovation-related capabilities that enhance sustainable performance (e.g. Al-Hakimi *et al.*, 2022), where GMP serves as a catalyst for enterprises to incorporate environmental considerations into their processes, thereby driving innovation (Huang and Li, 2017). Based on the above and to address the current shortcomings in academic literature, this study explores whether GMP acts as a mediation mechanism in the GEO-GI link.

Furthermore, previous research findings regarding the connection between GEO and GI have presented conflicting results. While some scholars have contended that GEO is positively associated with GI (e.g. Guo *et al.*, 2020; Muangmee *et al.*, 2021), others have discovered it to be insignificant (e.g. Majali *et al.*, 2022). These contradictory results highlight the need for additional research to explore the contextual factors that might impact the link between GEO and GI within different environmental contexts. In line with this, contingency theory (CT) asserts that no single theory or approach can be universally applicable, and the success of enterprises is determined by the alignment between their organizational structure and specific environmental conditions (Lawrence and Lorsch, 1967). For example, a turbulent technological environment may bring some challenges to the firm's GI. Green technology turbulence (GTT) leads to unexpected risks. In the current study, we consider GTT as a crucial situational factor for environmentally innovative businesses that encounter technological uncertainty in the external surroundings. GTT is defined as "the rate of change in a market or industrial environment, representing ambiguity and risks of green technologies in the market" (Lisi *et al.*, 2020, p. 158). GTT plays a crucial role in formulating and executing strategies. Indeed, green entrepreneurship-oriented firms are more inclined to actively engage in acquiring external resources to ensure a steady inflow of resources, enabling them to effectively manage the swift technological changes (Zhou *et al.*, 2020). Therefore, GTT can act as a key boundary condition when studying the relationship between GEO and GI. In all, this study, guided by NRBV, PBV and CT, aims to answer the following questions:

RQ1. How does GEO affect GI?

RQ2. How does GMP affect GI?

RQ3. Does GMP mediate the relationship between GEO and GI?

RQ4. Does GTT moderate the relationship between GEO and GI?

The current study's contribution to literature is threefold. First, based on NRBV, PBV and CT, this research makes a significant contribution to the existing body of literature on sustainability. Driven by the inherent vision to bring about societal change, companies with GEO take proactive measures to manage their resources and adopt a positive orientation to shift from conventional systems to eco-friendly processes. Therefore, this study sheds light on the connection between GEO and GI. Second, although research on the association of GEO with GI is limited, previous research raised the issue that GEO alone is insufficient to drive GI without the presence of a mediating effect and there are some missing links in this relationship (Guo *et al.*, 2020). This study explores this previously unexplored aspect in extant literature by examining the mediating role of GMP in the GEO–GI relationship. Third, GTT is offered to manage the relationship between GEO and GI.

The study is organized into six sections in the following order: The literature review and the formulation of hypotheses are contained in Section 2. While Section 3 provides the methodology employed, the outcomes of the data analysis are presented in Section 4. Section 5 contains the discussion, including implications, and finally, Section 6 highlights the conclusions as well as limitations and potential directions for future research.

2. Literature review and hypotheses

2.1 Theoretical background

Expanding upon the principle of the resource-based view (RBV) (Barney, 1991), Hart (1995) introduced the NRBV framework, which incorporates natural environmental constraints and opportunities. Hart contends that a sustainable competitive advantage can be attained through firm resources and capabilities that are valuable, rare, difficult to replicate and nonsubstitutable (often referred to as VRIN). NRBV proposes that organizations should proactively enhance and align their interactions with the external natural environment. This can be accomplished by pursuing three distinct yet interconnected environmental strategies: reducing pollution, practicing product stewardship and promoting sustainable development (Hart, 1995; Hart and Dowell, 2011). By adopting NRBV, this study approaches GEO (Makhloufi *et al.*, 2022) as a resource that can allow a firm to secure a sustainable competitive edge. This can be accomplished through (1) enhancing the influence of GEO on GI and (2) adopting GMP to leverage a firm's GEO to develop and enhance its GI. Accordingly, NRBV offers a suitable theoretical foundation for examining how resources and capabilities influence the performance of GI.

Together with NRBV, this study adopted the PBV to explore the role of GMP when studying the link between GEO and GI. PBV is a relatively recent perspective introduced by Bromiley and Rau (2014) as an alternative approach to RBV, which explains how a firm's resources or capabilities create or sustain competitive advantage (Barney, 1991). PBV operates on the assumption that even minor routine actions undertaken by any company impact its performance. In contrast, the RBV concept is rooted in the belief that resources or capabilities responsible for creating or maintaining a competitive advantage must possess the VRIN characteristics (Peteraf, 1993). Consequently, it is challenging to envision resources of this nature that could equally apply to the realm of environmental practices, such as GMP in this case.

Besides NRBV and PBV, this study also adopts CT. As best practices in operations management (OM) have matured, studies on these practices have transitioned from merely demonstrating their value to delving into the contextual factors that influence their effectiveness (Sousa and Voss, 2008). According to CT, firms ought to adjust their organizational structure and practices to align with the environmental conditions in which they operate (Donaldson, 2001). CT elucidates the circumstances in which OM practices can boost the firm's performance. This underscores the importance of studying how the external

environment affects the inclination of green entrepreneurship-oriented managers to focus their attention on GI. Hence, through the CT lens, we argue that GEO, under specific levels of GTT, may provide a better explanation for GI enhancement.

2.2 Green innovation

GI is acknowledged as a critical determinant impacting both the ecological and economic achievements of organizations and communities (Wang, 2019). It is also viewed as a corporate initiative in response to ecological regulations (Tariq *et al.*, 2020). Indeed, companies are more inclined to embrace a GI strategy if they prioritize and demonstrate a genuine commitment to the environment and its preservation (Tseng *et al.*, 2013). Many researchers indicate that GI comprises two main approaches: green product innovation and green process innovation (e.g. Begum *et al.*, 2022; Xie *et al.*, 2019). While the former seeks to alter product designs by utilizing non-toxic substances or biodegradable materials in production, aiming to minimize environmental waste and reinforce energy efficiency (Lee, 2023; Wei *et al.*, 2023); The other aims to reduce energy consumption in the production process and convert waste into valuable items (Salvadó *et al.*, 2012).

2.3 Green entrepreneurial orientation and green innovation

GEO is a new but valuable subject in entrepreneurship and sustainability literature. In accordance with Dean and McMullen (2007), green entrepreneurship reflects the inclination to identify possible opportunities that can offer economic and environmental advantages by initiating eco-friendly practices. Research on GEO (e.g. Jiang *et al.*, 2018) emphasizes its importance resulting from the dynamic nature of the decision-making model. Furthermore, previous researchers' work demonstrates that GEO is deeply ingrained in a company's proactive attitude, enhancing its ability to initiate eco-friendly projects and enhance business performance (Muangmee *et al.*, 2021).

In fact, Schuler (1986) argues that the pace of innovation distinguishes entrepreneurship-oriented companies from others, defining entrepreneurship as a vehicle for driving innovation. Related to this, Guo *et al.* (2020) propose that GEO consists of an innovative orientation as well as a social orientation. Importantly, GEO can contribute to the development of eco-friendly innovative products (Teece, 2016). While the ultimate aim of green entrepreneurship-oriented companies is to achieve economic benefits (Guo *et al.*, 2020), they find it more feasible to pursue GI compared to those solely focused on economic interests (Drucker, 2002). Based on NRBV, Makhloufi *et al.* (2022) argue that GEO can be suitable for enhancing sustainability goals. Hence, GEO is recognized as a crucial element addressing NRBV's environmental concerns and enhances the company's ability to operate in an environmentally friendly manner (Makhloufi *et al.*, 2023). Indeed, Guo *et al.* (2020) claim that enterprises with strong GEO exhibit responsible environmental management and showcase innovation in their products or processes. Recently, many studies revealed the positive link of GEO with GI. For example, Wang *et al.* (2022a) and Shehzad *et al.* (2023) indicated that GEO plays an essential role in enhancing GI. Accordingly, we propose that:

H1. GEO is positively associated with GI.

2.4 Green entrepreneurial orientation and green manufacturing practices

GMP plays an important role in manufacturing environmentally sustainable products. The 1980s marked the beginning of "green manufacturing" or production, with an emphasis on minimizing waste (Andaregie and Astatkie, 2022). Thereafter, the focus of green manufacturing shifted from the production process to the product, with an emphasis on minimizing manufacturing resources, energy consumption and harmful substances, as well

as simultaneously expanding the use of renewable resources (Seliger *et al.*, 2008). Overall, the adoption of cleaner production methods by industries to address adverse environmental impacts is commonly referred to as GMP (Al-Hakimi *et al.*, 2022).

In accordance with NRBV, a strategic orientation, such as GEO, can be regarded as a valuable intangible resource that enables firms to effectively adopt and implement strategic practices like GMP, ultimately leading to enhanced firm performance (Teece, 2016). GEO has three intrinsic characteristics; innovation, proactivity and risk-taking (Jiang *et al.*, 2018). Moreover, GEO allows companies the ability to sense, seize and transform (Teece, 2016), all of which have unclear relationships with GMP. Sensing capability identifies suitable opportunities in the market and proactively implements GMP to address the current and future challenges posed by environmentally conscious customers and stakeholders (Habib *et al.*, 2020). Additionally, GEO through the ability to seize encourages firms to mobilize resources in order to adopt GMP, which leads to improved production efficiency through reduced energy consumption and pollution prevention (Jiang *et al.*, 2018). Firms that embrace GEO capitalize on specific opportunities by adopting eco-friendly practices, such as recycling, energy-saving measures and the use of solar light. Moreover, the transformative capability of GEO encourages firms to embrace environmental strategies in uncertain environments, with traditional practices evolving into green practices driven by GEO's foresight in identifying market opportunities (Teece, 2016). Accordingly, we suggest that:

H2. GEO is positively associated with GMP.

2.5 Green manufacturing practices and green innovation

GMP and GI research is attracting researchers, practitioners and policymakers because of its embryonic stage (Waheed *et al.*, 2020). Businesses now prioritize green product design, process development and innovative technology development under GMP (Tseng, 2013). Consumer awareness has made green products essential, giving environmentally responsible companies an edge in the modern business world (Al-Swidi *et al.*, 2022). GI uses eco-friendly technologies and reduces production costs by using less raw materials, energy and waste (Waheed *et al.*, 2020). GI requires companies to reduce clean manufacturing costs and minimize pollutant emissions, which is achieved through GMP (Huang and Li, 2017). Hence, under PBV, GMP is recognized as a key mechanism implemented by firms in response to environmental concerns, which ultimately strengthens their GI (Bromiley and Rau, 2014). GI goals can be accomplished by implementing GMP (Al-Hakimi *et al.*, 2022). In this context, Roy and Khastagir (2016) argued that green manufacturing was associated with the improved ecological performance of the Indian petrochemical industry by improving the company's ability to innovate in an eco-friendly way both in products and processes. Based on the preceding discussion, we assume that:

H3. GMP is positively associated with GI.

2.6 Mediating of green manufacturing practices

Although limited, prior research (e.g. Guo *et al.*, 2020; Muangmee *et al.*, 2021) has established the direct impact of GEO on GI. Nevertheless, there has been a noticeable absence of attention to the potential mediating role played by GMP in this relationship. GEO presents an opportunity for firms to develop innovative products (Salavou and Lioukas, 2003). Nevertheless, this opportunity is significantly magnified when firms possess the capability to effectively implement GMP (Al-Hakimi *et al.*, 2022). Thus, GEO may exert an indirect influence on GI (Alegre and Chiva, 2013) through the adoption of GMP (Waheed *et al.*, 2020). GMP is expected to enhance GI (Al-Hakimi *et al.*, 2022). Achieving this, however, necessitates organizational initiatives and resource allocation that can be effectively utilized in the context

of GEO (Afum *et al.*, 2023). The NRBV proposes that companies ought to utilize eco-friendly resources to attain a competitive edge (Hart, 1995). These green resources represent dynamic entrepreneurial endeavors geared towards achieving sustainable performance (Paulraj, 2011). It is clear that GEO incorporates various entrepreneurial traits, serving as an approach to decision-making within the strategy development process (Hughes *et al.*, 2018). However, it's important to note that GEO alone cannot directly lead to GI; rather, it relies on complementary tactical actions like GMP.

A company's tendency toward environmental concerns may result in the adoption of green practices (such as GMP), which can subsequently influence the development of innovative products (Mullens, 2018). Based on NRBV and PBV frameworks and existing research, executives at environmentally conscious companies engaged in entrepreneurship invest in and implement GMP to create eco-friendly products that meet customer needs (Afum *et al.*, 2023). In this context, the researchers also argue that there is some missing mediation connection between GEO and GI (ibid). For instance, Martin and Javalgi (2016) and Alegre and Chiva (2013) concluded that the link between entrepreneurial orientation and innovation performance is mediated by marketing capability and organizational learning capability, respectively. The relationship between GEO, GMP and GI has not been previously examined. Based on the preceding discussion, it becomes evident that while GEO may exert a direct impact on GI, a more comprehensive understanding of the relationship between these crucial factors emerges when GMP is considered. Therefore, we suggest that:

H4. GMP mediates the GEO–GI relationship.

2.7 Moderating of green technology turbulence

Although numerous studies have shown a positive link between GEO and GI, there are also some studies that do not fully support this association (e.g. Majali *et al.*, 2022). The inconsistency in these findings can be attributed to the intricate nature of the link between GEO and GI, which remains not fully comprehended. Indeed, a technologically turbulent market is characterized by uncertainty and unpredictability regarding green technologies and short cycles of innovation in green technologies, while companies face competitive pressures to keep up with the changing landscape of green technology within the industry (Wang *et al.*, 2015). In this regard, Iqbal *et al.* (2021) claim that in a situation of technological turbulence, technologies become obsolete to be replaced by new disruptive technologies. This, in turn, empowers leaders to enhance their innovative capabilities, enabling them to adapt their business models, enhance their products and capture new market share (Pandit *et al.*, 2018). In a scenario characterized by a significant level of technology turbulence, companies proactively seek to acquire new technology and knowledge from their partners (Cai *et al.*, 2014), enhancing the firms' abilities to address environmental concerns through GI. As the level of technology turbulence intensifies, organizations that adopt a GEO tend to prioritize the integration of novel green technologies. Conversely, in an environment with a low level of technology turbulence, the external technological landscape remains relatively stable, resulting in reduced demand for resources and capabilities (Zhou *et al.*, 2020). Hence, in an environment characterized by a high level of technology turbulence, the adoption of GEO is more likely to stimulate innovation in green technologies. Considering the foregoing, we assume that:

H5. GTT positively moderates the GEO–GI relationship.

The proposed research model, illustrated in Figure 1, displays the relationship between GEO and GI in the presence of GMP as a mediating variable and GTT as a moderating variable, supported by the NRBV, PBV and CT frameworks that guide hypotheses development.

3. Methodology

3.1 Sampling and data collection

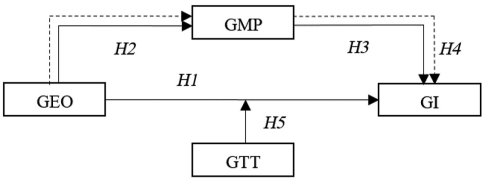
To examine the proposed model, a survey-based methodology was used with data collected, on a cross-sectional basis, from middle-level managers in large manufacturing firms in Yemen in collaboration with human resource (HR) departments, using a convenience sampling technique due to the absence of a sampling frame; this technique is commonly employed in similar studies, such as Apolinário *et al.* (2023) and Gelaidan *et al.* (2023). The population of this study encompasses several manufacturing industries, such as pharmaceuticals, food and beverage, plastics and packaging, as well as chemical and petrochemical industries.

Before data collection, and to ensure the scale's reliability and validity and prevent data bias, we performed face and content validity tests. Five academics reviewed the questionnaire and offered their feedback to improve the relevance and comprehensibility of the items. Additionally, a pretest involving five individuals from the target population was conducted to make certain that all of the items were understood correctly. Consequently, the questionnaire was revised to consist of two sections: the first pertaining to demographic factors and the second focusing on the constructs.

To incentivize participants to fill out the questionnaire and boost the response rate, the questionnaire included a statement guaranteeing respondents' anonymity. Furthermore, regular e-mail reminders were sent out. A total of 400 participants took part in this study. Out of the distributed questionnaires, 288 were returned and 279 of them were complete and suitable for analysis, which is a reasonable sample size for performing hierarchical or multiple regression analysis (Tabachnick and Fidell, 2013). To get greater accuracy in estimating the minimum sample size, we evaluated the statistical power using G*Power, as suggested by Faul *et al.* (2007). After considering a statistical power of 80%, an effect size of 0.15 and a significance level of 5% (Cohen, 2013), the analysis determined that a minimum of 85 cases was needed. Consequently, the chosen sample size for this study, which was 279 cases, was deemed sufficient. Furthermore, the sample size of 279 respondents satisfied the prescribed criteria, which is defined as being "ten times the largest number of structural paths directed at a particular latent construct in the structural model" (Hair *et al.*, 2011, p. 144).

In general, the response rate was about 69.7%. Some authors have suggested that 20% represents the minimum acceptable response rate for empirical research in the field of OM (Malhotra and Grover, 1998). In a study carried out by Baruch and Holtom (2008), which analyzed 1607 studies published in 17 referred journals, the average response rate from organizations was found to be 35.7%, with a standard deviation of 18.8. Therefore, a response rate of 69.7% in this research can be deemed satisfactory for conducting statistical analysis and drawing meaningful conclusions. Data collection for the study took place over a period of four months, specifically from September to December 2022.

This study's participants varied in terms of demographic and organizational characteristics. The majority of respondents (96.1% of the total) were male, with 3.9% being female. In terms of educational level (secondary and below-7.53%, diploma-1.79%, bachelor-69.53%, master and above-21.15%); years of experience (below 5 years-29.39%,



Source(s): Authors' own work

Figure 1.
Research model

from 5 to 10 years-23.65%, more than 10 years-46.96%); and job position (factory manager-1.79%, sector manager-13.62%, production/manufacturing manager-31.19%, research & development manager-15.41%, marketing manager-26.88% and financial manager-11.11%).

3.2 Measures

For this study, we utilized a questionnaire tool to collect the data required for assessing the links within the proposed model. The construct measurement items were adopted from previous studies; GEO was measured with 5 items adopted from Habib *et al.* (2020). While GI was measured by 4 items adopted from Frondel *et al.* (2007) and Xie *et al.* (2019), GMP was measured with 5 items adopted from Afum *et al.* (2020). Finally, GTT was measured by 3 items adopted from Sheng *et al.* (2011) and Wang *et al.* (2022b).

To evaluate the consistency of responses across all questionnaire items, a 5-point Likert scale ranging from "Strongly Disagree" (1) to "Strongly Agree" (5) was employed. The constructs and corresponding items employed for their measurement can be found in Appendix.

3.3 Common method bias

After the data collection phase, the initial step involved examining common method bias (CMB), which is "a common issue in statistical-based investigations when the data is collected from the same respondents" (Podsakoff and Organ, 1986, p. 533). Specifically, "Harman's one-factor" test was carried out as per the procedures of Podsakoff *et al.* (2012), in order to verify the absence of CMB. According to Podsakoff *et al.* (2012), a preliminary factor analysis is conducted for all questionnaire items such that if a single factor stands out in the analysis or if the first factor elucidates over 50% of the variance, it indicates a substantial effect of error variance. In our study, the factor identified accounted for 32.9% of the total variance, indicating that CMB was not a concern for the collected data.

4. Results

4.1 Descriptive statistics and normality test

Table 1 presents the results of the normality assessment, as indicated by the mean, standard deviation, skewness and kurtosis. The results indicate that GI has the highest composite mean at 3.65, followed by GMP with a mean of 3.58, GTT with a mean of 3.39 and GEO with a mean of 3.35, implying that a significant proportion of the participants generally expressed agreement with the statements presented to them. To evaluate the normality of the data distribution, calculations were made for skewness and kurtosis values. Following the criteria proposed by Hair *et al.* (2014) and Kline (2015), data is deemed to follow a normal distribution when the skewness value falls within the −2 to 2 range and the kurtosis value falls within the −7 to 7 range, which has been adopted in similar studies (e.g. Arslan and Coşkun, 2022). For this study, the findings reveal that the skewness and kurtosis values fall within the acceptable range for a normal distribution. Consequently, it can be concluded that the data follows a normal distribution.

Construct	Mean	S.D.	Skewness	Kurtosis
GEO	3.348	0.570	0.602	0.560
GMP	3.580	0.602	0.144	−0.568
GTT	3.393	0.586	0.546	−0.248
GI	3.650	0.604	0.040	−0.215

Source(s): Derived from the statistical analysis of this study (SPSS 25)

Table 1.
Preliminary statistics of constructs

4.2 Reliability and validity

In this step, we carried out some tests to validate the consistency of the constructs with the basic assumptions set for the analysis of covariance. First, the validity of the scales was evaluated, and the findings are provided in Table 2 below. In accordance with Hair *et al.* (2018), "Cronbach alpha (α)", "composite reliability (CR)" and "average variance extracted (AVE)" values must meet the minimum cut-off of 0.70, 0.70 and 0.50, respectively. The results show that α, CR and AVE values exceed the aforementioned thresholds, suggesting that there are no concerns regarding convergent validity in this study.

Moreover, the "Heterotrait-Monotrait (HTMT)" method, as outlined by Henseler *et al.* (2015), was employed to verify discriminant validity. According to Henseler *et al.* (2015), the values within the HTMT matrix, especially between the constructs, must not surpass 0.90. In our study, the results demonstrated that the values did not surpass this threshold, as presented in Table 3. From the results presented in Tables 2 and 3, it is evident that all requirements, including loadings, reliability and validity, were met, which emphasizes the measurement model validity.

Finally, confirmatory factor analysis was conducted via AMOS v.24, on the above measures to assess the fitness of the proposed model with the collected data. The model fit indices, including (x2/df = 2.147; $p = 0.000$; Goodness of fit index (GFI) = 0.915; Comparative fit index (CFI) = 0.974; Tucker–Lewis index (TLI) = 0.966 and Root mean square error approximation (RMSEA) = 0.064), indicate that the measurement model fit is considered acceptable, as suggested by Byrne (2016).

Table 2. Convergent validity

Construct	Item	Loading	α	CR	AVE
GEO	GEO1	0.761	0.92	0.929	0.725
	GEO2	0.881			
	GEO3	0.883			
	GEO4	0.867			
	GEO5	0.859			
GMP	GMP1	0.895	0.96	0.962	0.836
	GMP2	0.898			
	GMP3	0.938			
	GMP4	0.915			
	GMP5	0.924			
GTT	GTT1	0.715	0.82	0.871	0.694
	GTT2	0.917			
	GTT3	0.854			
GI	GI1	0.878	0.94	0.945	0.811
	GI2	0.91			
	GI3	0.903			
	GI4	0.911			

Source(s): Derived from the statistical analysis of this study (SPSS 25)

Table 3. Discriminant validity (HTMT)

Construct	GEO	GMP	GTT	GI
GEO				
GMP	0.263			
GTT	0.423	0.163		
GI	0.246	0.329	0.066	

Source(s): Derived from the statistical analysis of this study (SPSS 25)

4.3 Hypotheses testing

In this study, we utilized PROCESS (Hayes, 2018) to test the hypotheses (Model 5). PROCESS can evaluate a complex model, which includes moderator and mediator variables and has been extensively utilized in prior research (e.g. Al-Swidi *et al.*, 2022). While the multi-step regression approach has potential shortcomings (e.g. the type I error regarding the mediation) in Baron and Kenny (1986), which may lead to low statistical power (MacKinnon *et al.*, 2002); PROCESS provides a more robust strategy test for determining the size and significance of an effect via macro technique in SPSS, which depends on a nonparametric bootstrapping procedure (Preacher and Hayes, 2004). To ensure that the PROCESS-based multiple regression analysis is accurate, variance inflation factor (VIF) was computed for the model, where the estimated VIF values (between 1.069 and 1.210) were below the cut-off value of 3, indicating that there is no problem related to the multiple linear relationships of this study.

The results are depicted in Table 4. In H1, we expect GEO to significantly and positively influence GI. Our results support H1 ($\beta = 0.176, p < 0.01$). As expected, there is also a positive linkage between GEO and GMP ($\beta = 0.261$, $p < 0.01$), supporting H2. Moreover, the results demonstrate that GMP significantly and positively influence GI, which supports H3.

To assess the impact of the suggested mediator in H4, we followed Awang's (2016) guidelines (direct and indirect effect). The results summarized in Table 5 revealed that GMP mediates the association between GEO and GI. Although GEO had a significant indirect effect on GI ($\beta = 0.075$, $p < 0.05$), it also had a significant direct effect ($\beta = 0.176$, $p < 0.01$), implying that GMP partially mediates the GEO-GI relationship; therefore, H4 is supported.

Furthermore, the findings confirm that GTT moderates the GEO-GI link. Figure 2 shows that GTT acts as a moderator, with the line increasing more strongly at high CI levels, supporting H5.

5. Discussion

The current study has involved gathering primary data from large manufacturing firms in Yemen and has addressed the need for additional empirical research to enhance our understanding of the connection between GEO and GI. This study offers new insights, not only regarding the direct influence of GEO but also concerning its indirect influence on GI through the intermediary role of GMP, alongside the moderating impact of GTT in the link between GEO and GI.

First, the research model confirms the robust positive causal relationship between GEO and GI, as proposed in hypothesis H1. A higher level of GEO is associated with a higher level

Path	Mode	Direct effect β (SE)	Bootstrap (LLCI, ULCI)	Results
GEO-GMP		0.261 (0.061) ***	(0.1401, 0.3821)	*Supported*
GMP-GI		0.286 (0.058) ***	(0.172, 0.401)	*Supported*
GEO-GI		0.176 (0.065) ***	(0.048, 0.305)	*Supported*
ROC*GEO-GI		0.217 (0.102) **	(0.017, 0.417)	*Supported*
Conditional effects of the focal predictor at values of ROC	Low (−0.5866)	0.049 (0.091)	(−0.129, 0.228)	
	Medium (0.00)	0.176 (0.065) ***	(0.048, 0.305)	
	High (0.5866)	0.304 (0.086) ***	(0.134, 0.473)	

Note(s): "***$p < 0.01$; **$p < 0.05$; *$p < 0.10$"
Source(s): Derived from the statistical analysis of this study (PROCESS macro 4.1)

Table 4.
Results from the model 5 of PROCESS Macro

of GI. If companies want to enhance GI, they should embrace GEO. Consistent with prior literature (Frare and Beuren, 2022; Tuan, 2023), the findings indicate that GEO positively affects GI. This implies that GEO within firms facilitates the enhancement of GI. Presently, an increasing number of firms perceive GEO as a strategic approach to foster innovation and minimize potential environmental harm (Mazzucato, 2016). On the other hand, this finding contradicts previous research findings in developing economies (Majali *et al.*, 2022). The lack of consistent evidence that GEO positively affects GI could be due to two reasons; (i) Embracing eco-friendly practices often involves the adoption of new technologies, which is a costly affair. Consequently, managers may lack motivation to allocate resources and make efforts to enhance their company's sustainability, especially when they do not realize any market advantages and benefits from implementing advanced environmental practices that exceed short-term stakeholder requirements. (ii) These results could reflect the lack of a short-term impact, as the impact of GEO on GI may take time to materialize.

Second, the findings also demonstrate that GEO positively affects GMP. Green entrepreneurship-oriented firms can proactively sense suitable opportunities in the market, mobilize resources and then launch green practices to address the current and future challenges posed by environmentally conscious customers and stakeholders. Our results align with prior research (Habib *et al.*, 2020), which confirms the important role of GEO in the adoption of green practices. Therefore, firms should value their GEO to enhance their sustainable development practices.

Third, GMP positively affects GI. Previous studies report similar findings in countries such as Saudi Arabia (Al-Hakimi *et al.*, 2022), China (Waheed *et al.*, 2020) and Turkey (Yıldız *et al.*, 2023). This finding is reasonable, as GMP plays a significant role in minimizing adverse environmental effects and thus attaining superior levels of GI within firms.

Fourth, the findings support the notion that GEO affects GI indirectly through GMP. In other words, incorporating GMP as a mediator provides a more accurate explanation of the

Table 5. Mediation analysis results

	Indirect effect				Direct effect				
		Bootstrap				Bootstrap			
Path	β	BootSE	LLCI	ULCI	β	BootSE	LLCI	ULCI	Results
GEO-GMP-GI	0.075**	0.025	0.033	0.130	0.176***	0.065	0.048	0.305	*Supported (Partial mediation)*

Note(s): "***$p < 0.01$; **$p < 0.05$; *$p < 0.10$"
Source(s): Derived from the statistical analysis of this study (PROCESS macro 4.1)

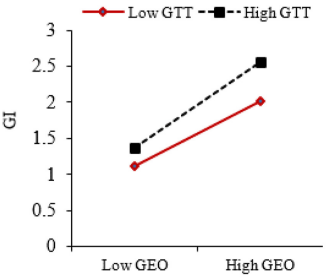


Figure 2. Moderating effect of GTT

Source(s): Authors' own work based on the statistical analysis (PROCESS macro 4.1)

relationship between GEO and GI. This finding offers nuanced insights into why companies ought to continue to invest in GMP as it contributes to translating green entrepreneurship-oriented firms' efforts into GL. From a theoretical standpoint, the influence of a company's GEO on GI, mediated by GMP, signifies the sustainable competitive advantages that emerge in markets through intricate associations with GMP. These findings are consistent with the PBV (Bromiley and Rau, 2014), where firms should apply GMP, like recycling, materials consumption reduction and power consumption reduction, to improve their GI performance.

Finally, the moderation test revealed that GTT positively moderates the GEO-GI relationship (hypothesis H5). This could be due to two reasons; (i) In the event of green technology disruptions, green entrepreneurship-oriented firms tend to prioritize replacing green technologies that become obsolete with new ones. This, in turn, empowers firms to enhance their innovative capabilities, enabling them to adapt their business models, enhance their products and capture new market share (Pandit *et al.*, 2018). (ii) GTT proactively pushes firms to acquire new knowledge to keep pace with the changing landscape of green technology within the industry (Wang *et al.*, 2015), enhancing their abilities to address environmental concerns through GI and counter competitive pressures.

5.1 Implications for theory

Theoretically, this research has notable contributions. First, by advancing the NRBV lens, this study viewed GEO as a strategic resource embedded within a green organizational culture to enhance GI and address environmental activities (Hart and Dowell, 2011). Most previous studies have focused on external factors influencing GI adoption, while few have addressed internal factors. Consequently, this study adds to GI understanding by giving valuable insights. The second contribution of this study pertains to the exploration of GMP. While prior research has primarily investigated the influence of different institutional pressures on GMP (e.g. Gouda and Saranga, 2020), limited research has been conducted to explore firm-level factors that precede GMP. This study addresses this research gap by showing that GEO is a significant antecedent in GMP adoption.

Third, using PBV, this study investigates how GEO affects GI by exploring the mediation mechanism (GMP in this case). Despite some researchers have investigated the linkage between GEO and GI (e.g. Guo *et al.*, 2020; Shehzad *et al.*, 2023), the findings remain inconclusive. In fact, most previous studies have focused on the direct association between GEO and GI (e.g. Muangmee *et al.*, 2021), neglecting behavioral processes and potential mediators. In contrast, this study investigates how GEO affects GI, revealing previously unexplored aspects. Consistent with the PBV (Bromiley and Rau, 2014), this research revealed that GEO indirectly affects GI by facilitating GMP within core environmental activities.

Finally, this study viewed GTT, based on CT, as a situational factor that can help environmentally innovative firms facing technological turbulence in the external surroundings leverage GEO potential. By doing so, it clarifies how GEO affects GI and enhances CT studies. Prior studies examining the relationship between entrepreneurial orientation and firm performance often overlook environmental uncertainty (Lumpkin and Dess, 2001). Although these studies agree with this work, investigating GEO in a static context is scientifically inadequate, as GEO is a strategic orientation rather than a fixed management system (Jiang *et al.*, 2018). Therefore, studying GEO in an uncertain environment is both scientifically valid and reasonable. This is in line with our findings that showed that GTT positively moderates the GEO-GI link, indicating that GEO is influenced by the environment.

5.2 Implications for practice

Practically, this research has several implications. First, the research reveals that GEO positively affects GI. These findings suggest that if Yemeni large firms aim to improve GI, it is

crucial for managers to adopt GEO and integrate it into the corporate strategy. For policymakers, particularly those focused on promoting GI among local firms, especially during the early stages, encouraging the adoption of GEO by firms becomes important. One approach could be the development of training program policies that strategically incentivize firms to enhance their GEO. By doing so, policymakers can effectively stimulate the development of GI, fostering a conducive environment for GI. Second, the outcomes of this study demonstrate that GMP positively affects GI. As an important operational practice of eco-friendly firms, GMP can be a crucial factor in achieving GI. In the global context of shifting towards a circular economy and achieving sustainable development, firms can adopt GMP, which may be of particular interest to LDCs such as Yemen, which enhances GI. Third, our findings indicate that GMP acts as a mediator in the influence of GEO on GI. This finding addresses the question of why, despite having a high level of GEO in the firm's management, there may still be a lack of progress in GI development, particularly in terms of GI. It suggests that this discrepancy could be attributed to insufficient attention given to GMP. Fourth, it is crucial for managers to recognize that the positive influence of GEO on GI can vary depending on the context of GTT. Ignoring GTT may greatly reduce the impact of GEO on GI. Hence, managers should prioritize evaluating the technological environmental conditions of their firms when adopting GEO to improve its GI.

6. Conclusions, limitations and future research directions

This empirical investigation was carried out on large manufacturing firms in Yemen, an example of a LDC. The results of this study boost our understanding of the subject and address a significant research gap in sustainability literature. This study suggests a new model that offers a broader view of the GEO-GI relationship by investigating the mediating role of GMP and the moderating role of GTT. The findings align with NRBV, PBV and CT as they provide empirical evidence supporting the positive and noteworthy impact of GEO on GI via GMP, under adopting GTT, for large manufacturing firms in Yemen. More specifically, the findings indicate that GEO is positively related to GMP, which in turn is positively related to GI. Furthermore, GMP acts as a mediator between GEO and GI. Importantly, the effect of GEO on GI is moderated by GTT.

Likewise other studies, this one has several limitations. First, the survey employed by this research is dependent on self-reported measures, which may be susceptible to CMB. Although we implemented a number of measures to mitigate this prejudice, the issue may remain (Hair *et al.*, 2018). Hence, future research may utilize longitudinal data to validate these findings. Second, since this study focused exclusively on large companies in less developed nations, specifically Yemen, future research can focus on SMEs or even micro-enterprises operating in various settings, including developed, developing and less-developed nations, as well as cross-national comparisons.

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Further reading

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Appendix

Variable	Items
Green entrepreneurial orientation	GEO1. In general, our firm favors a strong emphasis on green practices, such as R&D, technological leadership and innovation
	GEO2. When facing uncertainty, we typically adopt a proactive posture in order to catch potential green opportunities
	GEO3. In dealing with competitors, we typically initiate green actions that competitors respond to
	GEO4. Our firm favors a tendency to be a leader, and always introduce green products, service, or technology first
	GEO5. In dealing with competitors, we typically adopt a competitive 'undo-the competitors' posture
Green manufacturing practices	GMP1. Our firm produces products with reused and recycled contents such as recycled plastics and glass
	GMP2. Our firm produces products that are free from hazardous substances such as lead, mercury and chromium
	GMP3: Our firm produces products that reduce the consumption of materials and energy during use
	GMP4. Our firm reduces power consumption in products during manufacturing and transportation
	GMP5. Our firm designs products to ensure that they have reusable and recyclable contents
Green technology turbulence	GTT1 Green technology in our industry is changing fast
	GTT2 The direction of green technology in our industry is hard to predict
	GTT3 Most green technology innovations in our industry are radical changes to existing technologies
Green innovation	GI1. Our firm uses eco-friendly material
	GI2. Our firm uses environmental technologies
	GI3. Our firm uses pollution-control equipment
	GI4. Our firm adopts pollution-control projects and technologies

Source(s): Authors' own work based on the literature review

Table A1.
Questionnaire items

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