European Journal of Innovation Management

Received 30 April 2024
Revised 1 August 2024
Accepted 30 August 2024

Nexus among green entrepreneurship orientation, green ambidexterity innovation, green technological turbulence and green performance: moderated-mediation evidence from Malaysian manufacturing SMEs

Mohammad Imtiaz Hossain
Faculty of Management, Multimedia University – Cyberjaya Campus, Cyberjaya, Malaysia
Tze San Ong
School of Business and Economics, Universiti Putra Malaysia, Serdang, Malaysia and
Department of Business Administration, Daffodil International University, Dhaka, Bangladesh
Yasmin Jamadar
BRAC Business School, Brac University, Dhaka, Bangladesh
Boon Heng Teh
Faculty of Management, Multimedia University – Cyberjaya Campus, Cyberjaya, Malaysia, and
Ariful Islam
Sunway Business School (AACSB), Sunway University, Petaling Jaya, Malaysia

Abstract

Purpose – Amidst the challenges of globalisation and rapid technological advancements, small and medium-sized enterprises (SMEs) in the manufacturing sector are increasingly adopting smart manufacturing practices. Manufacturing SMEs in Malaysia encounter difficulties ensuring sustainability performance and maintaining green ambidexterity innovation (GAI), constrained by limited resources and other barriers. However, academic exploration of these challenges remains limited, particularly within the context of Malaysian SMEs. Thus, based on the natural-resource-based view (NRBV), contingency theory (CT) and ambidexterity paradigm, the goal of this study is to examine the influence of green entrepreneurship orientation (GEO) on corporate green performance (CGP) with the mediation of GAI and moderation of green technological turbulence (GTT) in Malaysian manufacturing SMEs.

Design/methodology/approach – This study follows a quantitative method, positivism paradigm, cross-sectional time horizon and structured questionnaire survey. In total, 313 validated responses from Malaysian manufacturing SMEs are analysed using partial least squares—structural equation modelling (PLS-SEM).

European Journal of Innovation Management
Vol. 28 No. 7, 2025
pp. 2761-2783

e-ISSN: 1758-7115
p-ISSN: 1460-1060
DOI 10.1108/EJIM-04-2024-0495

This project is funded by Universiti Putra Malaysia research grant (No: GP-GPB/2022/9716300).

Findings – The empirical results reveal a positive relationship among GEO, GAI and CGP. Moreover, GAI partially mediates between GEO and CGP. However, GTT did not moderate the GEO-CGP and GEO-GAI associations in the Malaysian manufacturing SMEs context.
Originality/value – The findings of this research offer significant insights for academia, policymakers, entrepreneurs, manufacturing management and pertinent stakeholders in developing green manufacturing firms concerning the balance of exploitation and exploration endeavours within the context of an uncertain and volatile industry landscape while simultaneously promoting GEO, GTT and CGP.
Keywords Green entrepreneurial orientation, Corporate green performance, Green ambidexterity innovation, Green technological turbulence
Paper type Research paper

1. Introduction

The manufacturing sector significantly contributes to a nation's economic growth and development by producing goods on a large scale (Hossain *et al.*, 2024a, b). With the utmost positive contribution of the manufacturing sector, it is also responsible for unsustainable activities (Ong *et al.*, 2022). Manufacturing, chemical waste disposal, deforestation and the combustion of fossil fuels and oil are primary contributors to global warming (Hossain *et al.*, 2024a, b). As a major output of manufacturing, plastic ranks as the third-largest contributor to global waste (Nyam *et al.*, 2024).

Despite the adverse impact of the COVID-19 pandemic on the current global manufacturing growth rate, it remains crucial for all nations to pursue their 2030 Sustainable Development Goals (United Nations Infrastructure and Industrialization, 2020; Secundo *et al.*, 2021). Unlike some environmentally damaging industries in other regions, Malaysia's manufacturing industry faces sustainability challenges from the triple bottom line (TBL) context: economy, environment and social (Hossain *et al.*, 2023). Malaysia faces significant air and water pollution levels, with ineffective waste management practices in manufacturing firms contributing to this issue. Environmental Performance Index (2022) reveals Malaysia's poor performance, ranking 130 among 180 countries in 2022, and key concern is the heavy metals group, where Malaysia ranks 57th.

The indispensable role played by small and medium-sized enterprises (SMEs) in the economic advancement of Malaysia remains incontrovertible, underscored by their representation of 97.4% of business establishments, totalling 1,173,601 entities as reported by OECD (2024). Noteworthy is the robust growth trajectory exhibited by SMEs, evidenced by their gross domestic product (GDP) expansion of 11.6% in 2022, outpacing the overall national GDP growth rate of 8.7%. This underscores the escalating significance of SMEs as pivotal drivers of economic proliferation. In terms of employment, SMEs constituted 48.2% of Malaysia's workforce in 2022, further solidifying their integral role in the nation's employment landscape. Functionally distinct from their larger counterparts, SMEs exhibit unique characteristics encompassing their scale and aspects, such as an informal managerial approach, pervasive owner-manager influence in decision-making processes and active community involvement. Despite their size and organisational structure divergence, SMEs collectively exert a disproportionately higher environmental impact than larger enterprises (Dey *et al.*, 2018).

Existing studies indicate that green entrepreneurship orientation (GEO) significantly contributes to the corporate green performance (CGP) (Asadi *et al.*, 2020; Shafique *et al.*, 2021). Grounded in the natural-resource-based view (NRBV), GEO facilitates the development of unique green products and services, enhances employee well-being, reduces resource cost through innovative processes and confirms profitable returns from investments in eco-friendly ventures (Shehzad *et al.*, 2023). GEO reflects a firm's disposition towards green innovation (GI), proactive engagement and risk-taking within its operational framework, constituting a critical internal factor influencing green performance (Jiang *et al.*, 2018; Ndou *et al.*, 2019). Moreover, organisations can fulfil their societal obligations by fostering GI, achieving economic prosperity and contributing to environmental conservation.

However, amidst the persistent technological disruptions in today's volatile, uncertain, complex and ambiguous (VUCA) landscape, SMEs face a dilemma in embracing GEO and GI. Green ambidexterity innovation (GAI) is a pivotal integration facilitator. Specifically, exploitative and exploratory innovations serve as essential components for organisations to navigate and harness the effects of technological turbulence by enhancing existing green processes, technologies and products. Green exploitative innovation involves leveraging existing environmental knowledge, capabilities and processes to advance current green products and designs, whereas green exploratory innovation entails the exploration of new environmental insights, knowledge and competencies to widen new green markets and goods (Asiaei *et al.*, 2023; Islam *et al.*, 2024; Ndou, 2021).

By contingency theory (CT), it is posited that no single theory or approach can universally apply, and the performance depends on synchronisation of organisational structure and contexts (Lawrence and Lorsch, 1967). Firms face challenges to cope with tumultuous technological changes in their GI endeavours. Green technological turbulence (GTT) encapsulates the unforeseen risks stemming from rapid environmental changes, embodying ambiguity and uncertainty on green technologies (Lisi *et al.*, 2020). GTT plays an important role in the formulation as well as execution of strategies. We regard GTT as a critical contextual determinant for environmentally innovative enterprises grappling with technological uncertainties in their external settings.

Based on an extensive literature review (Makhloufi *et al.*, 2023; Al-Swidi *et al.*, 2024; Ebrahimi and Mirbargkar, 2017), several gaps have emerged. Firstly, the discussion regarding the role of GAI in optimising green performance by harmonising both GEO and GTT still needs to be explored. We aim to address this void by synthesising insights from the green entrepreneurship and GI literature, proposing ambidextrous GI as a previously overlooked intermediary mechanism facilitating the translation of GEO into CGP. While prior studies by Chen *et al.* (2022), Asiaei *et al.* (2023) and Cao *et al.* (2022) have utilised GAI as a mediator with diverse constructs such as green organisational identity, green intellectual capital, top management's environmental awareness and green competitive advantage, the specific role of GAI in integrating GEO and GTT has received insufficient attention.

Secondly, the moderating influence of GTT on the relationship between GEO and CGP needs to be more adequately explored from an ambidexterity perspective. Prior relevant research by Lisi *et al.* (2020), Al-Swidi *et al.* (2024) and Aboalhool *et al.* (2024) did not consider this aspect. Consequently, our study endeavours to bridge these gaps by shedding light on the interplay between GEO, GAI, GTT and CGP within GI and entrepreneurship.

The remaining section is designed as follows: literature review and hypothesis development are in the second section; methodology, measurement of constructs, sample and data collection procedures are in the third section; data analysis and results are in the fourth section and the conclusion, discussion, limitations and future research directions are in the final section.

2. Theoretical background and hypotheses development

Expanding based on the resource-based view (RBV) by Barney (1991), Hart (1995) introduced the NRBV to convert natural environmental factors into a firm's competitiveness. Hart posits that a sustainable competitive advantage can be achieved with the proper utilisation of valuable, rare, difficult to replicate and irreplaceable resources and capabilities. NRBV advocates for organisations to proactively engage with the external natural environmental settings through pollution reduction, product stewardship and sustainable development (Hart, 1995). By embracing NRBV, the current study conceives GEO (Makhloufi *et al.*, 2023).

Consequently, NRBV provides a pertinent theoretical framework for assessing the effect of resources and capabilities on improving CGP through GI.

In addition to the NRBV, this study embraces CT. As evolution, organisational performance research has shifted to exploration of the complex circumstantial factors (Sousa and Voss, 2008) such as market turbulence and technological turbulence. CT posits that firms should adapt their organisational structures and practices with environmental constructs (Donaldson, 2001). It interprets the situations for bolstering firm performance through operation management, especially transactions from GEO firms towards GAI. Therefore, by integrating CT and ambidexterity lens with GEO and GTT, a more comprehensive elucidation for enhancing GAI and CGP is produced.

2.1 Green entrepreneurial orientation and corporate green performance

Green entrepreneurship represents the process of creating products and services, which are fully needed to create sustainable development and the total amount of activities that have the purpose to resolve environmental challenges and problems (Anghel and Anghel, 2022). GEO encompasses a business strategy prioritising green practices. This approach entails various strategies, such as waste reduction, resource conservation and developing green products. Embedded within the concept of GEO is a proactive stance towards innovation, actively seeking out opportunities and considering risks to foster sustainability through environmentally friendly processes, products and services (Marzouk and El Ebrashi, 2024). The primary objective of GEO is to address ecological concerns raised by stakeholders to adopt green practices (Aftab *et al.*, 2023). GEO is also exploring green sustainable business opportunities (Jiang *et al.*, 2018) that enhance the firm's capabilities and improve company performance (Momayez *et al.*, 2023). Moreover, GEO prioritises the establishment of green workplace, thereby fostering employee's higher pro green behaviour. GEO seeks to address environmental degradation by producing green products (Nordin and Hassan, 2019). Consistent with prior research, this study defines GEO as the structures, processes and behaviours of organisations that exhibit green innovativeness, proactiveness and risk-taking that enhance CGP (Shehzad *et al.*, 2023; Jiang *et al.*, 2018).

H1. GEO is significantly associated with CGP.

2.2 Green ambidexterity innovation and corporate green performance

GI represents the seamless integration of green development, ecological concepts and innovation theory within the framework of sustainable development, aiming to achieve holistic benefits encompassing economic, social and environmental dimensions. Drawing on the concept of "ambidexterity innovation", this study delineates GI into two facets: green exploitative innovation and green exploratory innovation. By the core tenets of ambidexterity theory (O'Reilly and Tushman, 2008), organisations are tasked with balancing paradoxical practices to enhance firm performance. Successful enterprises are strongly inclined to simultaneously pursue both types of innovation, thereby attaining ambidextrous innovation. This innovation enables firms to exploit existing resources while exploring new avenues, conferring a competitive advantage (Islam and Wahab, 2021).

Exploitative GI refers to leveraging current environmental knowledge, competences and practices to improve existing green goods and frameworks (Chen *et al.*, 2022). Conversely, exploratory GI entails discovering and applying novel insights, knowledge and skills pertaining to environmental concerns, aiming to cultivate unexplored green markets and products. Mia *et al.* (2022) suggested skills including green technical skills that can help innovative thinking competency and operative communication towards green entrepreneurship. Aydin *et al.* (2023) have demonstrated that GI enhances CGP of European firms, while Singh *et al.* (2023) found similar results in both developed and emerging economies.

Simultaneously, a higher degree of exploitative GI with higher utilisation of green technology ensures improved green products that lead to a competitive edge in terms of efficiency and benefits. In contrast, exploratory GI continuously enhances resource productivity within enterprises by introducing novel green designs, production methods and operational practices, which leads to premium benefits derived from green products. Additionally, exploratory GI has the potential to offset or even surpass the costs associated with environmental improvements.

H2. GAI is significantly associated with corporate green performance.

2.3 Green entrepreneurship orientation and green ambidexterity innovation

SMEs imbued with a robust GEO exhibit a heightened propensity to prioritise environmental concerns throughout their innovation processes. This emphasis on sustainability fosters the exploration of novel green technologies, processes and business models, thereby nurturing ambidextrous behaviour wherein they concurrently explore and exploit GI opportunities (Hossain *et al.*, 2023). Such SMEs, driven by a green entrepreneurial ethos, are more willing to undertake risks and proactively seek innovative solutions to environmental challenges. This proactive stance empowers them to explore fresh avenues for GI, advancing modern society to new heights (Chaarani and Raimi, 2022) while leveraging their existing green initiatives for competitive advantage.

Furthermore, SMEs characterised by GEO tend to allocate resources towards green endeavours. This resource commitment enables them to invest in research and development (R&D) for GI (Ong *et al.*, 2022) and allocate resources towards exploiting existing green technologies and practices, thereby facilitating green ambidexterity. Moreover, these SMEs cultivate a culture of learning and adaptation, which is crucial for ambidextrous innovation (Andrade *et al.*, 2023). They continuously glean insights from their successful and unsuccessful environmental initiatives and utilise this knowledge to adapt their strategies for exploring and exploiting GI opportunities.

H3. GEO is significantly associated with GAI.

2.4 The mediating role of green ambidexterity innovation

Green ambidexterity empowers SMEs to explore novel environmentally sustainable opportunities concurrently and capitalise on existing green initiatives (Andrade *et al.*, 2023). This enhanced innovation capacity enables SMEs to cultivate a diverse portfolio encompassing green products, services and processes, positively influencing their green performance. Entrepreneurs have to explore new opportunities in traditional society by fulfilling a market need through a modern and innovative combination of resources to produce superior value, but they have to use their intuitions along with their skills and knowledge, as the range of choices and the implications of exploitation of modern opportunities are unknown (Chaarani and Raimi, 2022). By adopting an ambidextrous approach to GI, SMEs can navigate dynamic environmental regulations, market trends and consumer preferences (Islam *et al.*, 2022). This adaptability ensures they remain agile in response to environmental challenges and opportunities, ultimately leading to enhanced CGP (Hossain *et al.*, 2023).

Moreover, GAI enables SMEs to optimise resource utilisation by simultaneously exploring new green opportunities and leveraging existing green capabilities (Shehzad *et al.*, 2023). This resource efficiency translates into cost minimisation, operational efficiency and a minimised environmental footprint, positively impacting various green performance indicators.

H4. GAI mediates between GEO and CGP.

2.5 The moderating role of green technological turbulence

SMEs with a robust GEO may encounter heightened uncertainty about which green technologies to invest in and how to implement them effectively. SMEs may grapple with adapting their strategies to rapidly evolving technological landscapes. The phenomenon of GTT necessitates flexibility and adaptability in SMEs' green strategies and practices (Hossain *et al.*, 2023).

SMEs characterised by a high level of GEO may find it imperative to continuously scan the environment for emerging green technologies, adapt their innovation processes accordingly and swiftly integrate new technologies into their operations (Shafique *et al.*, 2021). The ability to navigate GTT effectively enables SMEs to stay abreast of emerging opportunities and remain competitive in the green marketplace (Al-Swidi *et al.*, 2024). Thus, SMEs with an intense GEO must exhibit agility and responsiveness to effectively leverage emerging green technologies and capitalise on evolving market dynamics.

H5. GTT moderates between GEO and CGP.

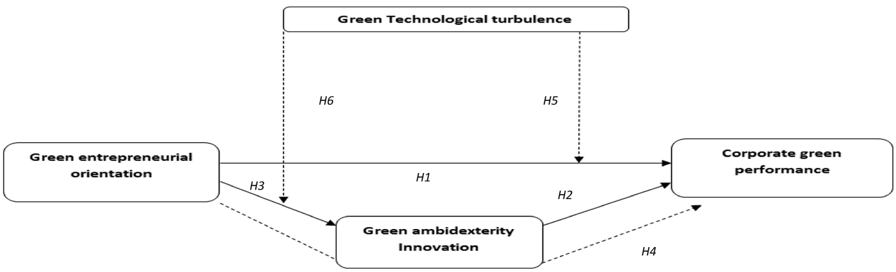
Iqbal *et al.* (2021) posit that due to technological turbulence, existing technologies often become out-dated, paving the way for the emergence of disruptive technologies and pushing leaders to improve innovative competences and redesign business models (Pandit *et al.*, 2018). Amid significant technological turbulence, corporations proactively pursue to procure new technology and knowledge from stakeholders and foster GAI.

To cope with technology turbulence, organisations embracing GEO tend to prioritise integrating novel green technologies. The fluidity of technological changes necessitates SMEs to swiftly respond to emerging opportunities and threats, adapting their strategies to explore and exploit GIs. Conversely, in environments with low levels of technology turbulence, the external technological setting remains constant (Lisi *et al.*, 2020). Thus, adopting GEO sets the platform to embrace high levels of technology turbulence.

Moreover, SMEs with a robust GEO can leverage collaborative networks to access expertise, share resources and jointly pursue initiatives for GAI (Al-Omush *et al.*, 2023). Collaborative endeavours assist SMEs in navigating GTT more effectively, thereby moderating the relationship between GEO and GAI.

H6. GTT moderates between GEO and GAI.

Based on the discussion, research framework is showed in Figure 1.



Source(s): Figure by authors

Figure 1.
Research model

3. Research method

3.1 Research design, population and sample

The research adhered to the positivism paradigm, employing a deductive approach and quantitative methodology. The positivism paradigm enables researchers to unearth pragmatic knowledge by utilising a hypothetical deductive observation approach. The present study utilised established theories such as the NRBV, CT and ambidexterity paradigm to extend green entrepreneurship, corporate sustainability, GAI and GTT knowledge domain, define four variables (GEO, GAI, GTT and CGP), formulate six hypotheses and empirically examine them and provide rationale for considering the positivism paradigm and deductive approach. Since the data were collected within a single temporal frame, this research was classified as cross-sectional. Finally, the present study employed a questionnaire-based survey strategy, as it allows for the collection of extensive data from respondents in a cost-effective manner, enabling the generalisation of conclusions representative of the entire population. Data collected through a structured questionnaire-based survey administered to mid- and top-level management personnel of manufacturing SMEs in Malaysia. The manufacturing sector is selected for investigation as a significant amount of emission (35.47 million) created from this sector, and mid- and top-level management respondents are chosen, as they are the right persons to provide reliable information about sustainable performance and relevant higher-order strategies (Hossain *et al.*, 2024a, b). The SME corporation's criteria defined manufacturing SMEs in Malaysia, which specify firms with sales turnover limits maximum RM50 million or full-time employees limited to 200 (FMM, 2021). Based on the Federation of Malaysian Manufactures (FMM) Directory (52nd Edition), there are 3,300 listed manufacturing companies in Malaysia, of which 76% (2,508 firms) are SMEs, constituting the population of this research. Based on Krejcie and Morgan's (1970) study, a sample size of 335 firms' responses was determined.

3.2 Data collection

The study employed a simple random sampling strategy, distributing approximately 700 questionnaires via email to the firms listed in the FMM directory. Data collection occurred from 15 January to 30 June, 2023, rendering the study cross-sectional. A total of 333 responses were collected, and after conducting thorough screening, 313 were deemed suitable for inclusion in the final analysis.

3.3 Measurement of the constructs

The measurement items for each variable were adapted from the prior literature. Details are given in Table 2.

3.4 Pre-test and pilot test

An industry professional and two professors of business conducted a pre-test to minimise errors and ensure the quality of the questionnaire. In total, 30 responses were collected and analysed for pilot testing and confirmed the reliability of the items.

4. Empirical results

4.1 Non-response bias (NRB) and common method bias (CMB)

Researchers compared the mean and standard deviation for the initial 30 and late 30 respondents to check non-response bias (NRB) suggested by Wallace and Cooke (1990). Descriptive comparison confirms that there is no NRB in the study.

According to Kock (2015), the model can be considered free of common method bias (CMB) if all variance inflation factors (VIFs) are equal to or lower than 3.3. In the current study, model's VIFs were lower than 3.3, as indicated in Table 4, thus signifying the absence of CMB.

4.2 Demographic characteristics

Among 313 respondents, the majority of the demographic information is as follows: *Type of Company* – food, beverage and tobacco (31%), electrical and electronics (11.8%) and chemicals (5%); *Company Age* – 1–10 years old (59.6%) and 11–20 years (16.7%) and *Number of Employees* – 31–80 (61%) and 81–130 (22%).

4.3 Model robustness analysis

The concept of robustness pertains to the degree of resilience exhibited by statistical models, tests and procedures in relation to the particular conditions under which a statistical analysis is conducted (Sarstedt *et al.*, 2020).

Firstly, non-existence of auto-correlation confirmed by Durbin–Watson statistic value is 1.70, which is within the range of 1.5–2.5. Secondly, non-linearity assessment was conducted using the quadratic effect, and the result evidenced that non-linearity is not a significant issue; the model is linear and robust as the quadratic effect for the constructs' interaction term showed insignificant effect (p-value> 0.05). Thirdly, Park and Gupta's (2012) Gaussian copula approach verified the endogeneity issue and model robustness as none of the Gaussian copulas is significant. Finally, following Sarstedt *et al.*'s (2017) systematic procedure for identifying and treating unobserved heterogeneity in using partial least squares (PLS) path models, we first ran the finite mixture partial least squares (FIMIX-PLS) procedure on the data. Following Matthews *et al.* (2016), we initiated the procedure by assuming a one-segment solution, using the default settings for the stop criterion (10^{-10} = 1.0E-10), the maximum number of iterations (5,000) and the number of repetitions (10). To determine the maximum number of segments to extract, we first computed the minimum sample size required to estimate each segment (Sarstedt *et al.*, 2017). The results of a post-hoc power analysis, assuming an effect size of 0.15 and a power level of 80%, suggest that the minimum sample size requirement is 85, which allows for extracting a maximum of three segments (313/85 = 3.6). We therefore re-ran the FIMIX-PLS for one to three segments, using the same settings as in the initial analysis. Lower Akaike's information criterion (AIC), AIC3, AIC4, consistent AIC (CAIC), Hannan–Quinn criterion (HQ), minimum description length with factor 5 (MDL5) and normalised entropy criterion (NEC) values indicate a better fit. Conversely, higher Log Likelihood values (less negative), normed entropy statistic (EN) and normed fit index (NFI) indicate a better fit.

The majority of criteria (AIC, AIC3, AIC4, HQ, Log likelihood, EN, NFI and NEC) suggest that the three-segment model provides the best fit for the data. BIC and CAIC suggest that a two-segment model might be better when penalising for model complexity. MDL5 favours the one-segment model, but this criterion is more conservative. Based on the fit indices, the three-segment model appears to be the most appropriate for capturing unobserved heterogeneity in the data. The two-segment model could be considered if there is a strong preference for simpler models with fewer segments. Since the metrics produced divergent results, researchers therefore conclude that unobserved heterogeneity is not at a critical level, which supports the results of the entire data set's analysis. The outcome of model robustness analysis showed in Table 1.

4.4 Goodness-of-fit (GoF) analysis

To evaluate the goodness-of-fit (GoF), standardised root mean squared residual (SRMR) of factor composite analysis, unweighted least squared discrepancy (d_ULS), geodesic distance

Auto-correlation assessment			
Durbin–Watson statistic			1.70

Non-linearity assessment Paths	Coefficient	T values	p values
QE (GTT) → CGP	−0.040	0.996	0.319
QE (GEO) → CGP	0.019	0.392	0.695
QE (GAI) → CGP	0.043	0.745	0.456

Endogeneity assessment Paths	Coefficient	T values	p values
Gaussian copula of model 1 (endogenous variable; GEO) GC (GEO) → CGP	0.028	0.087	0.931
Gaussian copula of model 2 (endogenous variable; GTT) GC (GTT) → CGP	−0.388	1.588	0.112
Gaussian copula of model 3 (endogenous variable; GAI) GC (GAI) → CGP	−0.130	1.023	0.306
Gaussian copula of model 4 (endogenous variables; GEO, GTT)			
GC (GEO) → CGP	0.052	0.164	0.870
GC (GTT) → CGP	−0.391	1.596	0.111
Gaussian copula of model 5 (endogenous variables; GEO, GAI)			
GC (GEO) → CGP	0.061	0.191	0.849
GC (GAI) → CGP	−0.132	1.042	0.297
Gaussian copula of model 6 (endogenous variables; GAI, GTT)			
GC (GAI) → CGP	−0.102	0.789	0.430
GC (GTT) → CGP	−0.352	1.392	0.164
Gaussian copula of model 7 (endogenous variables; GEO,GAI, GTT)			
GC (GEO) → CGP	0.076	0.240	0.810
GC (GTT) → CGP	−0.354	1.399	0.162
GC (GAI) → CGP	−0.105	0.812	0.417

Unobserved heterogeneity Number of segments Criteria	1	2	3
AIC (Akaike's information criterion)	1678.455	1634.407	*1608.9024*
AIC_3 (modified AIC with Factor 3)	1687.455	1653.407	*1637.9024*
AIC_4 (modified AIC with Factor 4)	1696.455	1672.407	*1666.9024*
BIC (Bayesian information criterion)	1712.171	*1705.585*	1717.542292
CAIC (consistent AIC)	*1721.171*	1724.585	1746.542292
HQ (Hannan–Quinn criterion)	1691.929	1662.851	*1652.31768*
MDL_5 (minimum description length with factor 5)	*1919.034*	2142.296	2384.101862
LnL (LogLikelihood)	−830.228	−798.203	*−775.4512*
EN (normed entropy statistic)	na	0.376	*0.591890647*
NFI (non-fuzzy index)	na	0.425	*0.561821617*
NEC (normalised entropy criterion)	na	195.231	*127.7382274*

Source(s): Estimated by authors using cross-sectional data gathered through survey

Table 1. Model robustness assessment results

(d_G), Chi-square and NFI are used to avoid model misspecification. To be considered a good fit, the SRMR value should be lower than 0.10 or 0.08 and NFI value should be closer to 1. The outcome of the GoF analysis is shown in Table 4; both SRMR (0.046) and NFI (0.895) values are within acceptable range and confirm model fitness. Moreover, lower values of d_ULS (0.595), d_G (0.214) and chi-square (400.015) indicate a better fit.

4.5 Convergent validity

Convergent validity, as defined by Bagozzi (1981), refers to the degree to which multiple items of the same variable demonstrate a strong correlation. To compute the average variance extracted (AVE), one squares the loading of each item on a construct and calculates the mean value, as Hair *et al.* (2019) outlined. Meanwhile, Cronbach's alpha (CA) coefficient, introduced by Cronbach (1951), assesses the internal reliability of measuring items. Similarly, composite reliability (CR), as described by Netemeyer *et al.* (2003), measures the internal consistency of scale items.

The analysis results in Table 2 indicate that all items exhibit an AVE exceeding the 0.5 threshold, with CA and CR values surpassing 0.7, thereby ensuring convergent validity.

4.6 Discriminant validity

Fornell and Larcker's (1981) criteria is the first strategy to check discriminant validity. As shown in Table 3, each construct's square root of the AVE exceeds its correlation with other variables, thereby confirming discriminant validity.

Additionally, Henseler *et al.* (2015) introduced the heterotrait-monotrait (HTMT) ratio to ensure the discriminant validity of variables if the correlation values are below 0.90. As depicted in Table 3, the HTMT values under acceptable range, thus establishing discriminant validity.

4.7 Structural model assessment

The first step involves addressing latent collinearity issues through the VIF. Subsequently, coefficient of determination (R^2), the effect size (f^2), the predictive relevance (Q^2predict) and the predictive accuracy [root mean squared error (RMSE), mean absolute error (MAE)] are checked. The results of R^2, f^2, VIF, Q^2predict, RMSE and MAE are presented in Table 4 below.

VIF values of 3.3 and above indicate collinearity existence (Hair *et al.*, 2019). Table 4 indicates no collinearity issue, as VIF values of all exogenous constructs against endogenous constructs are lower than 3.3. R^2 values are 0.25, 0.50 and 0.75, indicating weak, moderate and strong predictive accuracy levels, respectively (Hair *et al.*, 2019). This study's model prediction was weak. Cohen (1988) considers the f^2 values of 0.35, 0.15 and 0.02 as substantial, moderate and small effect sizes, respectively. The effect sizes of all exogenous constructs are small. Hair *et al.* (2019) coined that Q^2 values 0.00, 0.25 and 0.50 depict weak, moderate and substantial predictive relevance, respectively. The Q^2 value for endogenous constructs is small. Both RMSE and MAE values indicate good predictive accuracy for both endogenous variables, as the values are below 1. GAI has a slightly better predictive accuracy than CGP, as indicated by the lower RMSE (GAI = 0.937 and CGP = 0.946) and MAE (GAI = 0.735 and CGP = 0.775). The prediction errors are relatively low for both variables, indicating that the model is performing well in terms of accuracy. The errors for GAI are slightly lower, indicating marginally better performance in prediction accuracy.

Finally, hypotheses were tested by assessing the corresponding *t*-values of the path coefficients using bootstrapping with 5,000 resamples and a two-tailed test with a significance level of 0.05. The hypotheses test are results showed in Table 5, the structural model is shown in Figure 2 and the moderating effect slops are shown in Figure 3.

Constructs and sources	Items	Cronbach's alpha	Composite reliability	Average variance extracted
Corporate green performance (Hossain *et al.*, 2023)	CGP1: Reduced greenhouse gas emissions CGP2: Reduced water usage CGP3: Reduced energy use CGP4: Reduced consumption of hazardous/harmful/toxic Materials	0.875	0.914	0.727
Green ambidexterity innovation (Asiaei *et al.*, 2023)	*Exploitative green innovation* GAI1: Our firm improves current green products, processes and services GAI2: Our firm adjusts current green products, processes and services GAI3: Our firm extends current green market and GAI4: Our firm strengthens current green technology *Exploratory green innovation* GAI 5: Our firm adopts new green products, processes and services GAI 6: Our firm exploits new green products, processes, and services GAI 7: Our firm discovers new green market; and GAI 8: Our firm enters new green technology	0.931	0.943	0.675
Green entrepreneurial orientation (Idrees *et al.*, 2023)	GEO1: When facing with uncertainty, our firm has an aggressive attitude towards green projects GEO2: Our firm attach great importance to green research and development and green technology innovation GEO3: Our company has a tendency to become market leader and always takes the lead in introducing green products, services or technologies GEO4: We usually start green initiatives before our competitors GEO5: Our company has the attitude to "beat their competitors"	0.864	0.902	0.648
Green technological turbulence (Al-Swidi *et al.*, 2024)	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	0.738	0.851	0.655

Source(s): Estimated by authors using cross-sectional data gathered through survey

Table 2.
Convergent validity assessment results

Table 3.
Discriminant validity assessment results

	CGP	GAI	GEO	GTT
Fornell and Larcker criteria				
Corporate green performance (CGP)	0.852			
Green ambidexterity innovation (GAI)	0.298	0.822		
Green entrepreneurial orientation (GEO)	0.289	0.370	0.805	
Green technological turbulence (GTT)	0.324	0.270	0.300	0.809
Heterotrait-monotrait (HTMT) ratio				
Corporate green performance (CGP)				
Green ambidexterity innovation (GAI)	0.327			
Green entrepreneurial orientation (GEO)	0.330	0.408		
Green Technological turbulence (GTT)	0.399	0.321	0.375	

Source(s): Estimated by authors using cross-sectional data gathered through survey

Table 4.
Quality of the structural model

Endogenous variables	R^2	Q^2predict	RMSE	MAE	Exogenous variables	f^2	VIF
Corporate green performance	0.172	0.118	0.946	0.775	Green ambidexterity innovation	0.038	1.211
Green ambidexterity innovation	0.156	0.138	0.937	0.735	Green entrepreneurial orientation	0.023	1.225
					Green technological turbulence	0.049	1.180

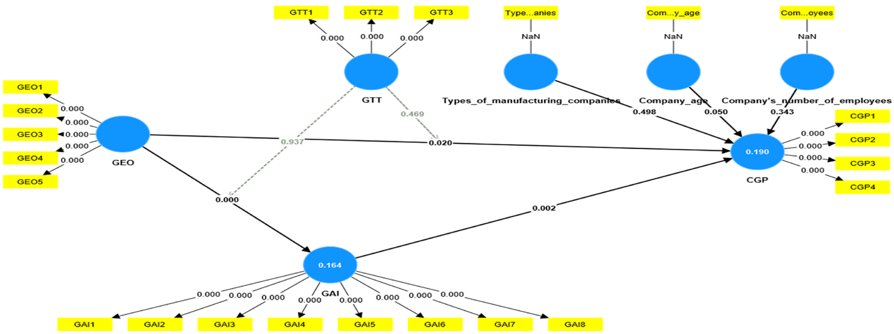
Goodness-of-fit (GoF) analysis for estimated model	
SRMR	0.046
d_ULS	0.595
d_G	0.214
Chi-square	400.015
NFI	0.895

Source(s): Estimated by authors using cross-sectional data gathered through survey

Table 5.
Path coefficient results

Paths	Beta	T-values	p-values	Decision significance ($p < 0.05$)
H1: GEO → CGP	0.151	2.324	0.020	Supported
H2: GAI → CGP	0.193	3.121	0.002	Supported
H3: GEO → GAI	0.318	5.174	0.000	Supported
H4: GEO → GAI → CGP	0.061	2.628	0.009	Partial Mediation
H5: GTT × GEO → CGP	0.044	0.724	0.469	No moderation
H6: GTT × GEO → GAI	−0.005	0.079	0.937	No moderation
Control variable 1: Types of manufacturing companies → CGP	−0.051	0.678	0.498	No Influence
Control variable 2: Company age → CGP	0.146	1.963	0.050	Influence
Control variable 3: Company’s number of employees → CGP	−0.049	0.949	0.343	No Influence

Source(s): Estimated by authors using cross-sectional data gathered through survey



Source(s): Figure from Smart-PLS software

Figure 2.
Structural model

4.8 Importance-performance map analysis (IPMA)

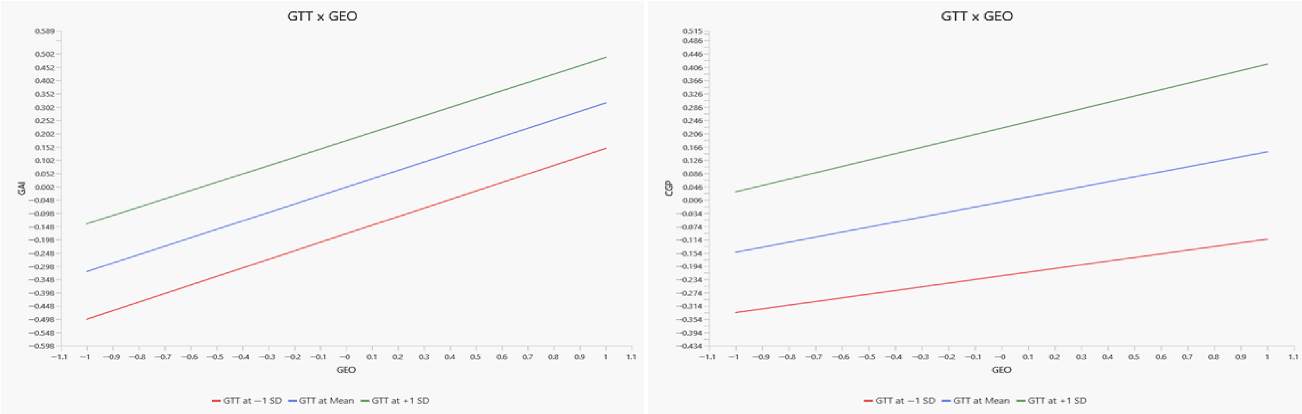
Ringle and Sarstedt (2016) asserted that importance-performance map analysis (IPMA) enhances the comprehension of PLS-SEM outcomes by offering more profound insights into causal relationships. Table 6 indicates the total effect and performance values of exogenous variables, predicting the endogenous variable, i.e. corporate green performance. For IPMA, it is necessary to focus on the constructs with high importance and low performance so that stakeholders can take the initiative to improve the performance of those certain constructs based on priority. Table 6 and Figure 4 suggest that Malaysian SMEs have to focus more on managing green technological turbulence and fostering green entrepreneurial orientation as their performances are lower, but their importance is higher.

5. Discussion

The study's results confirm significant associations for all hypothesised relationships, except for the moderation relationships. Concerning the positive association between GEO and CGP (H1), several previous studies such as De Guimarães *et al.* (2018) and Habib *et al.* (2020) have reported similar findings. GEO-driven firms are inherently driven by sustainability performance, focusing on green activities through strategy, products, innovations, process and supply chain activities to achieve competitive advantages. Jiang *et al.* (2018) also evidenced that GEO has a significant relationship with environmental and financial performance through GI, eco-design and risk-taking. Moreover, GEO helps to ensure CGP by providing a waste-free and environmentally friendly work environment, which boosts morale and productivity. Consequently, the more GEO capitalises on sustainable business prospects, the higher the green firm's capabilities, which lead to better CGP (Idrees *et al.*, 2023).

Secondly, the findings of this study regarding the association between GAI and CGP (H2) are well supported by previous research studies such as Úbeda-García *et al.* (2022). GI has emerged as a strategic tool for addressing environmental challenges while ensuring economic sustainability (Hossain *et al.*, 2023). Both green exploitative and exploratory innovation exhibit positive correlations that corporate CGP. This finding underscores the importance of ambidextrous organisations, which excel in engaging in both exploitative and exploratory innovations, in achieving CGP. It aligns with the central tenet of ambidexterity theory, which suggests that ambidextrous firms attain superior performance than conventional firms (Wei *et al.*, 2023). However, the level of performance through GAI depends on both external contextual factors such as market demand, environmental regulations and pressure from other stakeholders and internal organisational factors such as

Figure 3.
Interaction graphs



Source(s): Figure from Smart-PLS software corporate environmental ethics, environmental leadership, corporate culture and corporate capabilities (Chen *et al.*, 2022).

Thirdly, the positive association between GEO and GAI (H3) aligns with existing studies by Wang *et al.* (2022) and Shehzad *et al.* (2023). SMEs characterised by higher levels of GEO tend to exhibit more excellent ambidextrous behaviour, effectively balancing exploration and exploitation in their GI endeavours. As a core internal organisational strategy, GEO is a vital foundation and catalyst for businesses to develop green strategies, embodying the firm's GAI approach (Shehzad *et al.*, 2023; Jiang *et al.*, 2018). GEO empowers SMEs to explore new environmentally sustainable opportunities while concurrently leveraging existing green initiatives. This balanced approach enables SMEs to achieve green ambidexterity by continuously innovating and enhancing their environmental performance while maximising the benefits of their current green practices.

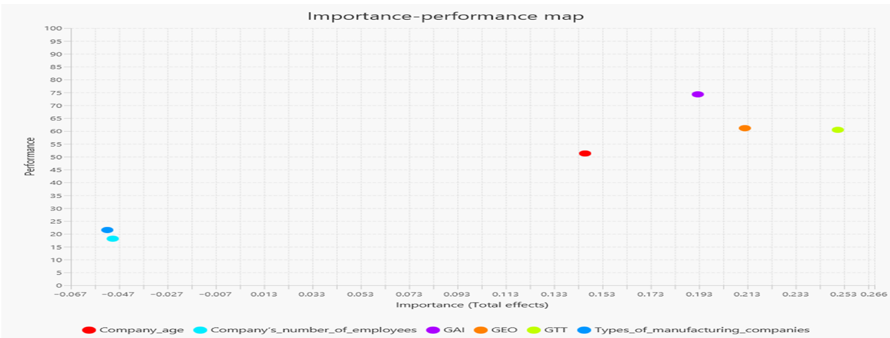
Fourthly, GAI partially mediates the relationship between GEO and CGP (H4). By engaging in ambidextrous GI efforts, SMEs can effectively navigate dynamic environmental regulations, market trends and consumer preferences (Shehzad *et al.*, 2023; Islam and Abd Wahab, 2023). This adaptability ensures their responsiveness to environmental challenges and opportunities, enhancing green performance. Ambidextrous GI allows SMEs to optimise resource utilisation by concurrently exploring new green opportunities and leveraging existing green capabilities (Asiaei *et al.*, 2023). These resource efficiency green performance indicators assist firms to achieve sustainable value creation. However, implementing GAI is not a straightforward task in SMEs that have resource constraints, as it involves greater risk, higher cost (Chen *et al.*, 2022) and strategic flexibility (Hossain *et al.*, 2023).

Finally, GTT did not exhibit moderation effects on both the associations between GEO and CSP (H5) and between GEO and GAI (H6). This finding is surprising yet novel, given that previous studies have often reported a positive impact of green technology turbulence on GEO, innovation and CGP, albeit without considering the perspective of ambidextrous

Table 6. Importance-performance map analysis (IPMA) results

Constructs	Importance	Performance
Green ambidexterity innovation (GAI)	0.193	74.271
Green entrepreneurial orientation (GEO)	0.212	61.121
Green Technological turbulence (GTT)	0.251	60.469

Source(s): Estimated by authors using cross-sectional data gathered through survey



Source(s): Figure from Smart-PLS software

Figure 4. IPMA graph

innovation. Scholars have suggested that technological turbulence pushes firms to innovate and improve the rate of success with unique products in turbulent settings (Jin *et al.*, 2022; Huo *et al.*, 2024). Furthermore, turbulent atmospheres necessitate firms to adapt to changing market situations with dynamism. These insignificant moderating outcomes highlight the complexity of the affiliation between technological turbulence and GI in SMEs, warranting further investigation into the underlying mechanisms at play.

The lower green technology adoption in the manufacturing marketplace can be a crucial reason for GTT's insignificant moderating impact. According to Ghobakhloo and Ching (2019), high technology adoption is observed only in 37% of manufacturing enterprises. If the government imitates proactive environmental regulation and policies, initiatives include financial incentives, capacity-building programs and technology transfer schemes, and this can help SMEs navigate technological turbulence. The Ministry of Environment and Water (KASA) is exploring the potential implementation of a "Climate Change Act" and a "Carbon Tax" to encourage sustainable practices. Additionally, the government is allocating RM35 million in Low Carbon Catalyst Grant (GeRAK) funds to local governments to promote climate change initiatives at the grassroots level (Abidin *et al.*, 2023).

6. The study implications

6.1 Theoretical and methodological implications

The current study expands the body of knowledge by integrating GEO, GAI, GTT and CGP into an original model and validates it empirically. This research provides valuable insights in the light of the NRBV, CT and ambidexterity paradigm to evaluate the impact of internal (GEO and GAI) and external (GTT) factors on CGP of Malaysian SMEs.

Secondly, this research contributes to resolving a critical debate concerning how GEO facilitates SMEs in achieving sustainable performance outcomes amidst complex and diverged environments, thereby ensuring CGP in Malaysian SMEs through the intervention of GAI. The organisational ambidexterity innovation capability exhibited by SMEs is shaped by adopting advanced technologies, enabling SMEs to proactively adapt and align with intelligent technologies in response to evolving demands, challenges and competitive uncertainties. This proactive approach reflects SMEs' proximity to embrace and leverage high-end technologies.

This research delves into ambidextrous innovative methods that effectively address paradoxes and promote GAI and CGP at the organisational level. By exploring the interplay between GEO, GAI and CGP, the research sheds light on how SMEs can navigate complexities and contradictions inherent in their environments to achieve sustainable business outcomes.

Thirdly, our research contributes to advancing knowledge regarding GTT as a moderator in an ambiguous setting within the manufacturing industry, thereby making a significant theoretical contribution. In today's age of disruption, GTT is an inevitable phenomenon. However, our empirical results indicate that GTT did not moderate the relationships between GEO, GAI and CGP. This finding underscores GTT's nuanced and context-dependent nature, which operates differently across various contexts and organisations (Hillmann and Guenther, 2021).

The non-significant result regarding the moderation effect of GTT provides valuable insights into the external environmental influences. It advances the development of CT related to technology adoption and ambidexterity. Moreover, this study enhances researchers' understanding of the intermediary mechanisms between GEO and CGP and the internal organisational mechanisms and capabilities necessary for enterprises to achieve GAI and development. By shedding light on these intricate relationships, our research contributes to the broader discourse on sustainability, innovation and organisational effectiveness in the manufacturing sector.

Finally, the advanced model robustness statistical analysis utilising SEM-PLS such as auto-correlation, non-linearity, endogeneity and heterogeneity assessment contributes methodologically in the knowledge domains of entrepreneurship, technology, ambidexterity and sustainability.

6.2 Managerial implications

The current research offers several managerial implications by providing insights into the impacts of GEO, GAI and GTT on CGP. The research framework and empirical findings serve as a recommendation for managing manufacturing SMEs to navigate these dynamics and enhance CGP effectively.

Firstly, the study highlights the importance of GAI as a channel for translating environmental resources, such as GEO, into enhanced performance. Managers should understand the way to coordinate various organisational green resources to create green value. Prioritising environmental legislation, adopting GAI strategies and accelerating firms' ability for ecological sustainability are the essential steps for promoting sustainable progress in society, culture and climate.

Secondly, managers should recognise and install flexible skills such as eco-friendly and agile entrepreneurship and innovative mindset, particularly in adapting to new technological advancements. They should reorganise and reintegrate resources to effectively capitalise on entrepreneurial opportunities.

Furthermore, fostering a collaborative atmosphere for GAI within the organisation is essential. Managers should encourage an environment where personnel can learn collaboratively and create new knowledge. Enhancing the organisation's ability to consume information and remain conscious of its surroundings is vital for fostering innovation and staying competitive in dynamic environments.

By embracing GEO, promoting entrepreneurial efforts and adopting an organisational climate of innovation and collaboration, managers can effectively direct the complexities of GI and technological turbulence, ultimately enhancing corporate green performance and contributing to sustainable development.

7. Conclusion, limitations and future research directions

Indeed, this study has identified several limitations that offer opportunities for future research to address and expand upon. Firstly, while our study focuses on CGP as an outcome variable, future research could further explore the association between GI and firm competitiveness and the mechanisms through which CGP translates into sustainable value creation in Malaysia and other Association of Southeast Asian Nations (ASEAN) countries. Investigating these relationships in different contexts would provide valuable insights into the broader implications of green initiatives on organisational success. Secondly, our study primarily relies on associations rather than causal impacts due to the cross-sectional nature of the data. Forthcoming research can conduct longitudinal or experimental studies, offering more robust evidence of causality.

Additionally, employing advanced statistical techniques such as integration of fuzzy-set qualitative comparative analysis (fsQCA) and necessity condition analysis (NCA) with PLS-SEM could further elucidate the complex mechanisms. Thirdly, while our study adopts a quantitative approach, integrating qualitative methods could provide deeper insights into the associations between GEO, GAI, GTT and CGP. Combining quantitative and qualitative approaches through mixed-methods research would offer more inclusive findings. Fourthly, future research could compare SMEs and large firms to discern potential differences in the relationships among this study's constructs. Utilising diverse datasets beyond FMM directories could enrich the comparative analysis and enhance the generalisability of findings. Finally, exploring market turbulence as an additional moderator alongside technological turbulence can provide interesting outcomes and offer valuable insights for managers and policymakers seeking to promote sustainability and innovation in dynamic business environments.

References

Abidin, N.Z.Z., Sirat, N.I.M. and Manshor, N.M. (2023), "Malaysia's climate change framework and local government response", *Environment-Behaviour Proceedings Journal*, Vol. 8 No. SI13, pp. 59-64, doi: 10.21834/e-bpj.v8isi13.5044.

Aboalhool, T., Alzubi, A. and Iyiola, K. (2024), "Humane entrepreneurship in the circular economy: the role of green market orientation and green technology turbulence for sustainable corporate performance", *Sustainability*, Vol. 16 No. 6, p. 2517, doi: 10.3390/su16062517.

Aftab, J., Abid, N., Cucari, N. and Savastano, M. (2023), "Green human resource management and environmental performance: the role of green innovation and environmental strategy in a developing country", *Business Strategy and the Environment*, Vol. 32 No. 4, pp. 1782-1798, doi: 10.1002/bse.3219.

Al-Omush, A., Momany, M.T., Hannoon, A. and Anwar, M. (2023), "Digitalization and sustainable competitive performance in small–medium enterprises: a moderation mediation model", *Sustainability*, Vol. 15 No. 21, 15668, doi: 10.3390/su152115668.

Al-Swidi, A.K., Al-Hakimi, M.A., Al-Sarraf, J. and Al Koliby, I.S. (2024), "Innovate or perish: can green entrepreneurial orientation foster green innovation by leveraging green manufacturing practices under different levels of green technology turbulence?", *Journal of Manufacturing Technology Management*, Vol. 35 No. 1, pp. 74-94, doi: 10.1108/jmtm-06-2023-0222.

Andrade, J., Franco, M. and Mendes, L. (2023), "Facilitating and inhibiting effects of organisational ambidexterity in SME: an analysis centred on SME characteristics", *Journal of the Knowledge Economy*, Vol. 14 No. 1, pp. 35-64, doi: 10.1007/s13132-021-00831-9.

Anghel, G.A. and Anghel, M.A. (2022), "Green entrepreneurship among students—social and behavioral motivation", *Sustainability*, Vol. 14, p. 8730, doi: 10.3390/su14148730.

Asadi, S., Pourhashemi, S.O., Nilashi, M., Abdullah, R., Samad, S., Yadegaridehkordi, E., Aljojo, N. and Razali, N.S. (2020), "Investigating influence of green innovation on sustainability performance: a case on Malaysian hotel industry", *Journal of Cleaner Production*, Vol. 258, 120860, doi: 10.1016/j.jclepro.2020.120860.

Asiaei, K., O'Connor, N.G., Barani, O. and Joshi, M. (2023), "Green intellectual capital and ambidextrous green innovation: the impact on environmental performance", *Business Strategy and the Environment*, Vol. 32 No. 1, pp. 369-386, doi: 10.1002/bse.3136.

Aydin, M., Degirmenci, T., Gurdal, T. and Yavuz, H. (2023), "The role of green innovation in achieving environmental sustainability in European Union countries: testing the environmental Kuznets curve hypothesis", *Gondwana Research*, Vol. 118, pp. 105-116, doi: 10.1016/j.gr.2023.01.013.

Bagozzi, R.P. (1981), "Evaluating structural equation models with unobservable variables and measurement error: a comment", *Journal of Marketing Research*, Vol. 18 No. 3, pp. 375-381, doi: 10.1177/002224378101800312.

Barney, J. (1991), "Firm resources and sustained competitive advantage", *Journal of Management*, Vol. 17 No. 1, pp. 99-120, doi: 10.1177/014920639101700108.

Cao, C., Tong, X., Chen, Y. and Zhang, Y. (2022), "How top management's environmental awareness affect corporate green competitive advantage: evidence from China", *Kybernetes*, Vol. 51 No. 3, pp. 1250-1279, doi: 10.1108/k-01-2021-0065.

Chaarani, H.E. and Raimi, L. (2022), "Determinant factors of successful social entrepreneurship in the emerging circular economy of Lebanon: exploring the moderating role of NGOs", *Journal of Entrepreneurship in Emerging Economies*, Vol. 14 No. 5, pp. 874-901, doi: 10.1108/JEEE-08-2021-0323.

Chen, Y., Gao, L. and Zhang, Y. (2022), "The impact of green organizational identity on green competitive advantage: the role of green ambidexterity innovation and organizational flexibility", *Mathematical Problems in Engineering*, Vol. 2022, pp. 1-18, doi: 10.1155/2022/4305900.

Cohen, J. (1988), *Statistical Power Analysis for the Behavioral Sciences*, 2nd ed., Erlbaum, Hillsdale, NJ.

Cronbach, L.J. (1951), "Coefficient alpha and the internal structure of tests", *Psychometrika*, Vol. 16 No. 3, pp. 297-334, doi: 10.1007/bf02310555.

de Guimarães, J.C.F., Severo, E.A. and de Vasconcelos, C.R.M. (2018), "The influence of entrepreneurial, market, knowledge management orientations on cleaner production and the sustainable competitive advantage", *Journal of Cleaner Production*, Vol. 174, pp. 1653-1663, doi: 10.1016/j.jclepro.2017.11.074.

Dey, P.K., Petridis, N.E., Petridis, K., Malesios, C., Nixon, J.D. and Ghosh, S.K. (2018), "Environmental management and corporate social responsibility practices of small and medium-sized enterprises", *Journal of Cleaner Production*, Vol. 195, pp. 687-702, doi: 10.1016/j.jclepro.2018.05.201.

Donaldson, L. (2001), *The Contingency Theory of Organizations*, Sage, Thousand Oaks, CA.

Ebrahimi, P. and Mirbargkar, S.M. (2017), "Green entrepreneurship and green innovation for SME development in market turbulence", *Eurasian Business Review*, Vol. 7 No. 2, pp. 203-228, doi: 10.1007/s40821-017-0073-9.

Environmental Performance Index (2022), available at: https://epi.yale.edu/epi-results/2022/component/epi

FMM (2021), available at: https://www.fmm.org.my/Publications-@-Publications_List.aspx

Fornell, C. and Larcker, D.F. (1981), "Evaluating structural equation models with unobservable variables and measurement error", *Journal of Marketing Research*, Vol. 18 No. 1, pp. 39-50, doi: 10.2307/3151312.

Ghobakhloo, M. and Ching, N.T. (2019), "Adoption of digital technologies of smart manufacturing in SMEs", *Journal of Industrial Information Integration*, Vol. 16, 100107, doi: 10.1016/j.jii.2019.100107.

Habib, M.A., Bao, Y. and Ilmudeen, A. (2020), "The impact of green entrepreneurial orientation, market orientation and green supply chain management practices on sustainable firm performance", *Cogent Business and Management*, Vol. 7 No. 1, 1743616, doi: 10.1080/23311975.2020.1743616.

Hair, J.F., Risher, J.J., Sarstedt, M. and Ringle, C.M. (2019), "When to use and how to report the results of PLS-SEM", *European Business Review*, Vol. 31 No. 1, pp. 2-24, doi: 10.1108/ebr-11-2018-0203.

Hart, S.L. (1995), "A natural-resource-based view of the firm", *Academy of Management Review*, Vol. 20 No. 4, pp. 986-1014, doi: 10.5465/amr.1995.9512280033.

Henseler, J., Ringle, C.M. and Sarstedt, M. (2015), "A new criterion for assessing discriminant validity in variance-based structural equation modeling", *Journal of the Academy of Marketing Science*, Vol. 43 No. 1, pp. 115-135, doi: 10.1007/s11747-014-0403-8.

Hillmann, J. and Guenther, E. (2021), "Organizational resilience: a valuable construct for management research?", *International Journal of Management Reviews*, Vol. 23 No. 1, pp. 7-44, doi: 10.1111/ijmr.12239.

Hossain, M.I., Kumar, J., Islam, M.T. and Valeri, M. (2023), "The interplay among paradoxical leadership, industry 4.0 technologies, organisational ambidexterity, strategic flexibility and corporate sustainable performance in manufacturing SMEs of Malaysia", *European Business Review*, Vol. 36 No. 5, pp. 639-669, doi: 10.1108/EBR-04-2023-0109.

Hossain, M.I., Ong, T.S., Tabash, M.I. and Teh, B.H. (2024a), "The panorama of corporate environmental sustainability and green values: evidence of Bangladesh", *Environment, Development and Sustainability*, Vol. 26 No. 1, pp. 1033-1059, doi: 10.1007/s10668-022-02748-y.

Hossain, M.I., Teh, B.H., Tabash, M.I., Chong, L.L. and Ong, T.S. (2024b), "Unpacking the role of green smart technologies adoption, green ambidextrous leadership, and green innovation behaviour on green innovation performance in Malaysian manufacturing companies", *FIIB Business Review*, 23197145231225335, doi: 10.1177/23197145231225335.

Huo, B., Wang, B. and Li, Z. (2024), "How to deal with technological turbulence for improving innovation performance", *Technology Analysis and Strategic Management*, Vol. 36 No. 3, pp. 549-562, doi: 10.1080/09537325.2022.2042510.

Idrees, H., Xu, J. and Andrianarivo Andriandafiarisoa Ralison, N.A. (2023), "Green entrepreneurial orientation and knowledge creation process as enablers of green innovation performance: the moderating role of resource orchestration capability", *European Journal of Innovation Management*, Vol. ahead-of-print No. ahead-of-print, doi: 10.1108/EJIM-02-2023-0143.

Iqbal, Q., Ahmad, N.H. and Li, Z. (2021), "Frugal-based innovation model for sustainable development: technological and market turbulence", *The Leadership and Organization Development Journal*, Vol. 42 No. 3, pp. 396-407, doi: 10.1108/lodj-06-2020-0256.

Islam, A. and Abd Wahab, S. (2023), "Ambidextrous innovation from a holistic perspective: leveraging into sustainable competitive advantage of SMEs", *International Journal of Business Innovation and Research*, Vol. 1 No. 1, p. 1, doi: 10.1504/IJBIR.2023.10054610.

Islam, A. and Wahab, S.A. (2021), "The intervention of strategic innovation practices in between regulations and sustainable business growth: a holistic perspective for Malaysian SMEs", *World Journal of Entrepreneurship, Management and Sustainable Development*, Vol. 17 No. 3, pp. 396-421, doi: 10.1108/wjemsd-04-2020-0035.

Islam, A., Abd Wahab, S., Latiff, A.S.A. and Mansoor, A. (2022), "Building strategic innovation model for small and medium enterprises of Malaysia: inclusion of a holistic philosophy", *International Journal of Business Innovation and Research*, Vol. 1 No. 1, p. 1, doi: 10.1504/IJBIR.2021.10049860.

Islam, A., Wahab, S.A., Maideen, M.B.H. and Hossain, M.I. (2024), "Innovation in a post-pandemic environment: leveraging the power of strategic wisdom", *International Journal of Management Concepts and Philosophy*, Vol. 17 No. 2, pp. 161-186, doi: 10.1504/ijmcp.2024.137636.

Jiang, W., Chai, H., Shao, J. and Feng, T. (2018), "Green entrepreneurial orientation for enhancing firm performance: a dynamic capability perspective", *Journal of Cleaner Production*, Vol. 198, pp. 1311-1323, doi: 10.1016/j.jclepro.2018.07.104.

Jin, C., Liu, A., Liu, H., Gu, J. and Shao, M. (2022), "How business model design drives innovation performance: the roles of product innovation capabilities and technological turbulence", *Technological Forecasting and Social Change*, Vol. 178, 121591, doi: 10.1016/j.techfore.2022.121591.

Kock, N. (2015), "Common method bias in PLS-SEM: a full collinearity assessment approach", *International Journal of e-Collaboration*, Vol. 11 No. 4, pp. 1-10, doi: 10.4018/ijec.2015100101.

Krejcie, R.V. and Morgan, D.W. (1970), "Determining sample size for research activities", *Educational and Psychological Measurement*, Vol. 30 No. 3, pp. 607-610, doi: 10.1177/001316447003000308.

Lawrence, P.R. and Lorsch, J.W. (1967), "Differentiation and integration in complex organizations", *Administrative Science Quarterly*, Vol. 12, pp. 1-47, doi: 10.2307/2391211.

Lisi, W., Zhu, R. and Yuan, C. (2020), "Embracing green innovation via green supply chain learning: the moderating role of green technology turbulence", *Sustainable Development*, Vol. 28 No. 1, pp. 155-168, doi: 10.1002/sd.1979.

Makhloufi, L., Vasa, L., Rosak-Szyrocka, J. and Djermani, F. (2023), "Understanding the impact of big data analytics and knowledge management on green innovation practices and organizational performance: the moderating effect of government support", *Sustainability*, Vol. 15 No. 11, p. 8456, doi: 10.3390/su15118456.

Marzouk, J. and El Ebrashi, R. (2024), "The interplay among green absorptive capacity, green entrepreneurial, and learning orientations and their effect on triple bottom line performance", *Business Strategy and the Environment*, Vol. 33 No. 3, pp. 1962-1976, doi: 10.1002/bse.3588.

Matthews, L., Sarstedt, M., Hair, J.F. and Ringle, C.M. (2016), "Identifying and treating unobserved heterogeneity with FIMIXPLS: Part II—a case study", *European Business Review*, Vol. 28 No. 2, pp. 208-224, doi: 10.1108/ebr-09-2015-0095.

Mia, M.M., Rizwan, S., Zayed, N.M., Nitsenko, V., Miroshnyk, O., Kryshtal, H. and Ostapenko, R. (2022), "The impact of green entrepreneurship on social change and factors influencing AMO theory", *Systems*, Vol. 10 No. 5, p. 132, doi: 10.3390/systems10050132.

Momayez, A., Rasouli, N., Alimohammadirokni, M. and Rasoolimanesh, S.M. (2023), "Green entrepreneurship orientation, green innovation and hotel performance: the moderating role of managerial environmental concern", *Journal of Hospitality Marketing and Management*, Vol. 32 No. 8, pp. 981-1004, doi: 10.1080/19368623.2023.2225495.

Ndou, V. (2021), "Social entrepreneurship education: a combination of knowledge exploitation and exploration processes", *Administrative Sciences*, Vol. 11 No. 4, p. 112, doi: 10.3390/admsci11040112.

Ndou, V., Mele, G. and Del Vecchio, P. (2019), "Entrepreneurship education in tourism: an investigation among European Universities", *Journal of Hospitality, Leisure, Sport and Tourism Education*, Vol. 25, 100175, doi: 10.1016/j.jhlste.2018.10.003.

Netemeyer, R.G., Bearden, W.O. and Sharma, S. (2003), *Scaling Procedures: Issues and Applications*, Sage, Thousand Oaks, CA.

Nordin, R. and Hassan, R.A. (2019), "The role of opportunities for green entrepreneurship towards investigating the practice of green entrepreneurship among SMEs in Malaysia", *Review of Integrative Business and Economics Research*, Vol. 8, pp. 99-116.

Nyam, T.T., Ayeleru, O.O., Ramatsa, I.M. and Olubambi, P.A. (2024), "Conversion of waste plastics into value-added materials: a global perspective", in Parameswaranpillai, J. and Deshmukh, K. (Eds), *Plastic Waste Management: Methods and Applications*, pp. 227-258.

OECD (2024), "Financing SMEs and entrepreneurs 2024: an OECD scoreboard", available at: https://www.oecd-ilibrary.org/sites/ea9dc78b-en/index.html?itemId=/content/component/ea9dc78b-en (30.4.2024)

Ong, T.S., Latif, B. and Di Vaio, A. (2022), "GEO and sustainable performance: the moderating role of GTD and environmental consciousness", *Journal of Intellectual Capital*, Vol. 23 No. 7, pp. 38-67, doi: 10.1108/jic-10-2021-0290.

O'Reilly, III, C.A. and Tushman, M.L. (2008), "Ambidexterity as a dynamic capability: resolving the innovator's dilemma", *Research in Organizational Behavior*, Vol. 28, pp. 185-206, doi: 10.1016/j.riob.2008.06.002.

Pandit, D., Joshi, M.P., Sahay, A. and Gupta, R.K. (2018), "Disruptive innovation and dynamic capabilities in emerging economies: evidence from the Indian automotive sector", *Technological Forecasting and Social Change*, Vol. 129, pp. 323-329, doi: 10.1016/j.techfore.2017.09.035.

Park, S. and Gupta, S. (2012), "Handling endogenous regressors by joint estimation using copulas", *Marketing Science*, Vol. 31 No. 4, pp. 567-586, doi: 10.1287/mksc.1120.0718.

Ringle, C.M. and Sarstedt, M. (2016), "Gain more insight from your PLS-SEM results: the importance-performance map analysis", *Industrial Management and Data Systems*, Vol. 116 No. 9, pp. 1865-1886, doi: 10.1108/imds-10-2015-0449.

Sarstedt, M., Ringle, C.M. and Hair, J.F. (2017), "Partial least squares structural equation modeling", in Homburg, C., Klarmann, M. and Vomberg, A. (Eds), *Handbook of Market Research*, Springer, Heidelberg, pp. 1-40.

Sarstedt, M., Ringle, C.M., Cheah, J., Ting, H., Moisescu, O.I. and Radomir, L. (2020), "Structural model robustness checks in PLS-SEM", *Tourism Economics*, Vol. 26 No. 4, pp. 1-24, doi: 10.1177/1354816618823921.

Secundo, G., Mele, G., Del Vecchio, P., Gianluca, E., Margherita, A. and Valentina, N. (2021), "Threat or opportunity? A case study of digital-enabled redesign of entrepreneurship education in the COVID-19 emergency", *Technological Forecasting and Social Change*, Vol. 166, 120565, doi: 10.1016/j.techfore.2020.120565.

Shafique, I., Kalyar, M.N. and Mehwish, N. (2021), "Organizational ambidexterity, green entrepreneurial orientation, and environmental performance in SMEs context: examining the moderating role of perceived CSR", *Corporate Social Responsibility and Environmental Management*, Vol. 28 No. 1, pp. 446-456, doi: 10.1002/csr.2060.

Shehzad, M.U., Zhang, J., Latif, K.F., Jamil, K. and Waseel, A.H. (2023), "Do green entrepreneurial orientation and green knowledge management matter in the pursuit of ambidextrous green innovation: a moderated mediation model", *Journal of Cleaner Production*, Vol. 388, 135971, doi: 10.1016/j.jclepro.2023.135971.

Singh, A.K., Raza, S.A., Nakonieczny, J. and Shahzad, U. (2023), "Role of financial inclusion, green innovation, and energy efficiency for environmental performance? Evidence from developed and emerging economies in the lens of sustainable development", *Structural Change and Economic Dynamics*, Vol. 64, pp. 213-224, doi: 10.1016/j.strueco.2022.12.008.

Sousa, R. and Voss, C.A. (2008), "Contingency research in operations management practices", *Journal of Operations Management*, Vol. 26 No. 6, pp. 697-713, doi: 10.1016/j.jom.2008.06.001.

Úbeda-García, M., Marco-Lajara, B., Zaragoza-Sáez, P.C., Manresa-Marhuenda, E. and Poveda-Pareja, E. (2022), "Green ambidexterity and environmental performance: the role of green human resources", *Corporate Social Responsibility and Environmental Management*, Vol. 29 No. 1, pp. 32-45, doi: 10.1002/csr.2171.

United Nations Infrastructure and Industrialization (2020), "United Nations Sustainable Development", available at: https://www.un.org/sustainabledevelopment/infrastructure-industrialization/.

Wallace, R.S.O. and Cooke, T.E. (1990), "The diagnosis and resolution of emerging issues in corporate disclosure practices", *Accounting and Business Research*, Vol. 20 No. 78, pp. 143-151, doi: 10.1080/00014788.1990.9728872.

Wang, S., Abbas, J., Sial, M.S., Álvarez-Otero, S. and Cioca, L.I. (2022), "Achieving green innovation and sustainable development goals through green knowledge management: moderating role of organizational green culture", *Journal of Innovation and Knowledge*, Vol. 7 No. 4, 100272, doi: 10.1016/j.jik.2022.100272.

Wei, S., Liu, W., Lin, Y., Wang, J. and Liu, T. (2023), "Smart supply chain innovation model selection: exploitative or exploratory innovation?", *International Journal of Logistics Research and Applications*, Vol. 26 No. 4, pp. 478-497, doi: 10.1080/13675567.2021.1965104.

About the authors

Mohammad Imtiaz Hossain is a Ph.D. Fellow at Multimedia University, Malaysia. He pursued MSc in Business Economics at the School of Business and Economics, Universiti Putra Malaysia, Malaysia (AACSB and EQUIS accredited). He has completed Bachelor in Business Management from Binary University, Malaysia and Diploma in Business from Mahsa Prima International College, Malaysia. His research interests include sustainability, SME, entrepreneurship, ambidexterity, innovation and many other interdisciplinary areas. He has published more than 45 academic articles and chapters-in-book both locally and internationally. Additionally, he is also serving as a reviewer for some prominent journals. He presented papers in several international conferences and clinched the "Best Paper Award" and "Best Presenter Award".

Dr Tze San Ong is Full Professor at the School of Business and Economics, Universiti Putra Malaysia. She earned her Ph.D. from the University of Leeds, UK, in 2005. Her research has been published in various prestigious journals, such as the *Journal of Cleaner Production, Business Strategy and the Environment, the International Journal of Productivity and Performance Management, the Journal of Intellectual Capital, Resources, Conservation and Recycling, Ecosystem Health and Sustainability* and many more. To date, she has published more than 100 academic articles and book chapters both locally and internationally. Her research interests include corporate sustainability, corporate performance measurement system, corporate governance, management accounting and carbon accounting. Tze San Ong is the corresponding author and can be contacted at: tzesan@upm.edu.my

Dr Yasmin Jamadar is currently serving as Assistant Professor (Finance) at the BRAC Business School (BBS), BRAC University (BRACU). Before joining BRACU, she worked as a lecturer (Accounting and Finance) at Alfa University College, Malaysia. Dr Yasmin obtained her Doctor of Philosophy (Ph.D.) in Finance from the School of Business and Economics, Universiti Putra Malaysia (UPM) [AACSB and EQUIS accredited], and she graduated on time (GOT). Her research areas include corporate finance, corporate governance, accounting, sustainability, insider trading and earnings management. Her publications have appeared in various international refereed journals indexed in the Chartered Association of Business Schools (ABS), Web of Science (WoS), Australian Business Deans Council (ABDC) and Scopus. Additionally, Dr Yasmin is also serving as a reviewer for some prominent journals including the *Journal of Islamic Accounting and Business Research, Investment analyst and Managerial and Decision Economics* to name a few. She is a certified expert on STATA, Eviews and SPSS software. She presented papers at several international conferences in UK, Malaysia, UAE and Bahrain. Her corporate experience includes working as a business development executive in Nascenia IT, Bangladesh.

Dr Boon Heng Teh is Senior Lecturer at the Faculty of Management, Multimedia University, Malaysia. His research interests include finance, green accounting and audit. His research work has been published in social science and management journals, e.g. *Asian Social Science and Journal Pengurusan*. He is also the recipient of several research awards including the fundamental research grant scheme (FRGS) awarded by the Government of Malaysia.

Dr Ariful Islam is Lecturer at Sunway Business School at Sunway University, Malaysia. He completed his Ph.D. at the Department of Business Management, Putra Business School (AACSB). He spent the early part of his career in IT/telecom before transitioning to academia segment. His scholarly works published in different reputed ABS, ABDC, WoS, Scopus and ERA-indexed international journals. He also has several years of experience examining the factors associated with sustainable business growth to inform regional business policy and practice, with a particular focus on small enterprises.