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DIGITAL-DRIVEN GREEN TRANSFORMATIONAL LEADERSHIP, HRM, AND IN-NOVATION FOR SUSTAINABLE BUSINESS PERFORMANCE: THE MODERATING ROLE OF TOP MANAGEMENT KNOWLEDGE

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Abstract
Achieving healthy, sustainable business performance (SBPE) is an inclusive dream of every organization. The present paper examines the relationship between greener dynamics and SBPE in manufacturing firms in Egypt.The study takes a deductive approach, using resource-based view theory (RBV) to underpin its theoretical framework. It is based on renewed scholars like Wei *et al.* (2009), Singh *et al.* (2020), and Ismail (2025). The data were collected from top management-level employees of manufacturing firms in Egypt. Finally, the study concluded based on 392 samples.Using path analysis, the results exert a positive effect of green transformational leadership (GTLP), green HRM (GHRM), and green innovation (GRIN) on SBPE. Finally, top management knowledge values (TMKV) moderate the association between GTLP and SBPE, GHRM and SBPE, and GRIN and SBPE.The study's outcomes assist playmakers in coining policies to bring sustainability and performance to the firms. Finally, the study's empirical findings enrich the depth of the domain literature, specifically of manufacturing firms in developing economies.The study offers an extensive and integrated framework that conglomerates GTLP, GHRM and GRIN towards SBPE. Besides, the moderation contribution of TMKV further provides the robustness of the fulfilment of the gaps in practical knowledge existing gaps.

KEYWORDS Sustainable business performance**,** Top management knowledge values, Green transformational leadership, Green innovation, Manufacturing firms, Sustainability

JEL classification: L1, L2, L6, O3, Q5
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1. INTRODUCTION

In an era where global concerns about sustainable business performance (SBPE), sustainability and sustainable development have reached unprecedented heights, organizations must adapt and thrive in a business setting (Ghouri*et al.*, 2020; Ghose *et al.*, 2025; Kwarteng *et al.*, 2023; Zhao and Huang, 2022). The convergence of these elements

signifies a paradigm shift in organizational dynamics, highlighting a universal approach to sustainability that extends beyond mere compliance (Mousa and Othman, 2020). Through a comprehensive exploration of the interplay between leadership, HRM practices, and innovative strategies, the SBPE can be successfully achieved (Hundal, 2023; Mashhady, 2021; Malik *et al.*, 2021; Shah *et al.*, 2024b). As organizations grapple with the challenges of integrating environmentally conscious practices into their operations, understanding the nuanced roles of green transformational leadership (GTLP), green human resource management (GHRM), and green innovation (GRIN) becomes paramount for fostering a resilient, responsible, and competitive business environment (Zhao and Huang, 2022; AlAbbadi and Abu Rumman, 2023; Ha *et al.*, 2025; Priwarapan& Sonsuphap, 2025; Yeung & Wong, 2022).

Factors such as GTLP, GRIN and GHRM are the significant pillar of developing sustainability and organizational success (Kusi *et al.*, 2021; Suleman *et al.*, 2024).More specifically, Zhao and Huang (2022) suggested that improvement and robustness of GTLP bring massive SBPE make successful organizations. Similarly, GHRM positively contributes to the organizations in terms of recruitment and engagement, where employees ensure a more pro-environmental environment to bring smooth SBPE (Shah and Soomro, 2023; Ali *et al.*, 2024). In the same arena, the role of GRIN in enhancing SBPE is integral to creating a forward-thinking, environmentally responsible organization. By driving sustainable practices and fostering a culture of continuous improvement, GRIN contributes to resource efficiency, market differentiation, regulatory compliance, and overall long-term success in a rapidly changing business context (Zhao and Huang, 2022; Shah *et al.*, 2024a; Suleman *et al.*, 2024).

In the above literature, several constructs, including GTLP, GRIN and GHRM, are found to be significant predictors of SBPE, organizational performance, firm performance and sustainability (Zhao and Huang, 2022; Al-Abbadi and Abu Rumman, 2023; Sisca and Wijaya, 2023). However, the literature still has a few gaps/ problems that need to be considered. Specifically, the literature does not provide evidence of a framework that may connect the GTLP, GRIN, and GRM towards SBPE moderated by TMKV. Besides, contextually, the investigation of this type of model still needs serious concentration, specifically in the manufacturing sector of Egypt.

In the context of Egypt, SMEs or manufacturing firms confront massive challenges such as limited resources, weak regulatory support, and cultural barriers that hinder the adoption of green practices. SMEs often lack the financial, technological, and managerial resources to implement Green HRM effectively, and motivating employees towards sustainability can be difficult (Abdelhamied*et al.*, 2023). Besides, eco-innovation adoption is hindered by high costs, regulatory barriers, and limited consumer demand for green products, especially in the manufacturing sector (Mady *et al.*, 2022). The lack of strong leadership in driving green initiatives further complicates sustainability efforts in SMEs (Salama *et al.*, 2022). Furthermore, the weak institutional environment in Egypt limits the ability of SMEs to integrate long-term sustainability into their business strategies, as many focus on short-term survival (Adel *et al.*, 2020). In short, GHRM, GRIN GTLP, etc., are the most influential problems along with other mentioned problems. Therefore, to tackle these issues, we raised the research questions:

RQ1:What is the role of GTLP, GHRM and GRIN in enhancing sustainable business performance (SBPE)?

RQ2: How does TMKV moderate the relationship between GTLP, GHRM and GRIN in enhancing SBPE?

The study examines the effect of greener dynamics towards SBPE directly and moderated by TMKV in the context of manufacturing firms in Egypt. The study inspires organizations to invest in and utilize eco-friendly technologies for developing a culture of sustainability and pro-environmental with greener aspects. Following this study, policymakers can satisfy consumer needs and maintain the environment, leading to enhanced SBPE. Finally, by improving an advantageous culture where management can bring values and sustainability, firms can better control transformational leadership styles to hearten their workforce, thingamajig effective green HRM practices, and push innovation toward sustainability.

The structure of the paper comprises, apart from the introduction section, Section 2 reviews the literature and develops the hypotheses; Section 3 outlines the research methodology; Section 4 presents the results; Section 5 discusses the findings; and Section 6 concludes the study.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1 Green transformational leadership (GTLP)

GTLP is a substantial and contributive factor that positively enhances organizations' performance by developing sustainable business plans and vision plans (Sing *et al.,* 2020; Ismail, 2025). GTPL leads the organizations and provides clear cut guidelines and ideas to their sub-ordinates to play their protagonist contribution to their organizations (Singh *et al.,* 2020;Zhao and Huang, 2022). According to Singh *et al.* (2020), good leaders acknowledge and are aware of their employees or work on the pro-environmental benefits for the organizations. Similarly, the factors such as GHRM, organizational support, GRIN, team resilience and GTLP are positive enablers of SBPE (Kusi *et al.,* 2021; Zhao and Huang, 2022). Besides, in the study of Singh *et al.* (2020), environmental sustainability, SBPE and environmental performance are predicted by effective leadership strategies, GTLP and the commitment of employees in the SMEs.

2.2 Green human resource management (GHRM)

GHRM is famous as the massive and positive predictor of SBPE and sustainability in the organizations (Singh *et al.*, 2020; Ali *et al.*, 2024). In the context of health and SMEs, GHRM positively contributes to enhancing performance (Mousa and Othman, 2020). Similarly, scholars of the domain like Shah and Soomro (2023), Ali *et al.* (2024) and Suleman *et al.* (2024) claimed the practical and substantial role of GHRM in developing sustainability, performance and also the success of the firms. In Chinese manufacturing firms, SBPE is positively affected by factors such as organizational support, GTLP and GRIN (Zhao and Huang, 2022; Ali *et al.,* 2024; Sahan *et al.,* 2025).

2.3 Green innovation (GRIN)

GRIN is the protagonist enabler of SBPE, sustainability and organizational success (Singh *et al.,* 2016; Zhao and Huang, 2022; Shah and Soomro, 2023). In the Chinese context, constructs such as organizational support, GHRM and GTLP are positive predictors of SBPE (Zhao and Huang, 2022; Cobbinah*et al.,* 2025). Shah *et al.* (2024b), Singh *et al.* (2020),Sisca and Wijaya (2023) demonstrate a positive connection between digital orientation, digital transformation, digital capability and firm performance. In the Pakistani context, GRIN, green entrepreneurship positively enhance sustainable development in knowledge-based organizations (Soomro *et al.*, 2024). The results of this study confirm the positive role of CSR and GRIN in promoting effective corporate governance. These researchers highlighted the importance of GRIN for many aspects of SBPE, including green intellectual capital and supply chain management. Asadi *et al.* (2020) focused on the Malaysian hotel industry and aimed to establish the relationship between GRIN and performance. The study by Larbi-Siaw

et al. (2022) investigates the connection between eco-innovation, SBPE, and the moderating influence of market instability in emerging nations. Consequently, the role of GRIN in developing SBPE, sustainability, and sustainability is massive and praiseworthy in almost all economies (Akhtar *et al.,* 2024).

2.4 Top management knowledge value (TMKV)

The significance of knowledge in organizational success is contingent upon the extent to which TMKV is used (Wei *et al.,* 2009;Mihalache *et al.,* 2012). The factors above, including decision-making, innovation, risk management, and organizational culture, are significantly impacted by it. Organizational leaders who place importance on and cultivate a mentality that values information contribute to their organizations' enduring viability and competitive advantage. The SBPE, GRM, green intellectual capital and GTLP positively reinforced through TMKV and top management support (Kılıç and Uludağ, 2021). Factors such as women's entrepreneurial self-efficacy and venture performance are predicted through formal and informal institutional support and entrepreneurial knowledge in the SME context of Pakistan (Abdelwahed *et al.,* 2023). Likewise, firm innovation is affected by TMKV (Mihalache *et al.,* 2012). According to Ling (2013), TMKV moderates the association between organizational performance and intellectual capital.

2.5 Sustainable business performance (SBPE)

SBPE is the most crucial aspect which every organization focuses on its development through several steps and strategies (Zhao and Huang, 2022; Singh *et al.*,2020; Baquero, 2025). Its enhancement (SBPE) becomes possible through GHRM, organizational citizenship behaviour, GTLP, organizational support, GRIN, etc. (Mousa and Othman, 2020; Zhao and Huang, 2022). In the perception of Al-Abbadi and Abu Rumman (2023) and Soomro *et al.* (2021), factors such as innovation, entrepreneurship and GHRM are the best predictors of SBPE in e-business firms. According to Sisca and Wijaya (2023), the role of GRIN is positive in achieving SBPE for SMEs during the COVID-19 pandemic. Employing SEM analysis, Kusi *et al.* (2021) demonstrate a positive effect of GTLP on SBPE.

As a result, the existing literature lacks an integrated model that combines a focus on factors such as GTLP, GHRM, GI, and TMKV on SBPE (Mousa and Othman, 2020; Singh et al., 2020;Zhao and Huang, 2022; Al-Abbadi and Abu Rumman, 2023; Akhtar *et al.,* 2024; Ali *et al.,* 2024). Moreover, the role of TMKV as a moderator has not been investigated in conjunction with these constructs (Kılıç and Uludağ, 2021). Furthermore, the contextual examination of the relationship between these constructs among the top management employees of Egyptian manufacturing firms is yet to be explored (Adel *et al.,* 2020; Mady *et al.,* 2022; Ahmed *et al..,* 2023) despite these confront significant challenges in terms of GHRM, GRIN, sustainability, SBPE, leadership, eco-innovation, consumer demand for green products (Salama *et al.,* 2022; Salama *et al.,* 2022; Abdelhamied*et al.,* 2023). Moreover, the literature indeed indicates positive links between these constructs. Pursuing the gaps (knowledge existing and contextual), the researchers developed a theoretical framework (see Figure 1). The framework's development consisted of factors such as GTLP, GHRM, and GRIN as predictors towards SBPE. We also added a moderating variable (TMKV), reinforcing the connections between greener dynamics and SBPE. TMKV underlines the cognitive resources, strategic foresight, and future-oriented thinking owned by senior executives. These enable organizations to adapt, innovate, and sustain competitive advantage in turbulent environments (Carmeli *et al.,* 2010). In this study, TMKV serves as a moderator, strengthening or weakening the connection between green capabilities (e.g., green innovation, green HRM, sustainability practices) and sustainable performance and eco-innovation. The rationale for adding moderation demonstrates that the experiences, values, and cognitive

frames of top executives significantly shape strategic choices and organizational outcomes (Hambrick, 2007). In firms where TMKV is lacking, such capabilities may be underutilized or misaligned with strategic goals. TMKV, therefore, brings the effectiveness of green initiatives and enhances organizational responsiveness to environmental and technological changes (Zhou *et al.*, 2019; Zhang & Zhu, 2022).

We underpinned the framework with the resource-based view theory (RBV), which demonstrates that practical innovation brings competition, ultimately making the organizations successful. We expected that greener dynamics such as GHRM, GRIN and GTLP would support the SBPE, which is aligned with the domain of RBV. More specifically, the development of SBPE is also reinforced through GHRM, GTLP and GRIN in the context of SMEs and manufacturing firms (Singh *et al.*, 2020;Weingarten *et al.*, 2013).

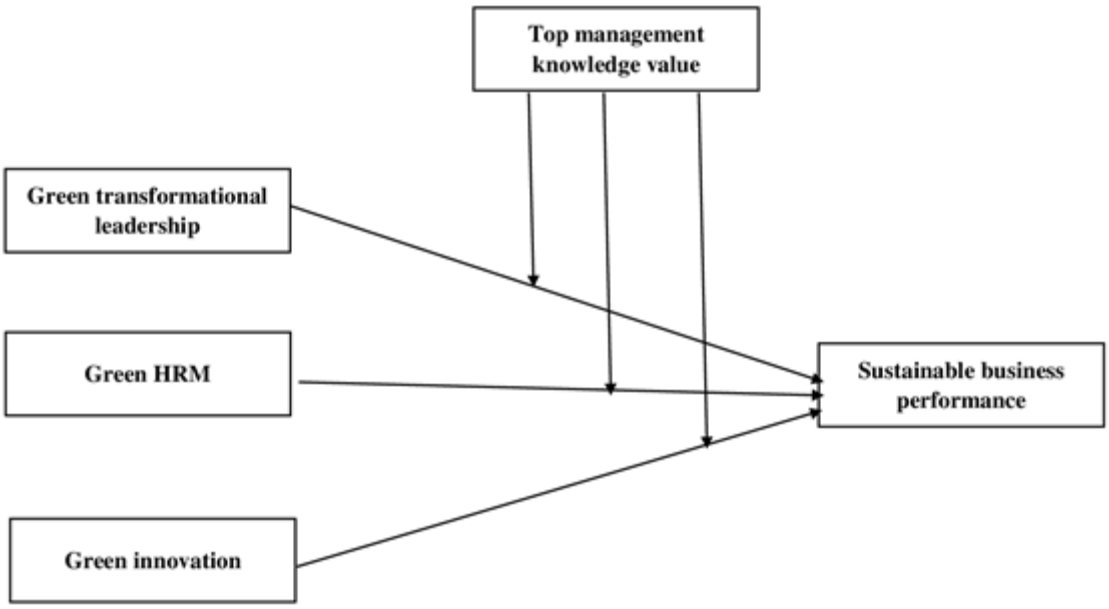

Figure 1. Theoretical model
Source: Developed by the researchers

2.6 Green transformational leadership (GTLP) and sustainable business performance (SBPE)

There is the protagonist predictive relevance of GTLP in the development of SBPE. It gears environmental sustainability by employing effective plans and strategies, as claimed by several renowned scholars of the domain, like Zhao and Huang (2022) and Umar *et al.* (2025).The constructs such as GTLP, GHRM and GRIN positively enhance the performance of firms (Kusi *et al.*, 2021). Moreover, in the same direction, the studies of Singh *et al.* (2020) and Zhao and Huang (2022) claim the positive contribution of the factors such as intellectual capital, GTLP, and green mindfulness in increasing environmental performance and SBPE. Kusi *et al.'s* (2021) empirical assessment establishes the meaningful influence of GTLP and perceived organizational support on SBPE. Singh *et al.* (2020) highlight the positive role of the interconnectedness of GTLP and GHRM in driving environmental performance and GRIN.

Consequently, existing studies have predominantly focused on contexts outside of Egypt, with limited attention given to manufacturing firms. Moreover, the literature has yet to

provide clear insights into the nuanced role of GTLP in the presence of GHRM and GRIN. These gaps create an opportunity for our proposed research to fill these cavities and contribute a more comprehensive understanding of the relationship between GTLP and SBPE, particularly within the unique context of Egyptian manufacturing firms.

H1. GTLP positively and significantly related with SBPE

2.7 Green human resource management (GHRM) and sustainable business performance (SBPE)

GHRM is of great prominence in developing success and sustainability in the firms. In the context of SME, it is the positive enabler of innovation, SBPE and organizational support (Zhao and Huang, 2022; Shah and Soomro, 2023). Mousa and Othman (2020) demonstrate a substantial and predictive contribution of GHRM in bringing the SBPE in the manufacturing firms specifically. GHRM is the predictor of corporate social responsibility and Decreasing Carbon emissions for sustainable practices (Faeni*et al.*, 2025). In the same way, GHRM practices assist in achieving sustainable development goals and sustainability (Zaidi *et al.*, 2025).

As a result, the current body of literature provides evidence supporting a substantial correlation between GHRM and SBPE. However, it is essential to note that there are considerable gaps in the available study, which necessitate more investigation. The existing body of research predominantly focuses on situations in other contexts rather than on GTLP, GHRM, GRIN, TMKV and SBPE, specifically among top management employees of Egyptian manufacturing firms. This study aims to fill these knowledge gaps by investigating the Egyptian manufacturing industry. Hence, we proposed:

H2. GHRM positively and significantly related with SBPE.

2.8 Green innovation (GRIN) and sustainable business performance (SBPE)

GRIN is pivotal in enhancing SBPE, as evidenced by a series of insightful studies. Asadi *et al.* (2020) emphasize the Malaysian hotel industry, creating a predictive link between GRIN and sustainability performance. According to Shah *et al.* (2024a) and Zhao and Huang (2022), economic sustainability, SBPE, and financial performance are predicted through network orientation, innovation, GTLP, organizational support, and GHRM.Factors such as digital GRIN and information management contribute to the massive contribution in reinforcing the SBPE (Akhtar *et al.*, 2024). Singh *et al.* (2016), Almeida and Wasim (2023) and Larbi-Siaw *et al.* (2022) conducted the empirical studies in developing and advanced countries and found the development of SBPE and sustainability through GRIN and eco-innovation. Finally, researchers like Sisca and Wijaya (2023) and Al-Abbadi *et al.* (2023) highlight GRIN as the best predictor for business sustainability, green intellectual capital, green supply chain management, and overall SBPE.

As a result, the impact of GRIN stands out as substantial and robust in contributing to SBPE. However, this assertion warrants further validation, particularly within the specific context of top management in Egyptian manufacturing firms, where such investigations are notably absent. This research endeavour seeks to provide empirical confirmation, shedding light on the nuanced dynamics of the association between GRIN and SBPE in the distinctive Egyptian manufacturing context: Hence:

H3. GRIN positively and significantly related with SBPE.

2.9 Top management knowledge value (TMKV) as moderator

The literature contributes to researchers' understanding of the moderating role of TMKV across diverse organizational and sustainability contexts. For instance, Mihalache *et al.*

(2012) suggest an attribution of the top management team that moderates the connection between offshoring and firm innovation. A well-known scholar like Ling (2013) accentuates the moderating role of knowledge management in the influence of intellectual capital on organizational performance. Similarly, Rong and Liu (2021) uncover the moderating role of TMKV in shaping enterprise innovation performance. An empirical assessment by Daoud *et al.* (2021) confirms the moderating role of top management commitment in using computer-assisted auditing techniques. Kılıç and Uludağ (2021)confirmed the mediating and moderating effect of TMKV, top management team and TMKV in moderating the relationship between GTLP, GRIN, GHRM and sustainable performance, employees' performance or sustainability.

As a result, the existing literature presents an inconsistent picture of the moderating and mediating role of TMKV in influencing the connections between critical factors such as GTLP, GRIN, GHRM, and SBPE. Recognizing the variability in results across studies, we aim to contribute to this discourse by investigating these relationships within the context of Egyptian manufacturing firms. Hence, we proposed:

H4. TMKV moderates the relationship between GTLP and SBPE.
H5. TMKV moderates the relationship between GHRM and SBPE.
H6. TMKV moderates the relationship between GRIN and SBPE.

3. RESEARCH METHODOLOGY

3.1 Approach and sample

The study is quantitative and uses cross-sectional data collected using a survey instrument. This type of design/ approach holds excellent prominence due to its presence of facts based on numerical data or the massive involvement of statistical analysis. In the domain literature, a majority of the researchers like Mousa and Othman (2020), Singh *et al.* (2020), Zhao and Huang (2022), Al-Abbadi and Abu Rumman (2023), Sisca and Wijaya (2023), Akhtar *et al.* (2024) and Ali *et al.* (2024).

The context of the study is Egypt’s manufacturing sector. We targated this sector because it hasa protagonist contribution in the economy of Egypt. It massively contributes in GDP which is approximately 16–17% and adjust a large number of labour force in employment(World Bank, 2023). The sector covers a wide range of industries, including textiles, food and beverages, chemicals, cement, steel, automotive components, plastics, and pharmaceuticals.

We targeted the top management-level employees of Egypt's manufacturing firms. These firms face massive challenges regarding GRIN, GHRM, sustainability, SBPE, leadership, eco-innovation, and profitability issues (Salama *et al.*, 2022; Salama *et al.*, 2022; Abdelhamied*et al.*, 2023). The top management employees are deeply aware of these issues, which helps the organizations achieve greener dynamics and productivity.

3.2 Common method bias

Common method bias (CMB) is a severe issue due to using a single-source data collection method through a survey questionnaire. To tackle this potential and vital issue, we followed the guidelines Kock and Lynn (2012) and employed a technique containing the regression of each construct against a common variable. In this way, we focused on the Variance Inflation Factor (VIF) to ensure whether CMB exists or not. More specifically, the values of VIF below 3.3 ensure no presence of bias, while values of VIF above 3.3 are considered to be the presence of CMB. As mentioned in Table 1, all the values of VIF against all constructs

appear to be below 3.3, which boosted our confidence in the validity of the dataset and that there is no concern about CMB.

Table 1.Variance Inflation Factor (VIF) for confirming CMB

S.No.	Construct	VIF
1	Sustainable business performance [SBPE]	2.229
2	Green transformational leadership [GTLP]	1.937
3	Green HRM [GHRM]	2.772
4	Green innovation [GRIN]	1.780
5	Top management knowledge values [TMKV]	2.399

Source: Researchers' own calculation

3.3 Data collection procedures

We applied a survey questionnaire as a principal tool for data collection. Before collecting a large amount of data, we conducted a pilot test by gathering 22 cases to confirm the reliability of the survey tool. In this regard, we assessed reliability in two steps; where in one step, we checked the internal consistency of the items through Cronbach's alpha, and in the second step, we ensured the loadings of the items of the scale. As a result, both consistency and loading of the items are found to be above the required values (>0.70) and fair. Moreover, we ensured the validity of the survey by getting respondents' feedback or comments regarding the language barrier and understanding of the theme of the items. Besides, we sent a few survey forms to industrial or manufacturing firms' experts to maintain the questionnaire's content and clarity and its usage in the context of manufacturing firms. As a result, we made a few minor modifications and launched a reliable and valid survey tool to collect large-scale data.

We used a convenience sampling technique to categorize suitable respondents. We applied a dual approach to confirm a robust data collection practice, i.e., online and offline (personal visit methods). To collect online data, we used various data collection channels, such as sending email questionnaires and sharing online links through WhatsApp groups (specifically formed during COVID-19) in Egyptian manufacturing. Instantaneously, personal visits were conducted to gather responses. Prior to administering the surveys, we arranged ethical reflections by assuring the respondents' privacy, confidentiality, and voluntary participation. We also obtained signed consent forms from all participants. Consequently, a total of 392 valid cases were gathered and afterwards utilized for the final analysis.

3.4 Measures

The research's reliability and credibility depend on the survey instrument's usage. In this regard, we adopted the items of the scale from previous domain literature. More specifically, we used six items to measure GTLP, ten items to measure GHRM, four to measure GRIN, and five to assess SBPE. These items are adopted from the study of Singh *et al.* (2020). Finally, we measured TMKV based on five items of Wei *et al.* (2009) (see Table 2). We applied a five-point Likert scale [strongly agree=1 to strongly disagree=5] to assess these items.

Table 2. Measures

Factor	Items details	Reference
Green transformational leadership [GTLP]	GTLP1: I inspire subordinates with the sustainable business plan. GTLP2: I provide subordinates a clear sustainable business vision. GTLP3: I encourage subordinates to work on the sustainable business plan. GTLP4: I encourage employees to attain sustainable business goals. GTLP5: I consider sustainable business beliefs of my subordinates. GTLP6: I stimulate subordinates to think and share their green ideas.	Singh *et al.* (2020)
Green HRM [GHRM]	GHRM1: Great effort goes into the select right person. GHRM2: Hiring only those who possess sustainable business values. GHRM3: Considerable importance is given to green staffing process. GHRM4: Every employee undergoes mandatory sustainable business development training. GHRM5: Sustainable business development training is designed to enhance employee's sustainable business skills and knowledge. GHRM6: Employees to use sustainable business development training in their jobs. GHRM7: Performance appraisal records sustainable business performance. GHRM8: Performance appraisal includes sustainable business incidents, responsibilities, concerns and policy. GHRM9: Employee gets reward for sustainable business management. GHRM10: Employee gets reward for acquiring specific sustainable business competencies.	Singh *et al.* (2020)
Green innovation [GRIN]	GRIN1: My organization uses materials that produce customer-oriented products. GRIN2: My organization uses materials that consume less energy and resources. GRIN3: My organization uses materials that design environment-friendly products and improve sustainable business. GRIN4: My organization uses materials that are easy to recycle, reuse, and decompose.	Singh *et al.* (2020)
Top management knowledge values [TMKV]	In our organization..... TMKV1: There is stated vision for managing knowledge. TMKV2: Organizational strategic plan focuses on knowledge management. TMKV3: Top management recognizes that knowledge assets can add value. TMKV4: Top management shows commitment toward knowledge management initiative. TMKV5: There is a dedicated personnel who lead and support knowledge management activities.	Wei *et al.* (2009)
Sustainable business performance [SBPE]	SBPE1: Sustainable business activities significantly reduced overall costs. SBPE2: Sustainable business activities significantly reduced the lead times. SBPE3: Sustainable business activities significantly improved product/process quality. SBPE4: Sustainable business activities significantly improved the reputation of my organization. SBPE5: Sustainable business activities significantly reduced waste within the entire value chain process.	Singh *et al.* (2020)

Source: Adopted from the domain literature

4. RESULTS

4.1 Sample characteristics

In total, 392 respondents contributed to the study, where 69.39 %(n=272) were males against females 30.61 %(n=120). With regard to the age of respondents, a majority of respondents were between 30 and 39 years of age (38.78% or n=152); 30.10 %(n=118) were 40-40 years; 16.84 %(n=66) were 50-59 years; 11.73 %(n=46) were less than 30 years and finally, only 2.55% (n=10) were 60 years and above. Moreover, the industrial experience shows a majority of respondents (41.33% or n=162) were 11-15 years; 26.53 %(n=104) were 5-10 years; 18.37 %(n=72) were 16 and above; while only 13.77 %(n=54) were less than 5 years. Finally, 83.16% (n=326) respondents responded "Yes" regarding the green and sustainability implementation, while the remaining 16.84 %(n=66) responded "No".

4.2 Measurement model

We used analysis of moment structures (AMOS) IBM, version 26, where we conducted the structural equation modeling (SEM). We preferred The AMOS software, which is ideal for factor-based models and can deal with simple and complex models (Hair *et al.*, 2022). In the initial phase, we conducted a measurement model, where we ensured fundamental assumptions of measure such as factor loadings, composite reliability (CR) and the average variance extracted (AVE), which are strongly recommended by the renowned experts of data analysis like Hair *et al.* (2022). We fixed the cut-values >0.70 and >0.50 for leadings, CR and AVE respectively (Hair *et al.*, 2022). Regarding loading values, most items appeared above the suggested values, but items such as SBPE3, GTLP4, GHRM3, GHRM6, GHRM8 and TMKV4 were not found to be with the required values. Thus, these were excluded to make the analysis more robust. The range of the loadings remained at a minimum loading of 0.758(TMKV5), while the maximum was 0.881(GTLP1). Likewise, the CR values are also found within acceptable ranges for all the constructs, with minimum values of 0.891(SBPE) and a maximum of 0.928(GHRM). Furthermore, the AVE's values are observed as satisfactory or above the cut-off values as a minimum of 0.650 (GHRM) and a maximum of 0.696(GTLP) (see Table 3 and Figure 2). Furthermore, we noted Cronbach's alpha (α) for all the constructs, as it appeared to be a minimum of 0.798(GRIN) and a maximum of 0.859(GHRM). These values are above the required values of>0.70 (Hair *et al.*, 2022).

Finally, to ensure more measurement validity, we applied discriminant validity, where we noticed the distinction among the model's constructs. In this regard, used Fornell and Larcker (1981) to gauge the correlations, which ranged from 0.314–0.590, which were less than the estimations of the square root of AVE at 0.604–0.808 (Table 4). Therefore, we established the validity with satisfactory scores.

Table 3. Measurement model

Construct	Item	Loadings scores [>0.70]	CR [>0.70]	AVE [>0.50]	α [>0.70]
Sustainable business performance [SBPE]	SBPE1	0.843	0.891	0.671	0.809
	SBPE2	0.832			
	SBPE4	0.809			
	SBPE5	0.792			
Green transformational leadership [GTLP]	GTLP1	0.881	0.919	0.696	0.842
	GTLP2	0.862			
	GTLP3	0.833			
	GTLP5	0.809			
	GTLP6	0.781			

Green HRM [GHRM]	GHRM1	0.861	0.928	0.650	0.859
	GHRM2	0.822			
	GHRM4	0.819			
	GHRM5	0.802			
	GHRM7	0.792			
	GHRM9	0.781			
	GHRM10	0.763			
Green innovation [GRIN]	GRIN1	0.851	0.897	0.686	0.798
	GRIN2	0.844			
	GRIN3	0.819			
	GRIN4	0.797			
Top management knowledge values [TMKV]	TMKV1	0.880	0.894	0.678	0.829
	TMKV2	0.851			
	TMKV3	0.800			
	TMKV5	0.758			

Source: Authors' own calculation
Note(s): Excluded items, SBPE3, GTLP4, GHRM3, GHRM6, GHRM8 and TMKV4

Table 4. Discriminant validity [Fornell-Larcker criterion for the full model]

Constructs	1 SBPE	2 GTLP	3 GHRM	4 GRIN	5 TMKV
1. SBPE	0.808				
2. GTLP	0.537	0.793			
3. GHRM	0.459	0.392	0.713		
4. GRIN	0.411	0.521	0.590	0.604	
5. TMKV	0.334	0.430	0.314	0.316	0.754

Source: Authors' own estimation
SBPE, sustainable business performance; GTLP, green transformational leadership; GHRM, green HRM; GRIN, green innovation; TMKV, top management knowledge value

4.3 Structural model

We observed the mode's fitness before jumping to the hypotheses assessment. As presented in Table 5and Figure 2, all the values of model fit indices, such as CMIN/df (3.830), AGFI (0.918), GFI (0.944), NFI (0.933), CFI (0.911) and RMSEA (0.038), appeared with acceptable values or above the required values.

Direct paths: With regard to direct paths, the results supported the H1 by demonstrating a positive effect of GTLP on SBPE (H1=β=0.697; t-value=4.013; p<0.1). Besides, the impact of GHRM on SBPE is positive (H2=β=0.087; t-value=3.320; p<0.1). Hence, H2 is supported. Finally, GRIN positively predicts SBPE (H3=β=0.079; t-value=4.841; p<0.1). Consequently, H3 is also accepted (see Table 6and Figure 2).

Moderation paths: The moderating paths suggest a positive moderating effect of TMKV in developing the connection between GTLP and SBPE (H4=β=0.089; t-value=3.591; p<0.1); GHRM and SBPE (H5=β=0.095; t-value=2.571; p<0.1) and GRIN and SBPE (H6=β=0.364; t-value=3.700; p<0.1). Thus, H4-H6 are supported (see Table 7and Figure 2).

Table 5. Model fitness

Construct	Acquired values [required values]	Acceptance [Yes/No]
χ^2/chi-square/*df* [CMIN/df]	3.830 [<5]	Yes
Comparative fit index [CFI]	0.911 [>0.90]	Yes
Normed fit index [NFI]	0.933 [>0.90]	Yes
GFI [Goodness-of-fit index]	0.944 [>0.90]	Yes
AGFI [Adjusted goodness-of-fit index]	0.918 [>0.90]	Yes
RMSEA [Root mean square error of approximation]	0.038 [0.05]	Yes

Source: Authors' own calculations

Table 6. Structural model [Direct paths analysis]

H.No.	Relationships	Estimate	SE	CR (t-value)	p-value	Acceptance [Yes/No]
H1	GTLP → SBPE	0.697	0.174	4.013	0.000	Yes
H2	GHRM → SBPE	0.087	0.026	3.320	0.001	Yes
H3	GRIN → SBPE	0.079	0.016	4.841	0.000	Yes

Source: Authors' own calculation
Notes: SE, standard error; CR, critical ratio; p<0.01

Table 7. Structural model [Moderation analysis]

H.No.	Relationships	Estimate	SE	CR (t-value)	p-value	Acceptance [Yes/No]
H4	TMKV*GTLP → SBPE	0.089	0.025	3.591	0.000	Yes
H5	TMKV*GHRM → SBPE	0.095	0.035	2.571	0.010	Yes
H6	TMKV*GRIN → SBPE	0.364	0.098	3.700	0.000	Yes

Source: Authors' own calculation
Notes: SE, standard error; CR, critical ratio; p<0.01

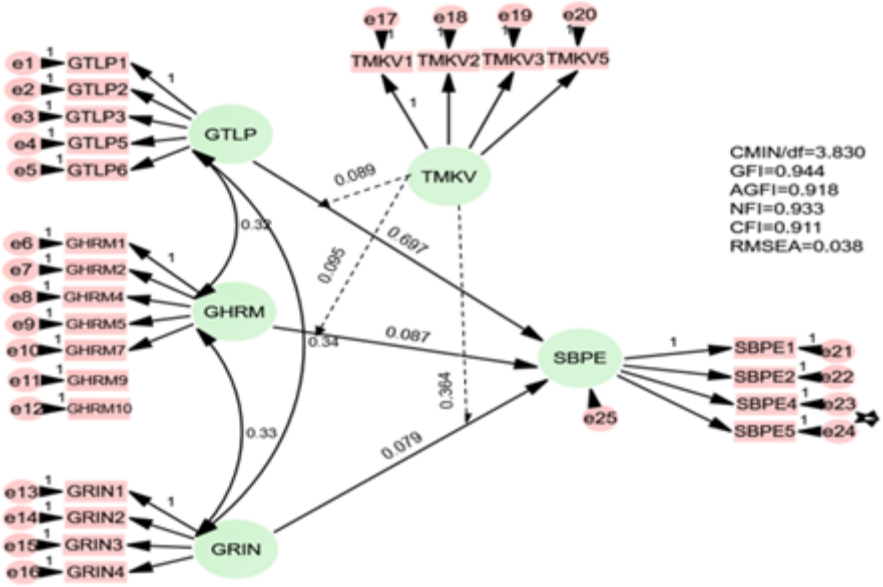

Figure 2. Path model

Source: Estimated by the researchers

5. DISCUSSION

The present study proposed exploring the relationship between greener dynamics and SBPE directly and moderated by TMKV. The findings of the study demonstrate a positive effect of GTLP on SBPE, which is supported by the domain literature like Singh *et al.* (2020),Nawangsari (2021) and Kusi *et al.* (2021). These results demonstrate that in the manufacturing sector, top management employees take more care of their subordinates and always encourage them to work on a sustainable business plan with great zeal and enthusiasm. They provide guidelines and sustainable business vision to their subordinates. The top management's top priorities are the business goals and plans, where they always boost their employees and subordinates towards fulfilling these organizational goals. They contemplate the sustainable business beliefs of their subordinates. Finally, they motivate subordinates to consider and share their green ideas with others to make better contributions towards the success of the organizations. The study also established a positive effect of GHRM on SBPE. These results are accorded with the field literature, which confirmed these positive too (see Singh *et al.*, 2020; Mousa and Othman, 2020; Zhao and Huang, 2022; Shah and Soomro, 2023). These positive outcomes suggest that in Egyptian manufacturing firms, the selection and hiring of employees with sustainable business values consider and certify alignment with their environmental goals from the start. Mandatory sustainability training and continuous development of green skills equip employees with the knowledge required to implement sustainable practices in their jobs. The rewards and performance appraisals connected to sustainable achievements further reinforce such behaviours, inspiring employees to contribute to sustainability initiatives. These GHRM elements generate a workforce that is both proficient and incentivized to augment the firm's SBPE.

Furthermore, the study also found a positive predictive effect of GRIN on SBPE. These results are also in line with several studies, i.e., Singh *et al.* (2020), Larbi-Siaw *et al.* (2022), Almeida and Wasim (2023), Sisca and Wijaya (2023), Al-Abbadi *et al.* (2023) and Akhtar *et al.* (2024). These positive connections demonstrate that firms using materials that produce customer-oriented products and firms enhance customer satisfaction and gain a

competitive advantage when they attract environmentally cognizant consumers. The focus on energy and resource efficiency assists in reducing operational costs, certifies compliance with environmental regulations, and supports long-term sustainability. Besides, designing environment-friendly products nurtures innovation and strengthens the organization's reputation as socially responsible. However, using materials that are easy to recycle and reuse diminishes waste, lowers costs, and builds more sustainable supply chains. These initiatives lead to improved business resilience, competitiveness, and overall SBPE.

Finally, the study confirmed a moderating effect of TMKV in moderating the association between GTLP and SBPE, GHRM and SBPE, and GRIN and SBPE. These results are also reinforced by the literature (Rong and Liu, 2021). These results reflect that when top management has a clear vision for managing knowledge and brings it into line with organizational strategy. The green leadership is more effective in integrating sustainability goals across the organization. Besides, recognizing knowledge as a valuable asset inspires investment in green innovations, which initiates sustainability, while top management's commitment to knowledge management confirms that green initiatives receive the essential resources and support. In addition, having dedicated personnel to lead knowledge management efforts warrants that green practices are established and knowledge is efficiently shared and applied throughout the organization.

6. CONCLUSION

In conclusion, the study's findings demonstrate a positive effect of GTLP, GHRM and GRIN on SBPE. Besides, the study also confirmed a moderating impact of TKMV in moderating the association between GTLP and SBPE, GHRM and SBPE, GRIN and SBPE among the manufacturing employees of Egypt. This suggests that the effective development of GTLP, GHRM, and GRIN positively brings SBPE, where TKMV makes a massive and robust contribution in controlling and facilitating these initiates.

The study provides practical implications and assists in ranking GRIN; such leaders inspire the development of eco-friendly products and processes, which can lead to improved resource efficiency, cost savings, and competitive advantage in both local and global markets. Besides, green leadership benefits firms by developing environmental regulations and reducing risks related to non-compliance. This leadership approach also improves the firm's reputation and brand image, enticing environmentally cognizant customers and investors, which in turn can upsurge long-term profitability and sustainability. Resource scarcity and environmental challenges are significant, and GTLP can drive a shift toward more sustainable and robust business models. For practitioners, this suggests that adopting GHRM strategies, i.e., sustainable recruitment processes, training programs concentrated on environmental awareness, and performance appraisal systems that highlight ecological responsibility, leading to enhanced operational efficiency, employee engagement, and overall competitiveness in the market. Besides, firms that arrange sustainability in their HR policies will likely increase their reputation, attract eco-conscious consumers, and boost a culture of innovation, eventually contributing to long-term profitability and sustainability. The study's findings encourage organizations to invest in research and development of sustainable technologies, espousing eco-friendly processes, and nurturing a culture of sustainability within their organizations. By doing so, organizations can meet governing requirements and consumer prospects and contribute to environmental maintenance, eventually leading to augmented financial performance and long-term viability in a quickly developing market context. Finally, the study assists organizations in preferring the development of the knowledge and competencies of their top management teams in environmental sustainability

and green practices. By boosting a conducive culture where management can bring values and sustainability, firms can better control transformational leadership styles to encourage their workforce, contrivance effective green HRM practices, and push innovation toward sustainability.

Regarding theoretical implications, the study expands existing theories on HRM by assimilating GHRM, GTLP, GRIN and TMKV in the directions of sustainability and performance. The study's positive insights can provide a basis for discovering various HRM practices associated with sustainability goals and the mechanisms towards SBPE. Moreover, the theoretical contribution of the study is specifically relevant in the context of developing economies, where sustainability practices are increasingly recognized as essential for competitive advantage. Hence, the study provides guidelines for other developing contexts to boost their SBPE. This research contributes to the literature by suggesting that TMKV influences and strengthens the connection between greener dynamics and SBPE. Moreover, this study enriches the indulgence of GTLP, GHRM, and GRIN to boost a culture of sustainability, particularly in developing economies like Egypt. Finally, the outcome of the study contributes to the domain literature by adding empirical evidence from a developing context.

The study has certain limitations as it applied a single source of data collection using a survey questionnaire. The study used only a few constructs, such as GTLP, GHRM, GRIN, SBPE and TMKV. The study is restricted to a moderating role of TMKV in moderating the connection between greener dynamics and SBPE. The study focuses only on top management-level employees of Egyptian manufacturing firms. Finally, the results are based on 392 samples only.

In the future, more longitudinal data should be utilized with different sources or mixed methods. These studies in future will overcome the restraint of cross-sectional data and provide an understanding of the causal relationships over time. The study should use other factors such as environmental culture, values, leadership styles, pro-environmental behaviour, etc., directly and indirectly in future studies. Other sectors, such as health and education, should also be considered. Finally, the sample size should be enhanced for credible and generalizable results.

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