Achieving green product and process innovation through green leadership and creative engagement in manufacturing

Saira Begum and Enjun Xia
School of Management and Economics, Beijing Institute of Technology, Beijing, China
Fayaz Ali
College of Management, Research Institute of Business Analytics and Supply Chain Management, Shenzhen University, Shenzhen, China
Usama Awan
Lappeenranta-Lahti University of Technology, Lappeenranta, Finland and Mount Allison University, Sackville, Canada, and
Muhammad Ashfaq
College of Management, Research Institute of Business Analytics and Supply Chain Management, Shenzhen University, Shenzhen, China

Abstract
Purpose – The aims of this study were three-fold: to determine the impact of green transformational leadership on creative process engagement, green product innovation and green process innovation; to examine the association of creative process engagement with green product and process innovation and to identify the mediating influence of creative process engagement in the association between green transformational leadership and green process and product innovation.

Design/methodology/approach – Data was collected through a survey questionnaire from 291 middle- and lower-level managers and employees through simple random sampling in four high-tech manufacturing industries situated in Beijing, Shanghai and Shenzhen in China. We examined the data through structural equation modeling using partial least squares to test the study hypotheses.

Findings – The findings unveiled that green transformational leadership and creative process engagement positively influence green product innovation and green process innovation. Similarly, green transformational leadership is positively linked with creative process engagement. The findings further revealed that creative process engagement mediates the impact of green transformational leadership on green process and product innovation. Hence, our findings provide strong support for the role of green transformational leadership and creative process engagement in improving green process and product innovation.

Research limitations/implications – Our sample is limited to China and collected from high-tech manufacturing industries.

Practical implications – Drawing on the componential theory of creativity, the authors suggest that organizational leaders, specifically those who practice green transformational leadership, should increase creative process engagement among subordinates, as it is a crucial intangible resource for green process and product innovation.

Social implications – We suggest that a combination of green transformational leadership and creative process engagement improves green process and product innovation as well as the environmental performance of a business by eliminating all forms of hazardous material and waste.

Originality/value – This work is one of the earliest empirical studies to evaluate the influence of green transformational leadership on fostering green product and process innovation and the mediating impact of creative process engagement on the linkage among green transformational leadership, green product and process innovation within the manufacturing context.

Keywords Green transformational leadership, Green process innovation, Green product innovation, Creative process engagement

Paper type Research paper
1. Introduction
Industrial activities continue to be the primary drivers of global economic development because of their high potential for innovation and productivity gains (Silva and Gouveia, 2020). Given the inefficient use of natural resources, industrial manufacturing and production processes are creating disastrous levels of environmental pollution, global warming, hazardous waste and ozone depletion, thus negatively influencing the ecosystem (Chang et al., 2021; Li et al., 2020). Environmental protection has emerged as a widely accepted concept in recent years, and governments across the globe are encouraging industries to consider environmental issues a crucial element of business management (Ali et al., 2020; Leonidou et al., 2015). Some studies have noted that environmental-friendly measures improve a firm’s image, reduce costs and effectively respond to environmental issues (Rehman et al., 2021; Mittal and Dhar, 2016). Recently, firms have started considering pro-environmental initiatives in product and process development to reduce negative environmental impacts in manufacturing firms (Weng et al., 2015; Lin et al., 2013). In this regard, green innovation in processes and products has long been considered an inevitable factor to minimize the unfavorable influence of conventional production processes and products in the ecosystem (Awan et al., 2021; Woo et al., 2014).

Green innovation refers to the development of environment-friendly products and production processes that reduce pollution, recycle waste and conserve energy (Chen et al., 2006). Consistent with Chen et al. (2006), we consider two dimensions of green innovation: green process innovation (GPRI) and green product innovation (GPI). GPI is defined as changing or modifying products by using nontoxic or environmentally healthy raw materials in the production process to enhance environmental well-being (Amores-Salvadó et al., 2014). Meanwhile, GPRI refers to the development of new or improved manufacturing equipment, as well as strategies and procedures for reducing the environmental effects caused by production and consumption activities (Shrivastava, 2018). Ren et al. (2021) stated that green management and innovation philosophy is a businesses’ response to mitigating environmental deterioration and achieving sustainable competitive advantage. Prior research conducted in manufacturing industries reveals green innovation as an important organizational antecedent to improve environmental performance (Rehman et al., 2021; Singh et al., 2020; Lin et al., 2013). However, the existing literature has yet to determine what drives GPI and GPRI in manufacturing industries (Kanwal and Awan, 2020). Reiter-Palmon and Illies (2004) divulged that firm’s creative activities are dependent upon leadership and extensive cognitive processes. Chen and Chang (2013) delineated the importance of green transformational leadership (GTL) to solve environmental concerns. Recently, GTL has been underscored as a popular leadership style to foster eco-friendly practices, as it inspires followers by providing them the direction, energy and autonomy to pursue environmental goals in business activities (Chen et al., 2014). Although GTL is an important factor, the increasing interest in GPI and GPRI has also encouraged academic researchers to explore other organizational antecedents (Awan et al., 2021), such as employee engagement in the creative processes (Zhang et al., 2020).

Creative process engagement (CPE) in terms of environmental context is defined as employees’ involvement in searching and identifying creative green solutions, actions and strategies that reduce emissions, conserve energy and promote the responsible management of waste (Zhang et al., 2020). Creative outcomes require a high degree of thinking and integration ability (Amabile and Pillemer, 2012). CPE exhibits cognitive and emotional conditions in which individuals strive to identify the issue, search for information and generate alternative solutions (Amabile, 1988). Moreover, CPE is a dynamic process that leads to innovative outcomes. One has to elucidate, structure and mark the problem clearly and correctly (Mumford et al., 2002). After problem identification, individuals need to gather the relevant information and process to find alternative solutions for green process and
product innovation (Mahmood et al., 2019). Employee involvement in the creative process is an emerging issue; hence, further research is needed to understand how it affects GPI and GPRI (Awan et al., 2021). Although previous studies have documented some organizational factors of GPI and GPRI, such as green dynamic capabilities (Chen and Chang, 2013), green human resource management (Singh et al., 2020) and green intellectual capital (Rehman et al., 2021), no study has explored CPE in terms of GPI and GPRI (Zhang et al., 2020). Therefore, researchers have increasingly become interested in how Chinese manufacturing firms can use CPE to generate GPI and GPRI (Awan et al., 2021). Here, we argue that GTL can involve individuals in CPE to drive the process of GPI and GPRI. Previous research has established a positive association between transformational leadership and the creative process (Mahmood et al., 2019). However, the influence of GTL on CPE for the achievement of environmental goals has been underexplored in the existing literature. Therefore, this study examines the distinct behavior of GTL in promoting CPE among employees to enhance GPI and GPRI. The research also examined the mediating influence of CPE in the association between GTL and GPI and GPRI.

The current study attempts to notice answers to two important research questions:

RQ1. Do GTL and CPE influence GPI and GPRI in manufacturing firms?

RQ2. Does CPE mediate the relationship among GTL, GPI and GPRI?

We draw upon the componential theory of creativity (Amabile, 1988) to show how GTL boosts CPE, GPI and GPRI. The creativity theory explains “all humans with normal capacities can produce at least moderately creative work in some domain, some of the time—and that the social environment (the work environment) can influence both the level and the frequency of creative behavior” (Amabile, 1997, p. 42). By answering the research questions above, the contribution of this study is manifold. First, our study’s main involvement is to give an enhanced understanding of the importance of green transformational leadership in fostering CPE, GPI and GPRI. Second, our research examines the significance of CPE in improving GPI and GPRI. Third, previous studies have observed the effects of CPE on green creativity (Puriwat and Hoonsopon, 2021). To add to the existing body of literature, this work seeks to identify GTL and CPE as important antecedents of GPI and GPRI. Finally, this study assesses how CPE mediates the effect of GTL on GPI and GPRI. Our work indicates that GTL has high potential in building creative processes to leverage new green solutions and approaches, discuss pro-environmental goals, provide consultations and urge responsible parties to listen. Therefore, individuals’ cognitive responses are crucial to create green actions that conserve the natural environment from the manufacturing and disposal of non-green products and production processes.

2. Theory and hypotheses
2.1 Componential theory of creativity

The componential theory of creativity explicates that every human with normal capacities can generate moderately creative work in any realm. This theory explicitly acknowledges CPE and its components as its central components (Gilson and Shalley, 2004). Amabile (1988) further explained that creativity has three main components: domain-relevant skills, creativity-relevant processes and task motivation. First, domain-relevant skills demonstrate that creativity is enhanced when employees increase their expertise, knowledge and skills by identifying a problem and searching for information about a particular domain. Such knowledge and talent help employees to produce innovative ideas and solutions for execution. Second, creativity-relevant processes include cognitive styles and risk-taking ability. In addition, this process implies that creativity is of wide significance for innovation (Puriwat and Hoonsopon, 2021). The cognitive processes involve using wide, flexible
categories for synthesizing information and producing innovative and efficient solutions to deal with problems. Employees are naturally involved in the creative processes when they carry out their tasks at the workplace. Third, intrinsic motivation is the passion for undertaking a task or activity because it is interesting and satisfying (Kessler, 2013). The central point of task motivation is a creative response, as people become creative when they discern the task to be interesting and challenging (Amabile et al., 1996). Previous studies have argued that various factors, such as leadership, creativity and innovation climate, stimulate innovation at the workplace (Al-Husseini et al., 2019; Jaiswal and Dhar, 2015; Jung et al., 2003). Product and process innovation can broadly be defined as the “organizational ability to discover and translate creative approaches to solve multiple organizational problems” (Awan, 2020, p. 1).

2.2 Green transformational leadership, green process innovation and green product innovation

Transformational leadership is defined as a leadership approach by which leaders influence followers through their charismatic behavior and encourage them to pursue organizational change effectively (García-Morales et al., 2012). This leadership style helps subordinates to broaden and elevate organizational goals and become increasingly committed to achieving them (Begum et al., 2020; Carreiro and Oliveira, 2019; Jung and Sosik, 2002). Transformational leaders exhibit four behaviors: intellectual stimulation, individualized consideration, idealized influence and inspirational motivation. In brief, intellectual stimulation can be expressed as leaders’ ethical conduct and attitude toward fostering creativity and independent thinking to reveal new perspectives that enable employees to challenge and change the status quo. Individualized consideration signifies a leader’s empathy and care regarding the development of employees. Idealized influence denotes a leader’s ethical conduct and attitude, which make leaders models in their followers’ eyes. Finally, inspirational motivation describes the ability to communicate a transforming vision and empower subordinates to take responsibility to achieve it (Ng, 2017). The behaviors that manifest in this style of leadership are likely to enhance creativity and innovation at the workplace by giving a shared vision and allowing followers to have the autonomy and encouragement to pursue the vision (Henker et al., 2015; García-Morales et al., 2012).

The resource-based view posits leadership as an important factor for environmental management in enterprises (Zhou et al., 2018). GTL is a popular leadership style in creating an innovative climate and stimulating employees to find out-of-the-box solutions to mitigate ecological harm (Wang et al., 2018). This leadership structure enhances environmental performance; however, the way it improves environmental well-being remains unexplored, thus evoking researchers to have a special interest in exploring it (Singh et al., 2020). Ahmeda et al. (2020) recounted that green innovation has emerged as an important research interest for green transformational leaders to improve environmental performance. In this investigation, we denoted GTL as a leadership structure with the key purpose of providing a clear organizational vision, inspiring and encouraging followers, and supporting their individual needs to achieve the articulated goals (Li et al., 2020). GTL encourages followers to value organizational goals and coaches them to effectively respond to change and solve the challenges concerning the protection of the natural environment from business processes (Chen and Chang, 2013). GTL improves environmental performance by involving organizations in innovative activities through producing sustainable initiatives and products (Li et al., 2020).

Prior literature has reported that the GTL approach should be adopted to enhance green practices (Li et al., 2020), and product development (Chen and Chang, 2013) to achieve superior performance. However, this study innovatively suggests that GTL influences GPI
and GPRI, a correlation that has not been investigated in the previous literature. This leadership stimulates subordinates to acquire new and current trends and knowledge from the market to involve them in initiating green product and process innovation measures. Leaders practicing GTL train employees on environmental practices and provide them with opportunities to engage in environmental management (Ng, 2017; Mittal and Dhar, 2016). Chen and Chang (2013) argued that GTL is a worthy leadership process that educates and improves green product development performance in the era of environmentalism. Based on the above discussion, we propose that GTL impacts GPI and GPRI.

\[ H1a. \text{ Green transformational leadership significantly influences green product innovation.} \]

\[ H1b. \text{ Green transformational leadership significantly influences green process innovation.} \]

2.3 Green transformational leadership and creative process engagement

CPE refers to engagement in creativity-relevant methods for products and processes; it includes problem identification, information search and encoding and idea generation (Zhang and Bartol, 2010a). More specifically, CPE is a cognitive process that involves the workforce identifying problems and developing hypotheses to generate unique and creative approaches (Cheng and Yang, 2019; Gilson and Shalley, 2004). Employee engagement in the creative process enhances innovative outcomes that correspond to fulfilling broader responsibilities in complex jobs; thus, CPE improves job performance and augments the competitive advantage of firms (Zhang and Bartol, 2010b). This creative process works in such a manner that it engages individuals emotionally, cognitively and behaviorally to discern multiple perspectives and to find the appropriate approach for conducting tasks (Amabile et al., 1996). CPE occurs at both individual and group levels. It requires a conducive environment for individuals to brainstorm ideas and then share them with other team members to discuss their advantages and disadvantages. Furthermore, these creative processes are effective when the environment is supportive of risk-taking and attempting new things (Axtell et al., 2000). In emerging economies, firms engage subordinates in creative processes to seek out novel solutions to remain competitive in the global innovation market. Zhang et al. (2020) argued that CPE components occur simultaneously to positively influence green innovation strategy to obtain ecological goals.

Leaders with transformational leadership attributes play an indispensable role in the facilitation of the creative process (Woodman et al., 1993). In terms of environmentalism, the relationship of GTL with the creative process is important to investigate. However, the existing literature has given little acceptance to this aspect. The strong association between leaders and employees is important in understanding environmental problems and creating their solutions (Mittal and Dhar, 2016). GTL has been a significant leadership structure that enhances employee motivation to become involved in creative activities. These leaders establish a relationship with subordinates and create a supportive workplace to engage followers in complex processes. Previous studies have revealed that the intellectual stimulation feature of GTL positively influences environmental management (Li et al., 2020). Green transformational leaders, through a strong vision, mentoring skills and intellectually stimulating abilities, influence the creative process in organizations (Zhou et al., 2018; Henker et al., 2015). Involvement in the creative process is sometimes risky and time-consuming; thus, the supervisor’s support is crucial in minimizing the potential risk. More importantly, receiving support from a leader through the perception of autonomy and participation in decision-making positively affects employees’ involvement in creativity (Md-Sidin et al., 2010). GTL intrinsically stimulates and empowers subordinates to engage in creative
processes and decision-making to understand environmental problems from multiple dimensions and formulate creative solutions (Zhang et al., 2020). Thus, we conclude that:

\[ H2. \text{ Green transformational leadership significantly influences creative process engagement.} \]

2.4 Creative process engagement, green process innovation and green product innovation

GPI and GPRI have achieved enormous acceptance over the last several decades due to the threats of industrial activities to the natural environment (Shrivastava, 2018). The green market size is expanding, and societal expectations are pressuring firms to incorporate sustainability issues in product development (Dangelico and Pujari, 2010; Pujari, 2006). GPI is the introduction of a new or improved product that ensures environmental sustainability by removing toxic agents and hazardous waste (Dangelico, 2016). Green products strive to safeguard the natural environment, thus providing a win-win situation by being green and competitive in the market (Lin et al., 2013). Investment in GPI helps firms from facing legal penalties and environmental protests (Wong, 2012). Meanwhile, GPRI refers to improving existing production processes or adding new processes to mitigate their influence on the environment through the conservation of energy and the control of air emissions and waste (Xie et al., 2016). Greener production processes require improvement of whole operational and managerial processes to enhance resource productivity. This kind of innovation is time-consuming, demands high-level investment and the results are not always perfectly direct (Li et al., 2017). GPI and GPRI explicitly embrace improving firm performance and solving ecological problems (Qi et al., 2021). Both types of innovations are effective in minimizing industrial impacts on the ecosystem; hence, understanding organizational antecedents would be highly beneficial to boosting these two.

In the focal study, we assert that employee involvement in the creative process influences GPI and GPRI. Currently, several manufacturing companies are undertaking product-oriented and process-oriented environmental-friendly strategies; however, the organizational factors that help to formulate and initiate such green strategic measures have got less attention in the literature (Ziegler and Seijas Nogareda, 2009). Given the increasing magnitude of ecological problems, enterprises have experienced growing pressure to improve and adopt creative approaches to remain relevant and successful in the market (Cheng and Yang, 2019). Considered a prerequisite to innovation (Cheng and Yang, 2019), creative processes are needed to produce original and useful eco-friendly products and processes (Gilson and Shalley, 2004; Zhang et al., 2020). Both GPI and GPRI require different degrees of need for a change in thinking among employees. For instance, GPRI requires cleaner production technologies and end-of-pipe technologies to replace specific materials with less-polluting ones and the unavailability of such technologies hinders GPRI. Meanwhile, GPI typically requires a more radical change because it involves the technical design, R&D and convincing customers to come along on the greening journey (Dangelico and Pujari, 2010). Zhang et al. (2020) argue that the employee creative process concerns developing ideas and strategies to produce green products and processes. Hence, organizations now put a premium on engaging employees in creative processes to explore eco-friendly solutions. Synonymous with creativity that strives to advance innovative solutions (Mahmood et al., 2019), CPE helps employees identify relevant procedures, collect information and use such data to formulate new applications and techniques for developing GPRI and GPI. Therefore, we posit that:

\[ H3a. \text{ Creative process engagement significantly influences green product innovation.} \]

\[ H3b. \text{ Creative process engagement significantly influences green process innovation.} \]
2.5 The mediating role of creative process engagement

Supportive leadership is the key to driving creative processes at the workplace (Caniëls, 2019). According to social cognitive theory, supervisor support is essential because individuals need support to learn and improve (Bandura, 1989). GTL provides a shared vision, gives direction, supports teamwork and encourages employees to engage in the process of change. Such leaders allow subordinates to learn and explore current trends and knowledge through communication and motivate them to participate in decision-making (Chen and Chang, 2013). Furthermore, these leaders inculcate environmental consciousness and intrinsically motivate followers to achieve environmental goals. When a leader emphasizes green prospects and approaches, then green solutions are harnessed through the resulting green culture (Mittal and Dhar, 2016). GTL promotes ethical values and creates a favorable environment toward risk and proactivity through experimentation and communication. This leadership helps and guides followers to practice the creative process to produce unique solutions (Wang et al., 2018). Moreover, GTL encourages followers to engage in environmental assignments and tasks that promote green innovation at the firm level (Ahmeda et al., 2020).

Our study proposes that CPE serves as a mediator among GTL, GPI and GPRI. Previous studies have determined that CPE intermediates the association between green transformational leadership and green creativity (Zhang et al., 2020). Thereby, a clear research gap exists in the investigation of CPE and its role in translating the effects of GTL on green GPI and GPRI. Increasingly, organizations are under pressure to improve, innovate and grow continuously; in this regard, CPE is pivotal in individual and organizational success (Piyathasanan et al., 2018). Employees possess a natural tendency to involve themselves in creative processes because these activities help to generate valuable and useful solutions to problems; thus, the activation level of employees increases through problem identification and information search (Mahmood et al., 2019; Kark et al., 2018). Employee involvement in organizational problems is influenced by organizational climate, leaders as role models and rewards and punishments (Ma and Jiang, 2018). Leaders’ encouragement enhances their subordinates’ focus on creative processes. Concerning this matter, GTL establishes a supportive workplace and engages employees in CPE to achieve environmental goals through green products and services (Zhang et al., 2020). Thus, in this study, we assert that CPE serves as an important mediator in translating the effects of GTL to augment GPI and GPRI (see Figure 1).

**H4a.** Creative process engagement mediates the relationship between green transformational leadership and green product innovation.

**H4b.** Creative process engagement mediates the relationship between green transformational leadership and green process innovation.

![Hypothesized model](Figure 1)
3. Methodology

3.1 Sampling and data collection

In the focal study, the authors collected data from four high-tech industries in Beijing, Shanghai and Shenzhen, cities considered high-tech hubs in China. The high-tech industries included electronics, industrial machinery, information technology and biotechnological firms. There are several reasons why we selected Chinese high-tech industries for this research. First, China is a growing economic superpower and an active player in global competition; hence, understanding Chinese high-tech manufacturing firms will have extensive implications for other regions (Chan, 2010). Second, we focused on high-tech manufacturing firms since they are under pressure to produce green products to meet ecological demands and satisfy the volatile needs of various markets (Huang and Jim Wu, 2010; Marcus and Fremeth, 2009). Finally, the short-term life of electronic devices and the hazardous waste and emissions produced during the manufacturing of products are the major problems damaging the ecosystem and human health (Zameer et al., 2020). The focal study highlighted the role of GTL, CPE, GPI and GPRI in high-tech manufacturing industries in combating environmental pollution to preserve the ecosystem.

Furthermore, the respondents of the survey were middle- and lower-level managers and employees from several manufacturing firms. This article examines how managers and employees formulate and execute their tasks while involved in the creative process. We invigorate tasks that engage managers and employees in creativity-related processes (Conway and Lance, 2010). Thereby, we reckon the usage of self-reports is justified to examine organizational tasks regarding problem identification and alternative idea generation to solve organizational challenges.

The questionnaire was first formulated in English and then translated into Chinese to maintain accuracy (Brislin, 1970). After data collection, we used the back translation procedure for a better understanding of the data. We selected simple random sampling to collect data. We chose this sampling procedure because it allows equal representation of the population and increases generalizability (Ghauri et al., 2020). In each questionnaire, we attached a cover letter, recorded the impetus of the study and ensured the confidentiality of respondents. We chose marketing, environmental department and research and development (R&D) to collect data. We disseminated 540 questionnaires and after the distribution, we received 312 useable returns. Out of them, 21 were skipped because of missing values. Thus, 291 valid responses were used in the data analysis.

In order to calculate the appropriate sample size to test our SEM model, we used G*Power application (Erdfelder et al., 2009), where the G*Power parameters contain 0.15 value for the $f^2$ (effect size), 0.05 for the $\alpha$ (error type) and 0.95 for the power along with four number of predictors. The results from the G*Power analysis suggested that a sample of 129 respondents is required to test the model, while 291 valid responses were used in this study, which exceed the sample size of 129. Additionally, the sample size of 291 is also met the required criteria, which is specified as “ten times the largest number of structural paths directed at a particular latent construct in the structural model” (Hair et al., 2011, p. 144).

3.2 Measurement instruments

All the constructs involved in the focal study have been validated in previous research (Chen and Chang, 2013; Chen et al., 2006). We used a five-point Likert scale for all variables to measure the constructs: 1 represented “strongly disagree” and 5 representing “strongly agree”. The GTL scale was adapted from Chen and Chang (2013) that included the following six items: (1) “The leader encourages human resources to achieve environmental goals”; (2) “The leader provides a clear environmental vision for the followers to follow”; (3) “The leader inspires followers with environmental plans”; (4) “The leader gets the employees to
work together for the same environmental goals”; (5) “The leader acts by considering the environmental beliefs of the individuals”; (6) “The leader stimulates subordinates to think about green ideas”. This GTL scale was validated and widely used to measure transformational leadership in the context of the environment (Chen and Chang, 2013). The scale contains four core dimensions of transformational leadership; “inspirational motivation, individualized consideration, idealized influence, and intellectual stimulation”. The employees answered six items to measure the leadership style of their direct supervisor.

The 11 items of CPE “(1) I spend considerable time trying to understand the nature of the problem”; (2) “I think about environmental problems from multiple perspectives”; (3) “I decompose a difficult environmental problem/assignment into parts to obtain greater understanding”; (4) “I consult a wide variety of information”; (5) “I search for information from multiple sources (e.g. personal memories, others’ experiences, documentation, and Internet)”; (6) “I retain large amounts of detailed information in my area of expertise for future use”; (7) “I consider diverse sources of information in generating new ideas”; (8) “I look for connections with solutions used in seemingly diverse areas”; (9) “I generate a significant number of alternatives to the same problem before I choose the final solution”; (10) “I try to devise potential solutions that move away from established ways of doing things”; (11) “I spend considerable time shifting through the information that helps to generate new ideas” were adapted from the study of Zhang and Bartol (2010b) to analyze how employees respond to the creative tasks. The questionnaire was originally formulated to analyze data from information technology firms; however, we modified sample questions to obtain data regarding how employees use creative processes to solve environmental issues in their respective organizations.

The four items of GPI are: (1) “The company chooses the materials of the product that produce the least amount of pollution for conducting product development or design”; (2) “The company chooses the materials of the product that consume the least amount of energy and resources for conducting the product development or design”; (3) “The company uses the fewest number of materials to comprise the product for conducting the product development or design”; (4) “The company would circumspectly deliberate whether the product is easy to recycle, reuse, and decompose for conducting the product development or design.” The four items of GPRI are: (1) “The manufacturing process of the company effectively reduces the emission of hazardous substances of waste”; (2) “The manufacturing process of the company recycles waste and emissions that allow them to be treated and reused”; (3) “The manufacturing process of the company reduces the consumption of water, electricity, coal, or oil”; (4) “The manufacturing process of the company reduces the use of raw materials” were obtained using the scale from a study of Chen et al. (2006). This scale focuses on the green processes and materials used by the company to make environmental-friendly products.

3.3 Control variables
In the componential theory of creativity, Amabile (1997) stressed the importance of employee level of education, expertise and skills that affect creative thinking in organizations. In our study, we utilized gender, age (1 = up to 25 years, 2 = 26–35 years, 3 = 36–45 years, 4 = 46 years or above), educational level (1 = diploma, 2 = undergraduate, 3 = postgraduate, 4 = doctorate) and experience as control variables.

4. Results and data analysis
4.1 Common method bias (CMB)
We checked for CMB through two frequently used techniques, namely “Harman’s one-factor test” (Harman, 1976) and the “variance inflation factor” (VIF; Kock, 2015). Both techniques are
highly used in SEM studies (Ashfaq et al., 2021a; Bahta et al., 2020; Zafar et al., 2021). The first technique indicates that a single factor should <50% of the variance (Harman, 1976), while the second technique recommends that VIF values should be <3.3 (Kock, 2015). In our model, a single factor extracted <50% of the variance. Moreover, all items have <3.3 VIF values (Table 1). After the results of both techniques, we concluded that this study is free from CMB.

4.2 Measurement model analysis
The measurement model analysis confirmed whether the constructs were measured correctly by the proposed variables. Data were analyzed using SmartPLS 3 (Ringle et al., 2015). SmartPLS software is becoming more and more prevalent in recent years with its useful features and easy-to-use interface to analyze the primary data (Hair et al., 2019). SmartPLS is suitable when the structural model contains several variables or complex, theoretical expansions of prior established theories (Hair et al., 2019). It allows the researchers to run the proposed model using a small sample size (Hair et al., 2019). Thus, we applied SmartPLS software in the current study for data analysis. Table 1 shows the indicators’ factor loadings, while Table 2 exhibits α (Cronbach’s alpha) and CR (composite reliability) values that were above the threshold value of 0.70 (Hair et al., 2019). In addition, the AVE (average variance extracted) values were >0.50 (Bagozzi and Yi, 1988). We further used two extensively accepted techniques, namely, Fornell and Larcker (1981) and heterotrait–monotrait (HTMT; Henseler et al., 2015), to assess the discriminant validity in the study, following the recent literature (Ashfaq et al., 2020; Ashfaq et al., 2021b; Begum et al., 2021). The first technique in Table 3 satisfied Fornell and Larcker’s (1981) criteria, whereas the second method in Table 3 also confirmed that the HTMT value was below 0.85 (Henseler et al., 2015).

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Items</th>
<th>Loadings</th>
<th>Variance inflation factor (VIF)</th>
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<tbody>
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<td>Green transformational leadership</td>
<td>GTFL1</td>
<td>0.765</td>
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<tr>
<td></td>
<td>GTFL2</td>
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<td></td>
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<td></td>
<td>GTFL6</td>
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<td>0.673</td>
<td>1.728</td>
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<td></td>
<td>CPE5</td>
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<tr>
<td></td>
<td>CPE6</td>
<td>0.754</td>
<td>1.694</td>
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<td></td>
<td>CPE7</td>
<td>0.642</td>
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<td></td>
<td>CPE8</td>
<td>0.715</td>
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<tr>
<td></td>
<td>CPE9</td>
<td>0.710</td>
<td>1.612</td>
</tr>
<tr>
<td></td>
<td>CPE10</td>
<td>0.706</td>
<td>1.747</td>
</tr>
<tr>
<td></td>
<td>CPE11</td>
<td>0.660</td>
<td>1.830</td>
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Table 1. Factor loadings and VIF
4.3 Structural model analysis

We used bootstrapping (5,000 resamples) to evaluate the suggested hypotheses. According to Table 4, all hypotheses were accepted. First, the influence of GTL on GPI ($\beta = 0.190, t = 3.166, p = 0.002$) and GPRI ($\beta = 0.438, t = 9.294, p = 0.000$) were statistically significant, thus supporting H1a and H1b. On the same note, GTL had a positive effect on CPE ($\beta = 0.150, t = 2.517, p = 0.012$), thus supporting H2. Finally, the influence of CPE on GPI and GPRI were observed to test H3a and H3b. The results indicated that CPE positively influenced GPI ($\beta = 0.250, t = 4.961, p = 0.000$) and GPRI ($\beta = 0.235, t = 4.690, p = 0.000$). Therefore, the results supported H3a and H3b.

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Cronbach’s alpha</th>
<th>Composite reliability</th>
<th>Average variance extracted (AVE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green transformational leadership</td>
<td>0.826</td>
<td>0.873</td>
<td>0.534</td>
</tr>
<tr>
<td>Green product innovation</td>
<td>0.811</td>
<td>0.876</td>
<td>0.638</td>
</tr>
<tr>
<td>Green process innovation</td>
<td>0.787</td>
<td>0.862</td>
<td>0.609</td>
</tr>
<tr>
<td>Creative process engagement</td>
<td>0.900</td>
<td>0.916</td>
<td>0.506</td>
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Table 2. Reliability and validity

<table>
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<th></th>
<th>1</th>
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<th>3</th>
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<tr>
<td>Fornell–Larcker</td>
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<tr>
<td>1. Creative process engagement</td>
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<tr>
<td>2. Green process innovation</td>
<td>0.300</td>
<td>0.78</td>
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<td>3. Green product innovation</td>
<td>0.278</td>
<td>0.537</td>
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<td>4. Green transformational leadership</td>
<td>0.150</td>
<td>0.473</td>
<td>0.227</td>
<td>0.731</td>
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</table>

<table>
<thead>
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<th>1</th>
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<tr>
<td>1. Creative process engagement</td>
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<tr>
<td>2. Green process innovation</td>
<td></td>
<td>0.672</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Green product innovation</td>
<td></td>
<td>0.296</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Green transformational leadership</td>
<td></td>
<td>0.569</td>
<td>0.262</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Discriminant validity

Note(s):Italic values are the $\sqrt{AVE}$

<table>
<thead>
<tr>
<th>Paths</th>
<th>Beta</th>
<th>$T$ values</th>
<th>$p$ values</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1a GTFL $\rightarrow$ Green product innovation</td>
<td>0.190  **</td>
<td>3.166</td>
<td>0.002</td>
<td>Accepted</td>
</tr>
<tr>
<td>H1b GTFL $\rightarrow$ Green process innovation</td>
<td>0.438  ***</td>
<td>9.294</td>
<td>0.000</td>
<td>Accepted</td>
</tr>
<tr>
<td>H2 GTFL $\rightarrow$ CPE</td>
<td>0.150  **</td>
<td>2.517</td>
<td>0.012</td>
<td>Accepted</td>
</tr>
<tr>
<td>H3a CPE $\rightarrow$ Green product innovation</td>
<td>0.250  ***</td>
<td>4.961</td>
<td>0.000</td>
<td>Accepted</td>
</tr>
<tr>
<td>H3b CPE $\rightarrow$ Green process innovation</td>
<td>0.235  ***</td>
<td>4.690</td>
<td>0.000</td>
<td>Accepted</td>
</tr>
</tbody>
</table>

Indirect effects

<table>
<thead>
<tr>
<th>Paths</th>
<th>Beta</th>
<th>$T$ values</th>
<th>$p$ values</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>H4a GTFL $\rightarrow$ CPE $\rightarrow$ Green product innovation</td>
<td>0.035  *</td>
<td>2.194</td>
<td>0.029</td>
<td>Accepted</td>
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<tr>
<td>H4b GTFL $\rightarrow$ CPE $\rightarrow$ Green process innovation</td>
<td>0.037  *</td>
<td>2.046</td>
<td>0.041</td>
<td>Accepted</td>
</tr>
</tbody>
</table>

Table 4. Hypothesis testing

Note(s): *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; Green transformational leadership (GTFL); Creative process engagement (CPE)
4.4 Mediation analysis
We followed Nitzl et al.'s (2016) guidelines for analyzing mediation effects in PLS-SEM. For example, in the first step, we assessed the indirect influence of GTL. With regard to outcomes, results indicated that GTL had an indirect effect on GPI (H4a: $\beta = 0.035$, $t = 2.194$, $p = 0.029$) and GPRI (H4b: $\beta = 0.037$, $t = 2.046$, $p = 0.041$). In the next step, we evaluated the direct influence of GTL without the removal of the mediator. The results showed the significant positive influence of GTL, thus leading to partial mediation (Table 4; Figure 2). Additionally, a positive sign (for indirect and direct effects) was found, which signify that CPE had “complementary partial mediation” (Nitzl et al., 2016). Therefore, H4a and H4b were supported.

5. Discussion
The findings demonstrate that the idiosyncratic influence of green transformational leadership increases CPE, GPI and GPRI. Our results support H1a and H1b, which posit a positive association of GTL with GPI and GPRI. Our findings further exhibit that GTL positively influences CPE. From a practical standpoint, managers of high-tech firms can develop a culture of involving employees in creative approaches to generate better solutions than their rival firms. Our findings also demonstrate the importance of GTL for CPE and GPRI, thus supporting H2, H3a and H3b, respectively. The results lend credence to some recent suggestions (Cheng and Yang, 2019; Zhang et al., 2020). Our results reveal that CPE is valuable in enhancing GPI and GPRI. We suggest that managers be aware of the creative culture and engage employees in problem identification and the development of alternative ideas to develop green products and procedures. Employee engagement in creative tasks and processes largely depends on their organization’s strategy in encouraging employees to become involved in the creative process. It further suggests that leaders should prevail the green culture in organizations and encourage workforce to become involved in creative processes to generate pro-green solutions and techniques for sustainable production and consumption.

Our findings further show that CPE partially mediates the relationship between GTL and GPI and GPRI. Much of the extant literature on CPE emphasizes employees’ propensity to engage in new product development (Cheng and Yang, 2019). However, studies have not tackled CPE for GPI and GPRI. Hence, this work fills the research gap. Our results support H4a and H4b and suggest that high-tech firms in China that actively focus on integrating CPE may obtain better results in GPI and GPRI. Our findings further suggest that GTL positively influences employee engagement in information search, problem identification and alternative idea generation. As a result, organizations develop new product designs by selecting the material that produces the minimum amount of pollution, utilizes less energy and reduces the emission of hazardous waste. Our findings strongly endorse that GTL and CPE promote GPI and GPRI. Hence, firms should introduce GTL and creative processes

Note(s): ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$
among the workforce to stimulate GPI and GPRI in the high-tech manufacturing sector. We further recommend that the creative process be recognized as essential in today’s uncertain business environment to combat environmental problems and boost firms’ productivity.

5.1 Theoretical contributions
The study adds to the emerging literature on GPI and GPRI in Chinese high-tech firms in multiple ways. First, the investigation adds to the existing literature that the promotion of GTL enhances GPI and GPRI in Chinese high-tech manufacturing firms (Gumusluoglu and Ilsev, 2009). Second, Zhang et al. (2020) stated a positive association between GTL and CPE under the strong influence of green innovation strategy. However, little is studied about whether the linkage between GTL and CPE is constant in different industries. Our study suggests that Chinese high-tech firms that actively follow green transformational leadership style and CPE are continuously generating unique ways to support GPI and GPRI.

Third, we present a strong positive association between CPE and GPI and GPRI. The study advances the notion that CPE facilitates GPI and GPRI. Cheng and Yang (2019) established a link between CPE and new product development. Recently, Zhang et al. (2020) predicted that CPE promotes green creativity. Based on creativity theory, this study contributes to our understanding of how an organizational creative resources and approaches encourage subordinates to be actively engaged in GPI and GPRI. Finally, our study confirms that CPE improves the relationship of GTL with GPI and GPRI. Moreover, it partially mediates the relationship of GTL with GPI and GPRI. Organizations should integrate GTL actively to achieve GPI and GPRI directly or indirectly via CPE. Finally, we inform managers that GPI and GPRI will be enhanced if an organization is willing to develop a culture of involvement in creative processes to explore and produce alternate solutions from a different perspective.

5.2 Managerial implications
The rise of consumer environmentalism and international environmental protection regulations convinced corporations to invest in environmental protection practices. In line with this, our results offer multiple implications for managerial practice to enhance environmental performance. First, the findings manifested that GTL promotes GPI and GPRI in high-tech firms in China. We suggest that apart from the conventional leadership styles, a new kind of leadership requires taking the initiatives necessary to transform conventional products and production processes into environmental friendly. The idiosyncratic influence of GTL motivates subordinates to work beyond their interest and produce out-of-the-box solutions to curb environmental degradation and enhance environmental well-being through introducing GPI and GPRI. Most importantly, managers engage employees in creative processes to develop new business models that work on augmenting productivity and a healthy environment through green processes and products. Furthermore, policymakers and government institutions start introducing green leadership, green process and product innovation practices to gain environmental sustainability. Governments, society and corporations have equal responsibility to achieve sustainable development goals through manufacturing and using green products and processes.

5.3 Limitations and future work
We exhibit certain limitations and avenues for further research. First, this investigation is cross-sectional; hence, a longitudinal design may offer a profound understanding of the variables. Second, we have sampled data from high-tech industries in China; future work could be conducted in the pharmaceutical, automotive and agricultural businesses in the country and in other regions to validate the results of our study. Another area of future research could focus on
how creative approaches strengthen green practices and services. Finally, the current study investigated the green transformational style of leadership. Therefore, future studies can explore other leadership styles, such as empowering leadership and transactional leadership.

6. Conclusion
GPI and GPRI are business responses to mitigate the uninterrupted environmental degradation that has been caused by industrial activities for more than a century. Currently, GTL and CPE are increasingly becoming important for both types of innovations. This study builds a framework for Chinese high-tech manufacturing firms to determine how GTL promotes GPI and GPRI directly and indirectly through the mediation of CPE. Using survey data, the focal study empirically evaluates the direct impact of GTL and the mediating role of CPE with GPI and GPRI. The results show that, first, GTL significantly impacts CPE, GPI and GPRI. Second, our study supports a partial mediating association of CPE between GTL and both GPI and GPRI. In doing so, we have concluded that Chinese high-tech firms that integrate GTL may achieve GPI and GPRI directly or indirectly via CPE. Overall, the intermediary role of CPE in the Chinese high-tech manufacturing industry is supported in the linkage between GTL and both GPI and GPRI. We conclude that GTL promotes CPE and cultivates a favorable environment to enhance GPI and GPRI.

References


Achieving green product and process innovation


Corresponding author
Fayaz Ali can be contacted at: fayazsamo@hotmail.com