

REVIEW ARTICLE

From Green Knowledge-Oriented Leadership to Frugal Innovation: Bridging Sustainability and Affordability in Fast-moving Consumer Goods (FMCG) Industry

Hossein Bakhtiari¹, *Hossein Shirazi², Kaveh Alba³

1. Department of Management, Faculty of Management and Industrial Engineering, Malek Ashtar University of Technology, Tehran, Iran

2. Department of Technology Management, Faculty of Humanities, Qom Branch, Islamic Azad University, Qom, Iran

3. Department of Technology Management, Faculty of Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran

Correspondence:

Hossein Shirazi

Email: HosseinShirazi@iau.ac.ir

Received: 30.May.2026

Received in revised form: 13.Sep.2026

Accepted: 20.Sep.2026

How to cite:

Bakhtiari, H., Shirazi, H., & Alba, K., (2026). From Green Knowledge-Oriented Leadership to Frugal Innovation: Bridging Sustainability and Affordability in Fast-moving Consumer Goods (FMCG) Industry. *Journal of Environmental Education and Sustainable Development*, 14(4), 205-233.

(DOI: [10.30473/EE.2026.78039.2933](https://doi.org/10.30473/EE.2026.78039.2933))

ABSTRACT

Attention to the Bottom of the Pyramid (BOP) has shown that providing affordable products to low-income groups can both create significant economic opportunities for businesses and help improve the quality of life for these groups. As environmental pressures intensify, global competition increases, and resources become more limited, organizations are compelled to adopt approaches that enhance economic efficiency and environmental sustainability simultaneously. In this context, frugal innovation (FI) has gained growing importance as an effective strategy for developing simple, low-cost, and efficient solutions, particularly in addressing the needs of low-income groups. Drawing on the Knowledge-Based View (KBV), Leader-Member Exchange (LMX) theory, and the Componential Theory of Creativity, this research investigates the effect of green knowledge-oriented leadership (GKOL) on FI and analyzes the mediating role of creative process engagement (CPE) and the moderating role of green knowledge sharing (GKS) in this relationship. Conducted within a post-positivist paradigm and using a deductive approach, the study is applied in terms of purpose and descriptive-survey in terms of method. The target population consisted of managers in the fast-moving consumer goods (FMCG) industry. Data were collected through a standardized online questionnaire, and analyzed using the PLS-SEM method in R software. The findings indicated that GKOL does not directly influence FI; rather, its effect is fully mediated through CPE. Furthermore, GKS enhances the impact of GKOL on CPE. These results enrich the literature on green leadership and FI and offer valuable practical insights for managers in the FMCG industry seeking to optimize resource management and enhance innovative processes.

KEYWORDS

Frugal Innovation, Creative Process Engagement, Green Knowledge-Oriented Leadership, Green Knowledge Sharing, Fast-Moving Consumer Goods.



Introduction

The concept of the base of the pyramid (BOP) highlights the importance of developing affordable products and services for low-income populations while creating business opportunities for organizations. In this context, frugal innovation (FI) has emerged as an effective approach for developing low-cost, simple, and environmentally sustainable solutions through the efficient use of limited resources (Aqmal et al., 2025). Increasing sustainability pressures from stakeholders and regulatory institutions have encouraged organizations to integrate environmental objectives with FI to achieve both economic value creation and environmental responsibility (Ting et al., 2024).

Recently, green knowledge-oriented leadership (GKOL) has received growing attention as a leadership approach that supports sustainable transformation by encouraging employees to acquire, share, and apply environmental knowledge (Al Koliby et al., 2025). By promoting green visions and knowledge-based empowerment, GKOL can stimulate employee creativity, green behaviors, and sustainable innovation outcomes (Begum et al., 2022). Previous studies have also indicated that green leadership contributes to innovation through mechanisms such as knowledge sharing, creativity support, and employee engagement (Shafait & Huang, 2024).

Among these mechanisms, green knowledge sharing (GKS) plays an important role by enabling employees to exchange environmental experiences, improve collective learning, and develop cost-effective solutions (Zairbani & Kumar, 2025). Knowledge exchange can enhance organizational capabilities and provide the foundation required for FI, particularly in competitive environments where organizations must achieve greater value with fewer resources (Makhloufi, 2024). Similarly, creative process engagement (CPE) represents an essential mechanism through which employees actively participate in generating and implementing innovative ideas.

Despite increasing research on green leadership and innovation, the relationship

between GKOL and FI remains insufficiently explored. Existing studies have mainly focused on environmentally oriented innovation outcomes, while the specific mechanisms through which GKOL promotes FI have received limited attention. In particular, the mediating role of CPE and the moderating role of GKS in explaining how leadership orientations are transformed into frugal solutions have not been systematically examined. Therefore, this study addresses this research gap by integrating insights from the Knowledge-Based View (KBV), Leader–Member Exchange (LMX) theory, and the Componential Theory of Creativity.

The fast-moving consumer goods (FMCG) industry provides an appropriate context for examining FI because firms in this sector face intense competition, increasing customer expectations for environmentally friendly products, and continuous pressure to improve cost efficiency. In Iran, the growing FMCG market has increased the importance of balancing affordability, quality, and sustainability. Therefore, understanding the organizational mechanisms that facilitate FI can provide valuable insights for companies seeking a competitive advantage while reducing environmental impacts.

Accordingly, this study develops and tests an integrated framework to answer the following research questions:

- Does GKOL affect FI?
- What role does CPE play in the relationship between GKOL and FI?
- What role does GKS play in the effect of GKOL on CPE?
- What role does GKS play in the relationship between CPE and FI?

Methodology

This study is grounded in the post-positivist paradigm and adopts a quantitative, applied research design using a survey strategy. The target population comprised managers of companies operating in the FMCG industry, and the sample size was determined using G*Power software, resulting in a minimum required sample of 312 participants. Data were collected through a standardized online questionnaire and subsequently analyzed.

Table 1 summarizes the measurement constructs used in the study.

Table 1. Questionnaire Structure

Variables	Role	Items	Sources
Green Knowledge-Oriented Leadership	Independent	1–6	(Al Koliby et al., 2025)
Frugal Innovation	Dependent	7–11	(Aqmala et al., 2025)
Creative Process Engagement	Mediator	12–22	(Begum et al., 2022)
Green Knowledge Sharing	Moderator	23–26	(Zairbani & Kumar, 2025)

Since the skewness and kurtosis tests indicated a non-normal data distribution, Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed using the SEMINR package in R. The measurement model was evaluated through factor loadings, Cronbach's alpha, composite reliability (ρ_C), ρ_A , AVE, Fornell–Larcker, and HTMT. The structural model was assessed using VIF, path coefficients (β), bootstrapping, effect size (f^2), coefficient of determination (R^2), and PLSpredict.

Results

To examine the research model and test the hypotheses, two systematic procedures were used to evaluate the measurement and structural models, following the guidelines of Hair Jr et al. (2021).

Outer (Measurement) Model Evaluation

- In the first part, the measurement models were evaluated according to the steps in Figure 1.



Figure 1. Systematic Procedure for Evaluating the Outer Model

Step 1- Assessment of Indicator Reliability: Factor Loadings

The first step evaluated indicator reliability using factor loadings. Loadings above 0.708 indicate that the construct explains more than 50% of the indicator variance (Hair Jr et al., 2021). Indicators with loadings between 0.40 and 0.708 were retained only when their removal did not improve AVE or reliability; otherwise, they were removed. After model refinement, items CPE7, CPE9, CPE10, and FI4 were removed, and all remaining indicators showed acceptable and statistically significant loadings.

Step 2- Assessment of Construct Reliability: Composite Reliability,

Cronbach's Alpha, and the ρ_A

The second step assessed internal consistency reliability using Cronbach's alpha, composite reliability (ρ_C), and ρ_A . Values above the recommended threshold (>0.7) indicate that the indicators consistently measure their underlying constructs (Hair Jr et al., 2021). According to the research results, all constructs demonstrated satisfactory internal consistency reliability.

Step 3- Assessment of Convergent Validity: Average Variance Extracted (AVE)

The third step examined convergent validity using the Average Variance Extracted (AVE). An AVE value of 0.50 or higher indicates that a construct explains at least 50% of the

variance in its indicators (Fornell & Larcker, 1981). The results confirmed convergent validity for all constructs.

Step 4- Assessment of Discriminant Validity: Fornell–Larcker Criterion and the Heterotrait–Monotrait Ratio (HTMT)

The fourth step assessed discriminant validity using the Fornell–Larcker criterion and the Heterotrait–Monotrait Ratio (HTMT). While the Fornell–Larcker criterion remains widely

reported, HTMT is considered a more robust assessment method, with HTMT values below 0.85 indicating adequate discriminant validity (Henseler et al., 2015). Finally, both criteria confirmed satisfactory discriminant validity.

Inner (Structural) Model Evaluation

- In the second part, the structural model was evaluated according to the steps in Figure 2.

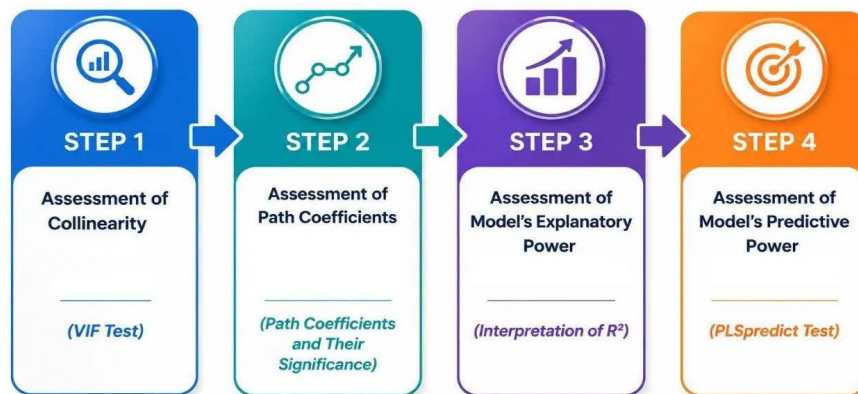


Figure 3. Systematic Procedure for Evaluating the Inner Model

Step 1- Collinearity Assessment: VIF Test

The first step examined collinearity among predictor constructs using the Variance Inflation Factor (VIF). VIF values below the recommended threshold indicate that multicollinearity is not a concern and that the estimated path coefficients are not biased (Hair Jr et al., 2021). According to the research results, VIF values were within the acceptable range, confirming the absence of collinearity.

Step 2- Path Coefficient Assessment: β , Bootstrapping, and Effect Size (f^2)

The second step evaluated the structural relationships by examining the path coefficients (β) and their statistical significance using bootstrapping. In addition, the effect size (f^2) was assessed to determine the contribution of each exogenous construct to the explained variance of the endogenous constructs. According to the research results, the effects of GKOL on CPE and CPE on FI were positive and significant, whereas the direct effect of GKOL on FI was not significant. The corresponding f^2 values

indicated substantial effects for the significant relationships.

Step 3- Assessment of Explanatory Power: R^2

The third step assessed the model's explanatory power using the coefficient of determination (R^2) and R^2 adjusted. R^2 indicates the proportion of variance explained in each endogenous construct, whereas R^2 adjusted provides a more conservative estimate by accounting for model complexity (Hair Jr et al., 2021). The results indicate moderate explanatory power for the endogenous constructs.

Step 4- Assessment of Predictive Power: PLSpredict

The fourth step evaluated the model's out-of-sample predictive power using the PLSpredict procedure. Predictive performance was assessed by comparing the RMSE (or MAE, when appropriate) values of the PLS-SEM model with those obtained from a benchmark linear regression model (LM). According to the guidelines proposed by Hair Jr et al.

(2021), lower prediction errors than the LM indicate stronger predictive performance. Based on the comparison between PLS-SEM MAE and LM-MAE, the results demonstrate that the research model has moderate

predictive power.

- Finally, the results of hypothesis testing are shown in Table 2.

Table 2. Path Coefficients and Hypothesis Results

Path	Path Coefficient	Indirect Path Coefficient	Moderating Path Coefficient	T-Value	Hypothesis Results
H1: GKOL → FI	0.082	-	-	1.61	Rejected
H2a: GKOL → CPE	0.566	-	-	17.44	Supported
H2b: CPE → FI	0.658	-	-	15.65	Supported
H2: GKOL → CPE → FI	-	0.373	-	10.68	Supported
H3: GKOL × GKS → CPE	-	-	0.102	2.24	Supported
H4: CPE × GKS → FI	-	-	0.008	-	Rejected

The findings provide a deeper understanding of the mechanism through which GKOL contributes to FI. The results show that the direct effect of GKOL on FI was not statistically significant, whereas its indirect effect through employees' CPE was significant. This finding suggests that merely adopting a green and knowledge-oriented leadership style is insufficient to generate resource-efficient innovations unless it stimulates employees to actively engage in creative problem identification, knowledge exploration, and idea generation. This interpretation is consistent with the Knowledge-Based View and the Componential Theory of Creativity, both of which emphasize that innovation emerges through knowledge integration and employees' creative involvement rather than managerial direction alone. The significant indirect-only mediation of CPE further indicates that creativity is the central mechanism through which leadership is translated into frugal innovation. Organizations seeking to achieve FI should therefore move beyond leadership initiatives alone and create environments that encourage experimentation, creative thinking, and employee participation in solving environmental and operational problems. These findings reinforce previous studies highlighting the importance of creativity as

the foundation of sustainable and resource-efficient innovation. The results also confirm that GKS strengthens the relationship between GKOL and CPE. This finding implies that the effectiveness of green knowledge-oriented leaders increases when environmental knowledge flows freely throughout the organization, enabling employees to transform leadership guidance into creative actions. However, GKS did not strengthen the relationship between CPE and FI, suggesting that once employees become actively engaged in creative processes, creativity itself becomes the principal driver of frugal innovation regardless of the intensity of knowledge exchange. From a managerial perspective, organizations should simultaneously develop green knowledge-oriented leadership capabilities, establish effective green knowledge-sharing systems, and foster organizational environments that encourage employees' creative engagement. Rather than focusing solely on cost reduction, managers should support creativity-oriented practices such as environmental problem-solving workshops, innovation teams, knowledge-sharing platforms, and reward systems that stimulate creative participation.

Conclusions

This study extends the literature by explaining

how green knowledge-oriented leadership contributes to frugal innovation through creativity and knowledge-based mechanisms. The findings demonstrate that creative process engagement provides an indirect-only mediation pathway between GKOL and FI, while green knowledge sharing enhances the influence of GKOL on employees' creative engagement. These results highlight the importance of integrating leadership, creativity, and knowledge management to achieve sustainable and resource-efficient

innovation. Like all empirical studies, this research has limitations, including its focus on a specific organizational context and a limited set of mediating and moderating variables. Future research may examine additional mediators and moderators, compare different leadership styles, investigate different forms of knowledge sharing, and validate the proposed model across diverse industries and organizational settings to enhance its generalizability.

از رهبری دانش محور سبز به نوآوری مقتصد: پل زدن میان پایداری و صرفه جویی در صنعت کالاهای تندمصرف

*حسین بختیاری^۱، حسین شیرازی^۲، کاوه آلبا^۳

۱. گروه مدیریت، دانشکده مدیریت و مهندسی صنایع، دانشگاه صنعتی مالک اشتر، تهران، ایران
۲. گروه مدیریت تکنولوژی، واحد قم، دانشگاه آزاد اسلامی، قم، ایران
۳. گروه مدیریت تکنولوژی، دانشکده مدیریت، دانشگاه آزاد اسلامی، واحد تهران مرکزی، تهران، ایران

نویسنده مسئول:

حسین شیرازی

رایانامه: HosseinShirazi@iau.ac.ir

تاریخ دریافت: ۱۴۰۵/۰۳/۰۹

تاریخ بازنگری: ۱۴۰۵/۰۶/۲۲

تاریخ پذیرش: ۱۴۰۵/۰۶/۲۹

استناد به این مقاله:

بختیاری، حسین. شیرازی، حسین. و آلبا، کاوه. (۱۴۰۵). از رهبری دانش محور سبز به نوآوری مقتصد: پل زدن میان پایداری و صرفه جویی در صنعت کالاهای تندمصرف، فصلنامه علمی آموزش محیط‌زیست و توسعه پایدار، ۱۴(۴)، ۲۰۵-۳۳۳.

(DOI: [10.30473/EE.2026.78039.2933](https://doi.org/10.30473/EE.2026.78039.2933))

چکیده

توجه به قاعده هرم نشان می‌دهد که ارائه محصولات با قیمت مناسب به اقشار کم‌درآمد هم می‌تواند فرصت‌های اقتصادی قابل توجهی را برای کسب‌وکارها ایجاد کند و هم به ارتقای کیفیت زندگی این گروه‌ها کمک کند. افزون بر این، با تشدید فشارهای محیطی، افزایش رقابت جهانی و محدودتر شدن منابع، سازمان‌ها ناگزیر به اتخاذ رویکردهایی هستند که به‌طور هم‌زمان کارایی اقتصادی و پایداری محیطی را افزایش می‌دهند. در این زمینه، نوآوری مقتصد به‌عنوان یک استراتژی مؤثر برای توسعه راه‌حل‌های ساده، کم‌هزینه و کارآمد، به‌ویژه در رسیدگی به نیازهای گروه‌های کم‌درآمد، اهمیت فزاینده‌ای پیدا کرده است. پژوهش حاضر با تکیه بر دیدگاه مبتنی بر دانش، نظریه تبادل رهبر-عضو و خلاقیت ترکیبی، تأثیر رهبری دانش‌محور سبز بر نوآوری مقتصد را بررسی می‌کند و نقش میانجی تعامل فرآیند خلاق و تعدیل‌کننده تسهیم دانش سبز را در این اثرگذاری تحلیل می‌کند. پارادایم این مطالعه، فرائیبات‌گرایی و رویکرد آن قیاسی است. از نظر هدف، کاربردی است و از منظر روش، توصیفی از نوع پیمایشی. جامعه هدف پژوهش، متشکل از مدیران فعال در صنعت کالاهای تندمصرف است. داده‌های مورد نیاز با استفاده از پرسشنامه استاندارد و به‌صورت برخط جمع‌آوری شدند و سپس با روش PLS-SEM در نرم‌افزار R تجزیه و تحلیل شدند. یافته‌ها نشان می‌دهد که رهبری دانش‌محور سبز به‌طور مستقیم بر نوآوری مقتصد تأثیر نمی‌گذارد؛ بلکه تأثیر آن به‌طور کامل از طریق تعامل فرآیند خلاق میانجی‌گری می‌شود. علاوه بر این، تسهیم دانش سبز تأثیر رهبری دانش‌محور سبز بر تعامل فرآیند خلاق را تقویت می‌کند. این نتایج، ادبیات مربوط به رهبری سبز و نوآوری مقتصد را غنی‌تر می‌سازد و بینش‌های عملی ارزشمندی را برای مدیران صنعت کالاهای تندمصرف که به دنبال بهینه‌سازی مدیریت منابع و تقویت فرآیندهای نوآورانه هستند، ارائه می‌دهد.

واژه‌های کلیدی

رهبری دانش محور سبز، تعامل فرآیند خلاق، تسهیم دانش سبز، نوآوری مقتصد، صنعت کالاهای تندمصرف.

Introduction

Today, more than 4 billion people in developing countries live on less than \$2 a day - a population referred to by Prahalad and Hart (2002) as the Bottom of the Pyramid (BOP). The BOP highlights the idea that providing affordable goods and services to low-income populations can create profitable opportunities for firms, while also improving the quality of life for this segment of society. In such a context, frugal innovation (FI) is an efficient approach that enables the delivery of affordable solutions, while reducing destructive environmental impacts. FI has been introduced as one of the most effective strategies for developing low-cost, simple, and environmentally friendly products and processes based on optimal resource utilization (Aqmal et al., 2025; Govindan, 2022). With rising stakeholder pressure and regulatory requirements related to sustainability, organizations have increasingly moved toward combining sustainability strategies with FI to create economic value while enhancing their environmental responsibility (Ting et al., 2024). In this regard, environmental sustainability scholars consider this combination a win-win opportunity, as innovative businesses focusing on resource sustainability have a better chance of gaining and maintaining market superiority (Li et al., 2024).

Recently, green knowledge-oriented leadership (GKOL) has gained importance as a leadership style capable of creating sustainable transformation within companies. Green knowledge-oriented leaders encourage employees to acquire, share, and use environmental knowledge, thereby creating the necessary foundation for generating sustainable and efficient ideas (Al Koliby et al., 2025). These leaders are responsible for motivating their employees to protect resources and the environment because researchers argue that leaders possess the capacity to inspire employees to play an active role in environmental responsibility (Saleem et al., 2020). When a leader emphasizes green visions and approaches, innovative ideas emerge through creativity (Mittal & Dhar, 2015). Studies have shown that knowledge-

oriented leaders, by combining environmental vision with knowledge empowerment, guide employees toward green behaviors, green creativity, and FI (Begum et al., 2022). Furthermore, research indicates that green leadership can enhance sustainable innovative outcomes by strengthening employees' creative process engagement (CPE), creativity-supportive climates, and knowledge-sharing mechanisms (Ahmeda et al., 2020).

In organizations focused on environmental protection, knowledge is disseminated to embed sustainability practices among employees. Such organizations prefer to adopt eco-friendly innovations (Shafait & Huang, 2024). This knowledge sharing creates a collaborative environment for innovative solutions that protect environmental resources (Abbas & Khan, 2023). Green knowledge sharing (GKS) enables employees to benefit from one another's environmental experiences, reduce errors, and arrive at new and cost-effective solutions (Zairbani & Kumar, 2025). This process enhances organizational knowledge, which in turn is considered one of the essential prerequisites for FI in competitive environments (Makhloufi, 2024).

Therefore, understanding the concept of GKOL, which supports sustainability goals, can improve our understanding of how innovative activities are influenced by leaders and help fill research gaps for future scholars (Al Koliby et al., 2025). Previous studies have shown that green leadership can facilitate green innovation and sustainable performance through mechanisms such as knowledge sharing, creative motivation, and leader-member exchange (LMX) (Kardoyo et al., 2020; Shahzad et al., 2020). However, the link between GKOL and FI requires further investigation, as most studies in this field have focused on green innovation. FI, representing a hybrid concept of thrift and sustainability, has received comparatively less attention (Aqmal et al., 2025; Govindan, 2022). This research gap highlights the importance of examining how GKOL can guide employees toward FI. Additionally, the intermediary mechanisms through which GKOL may lead to FI, with CPE as a mediator and GKS as a

moderator, have not been systematically explained in the literature. Hence, the present study attempts to help fill this research gap by drawing on the knowledge-based view (KBV), the LMX theory, and the componential theory of creativity.

Fast-moving consumer goods (FMCGs) are products that are purchased frequently and have a short production-consumption cycle (Mohammadian et al., 2016). This industry includes non-durable goods such as detergents and hygiene products, food and beverages, cellulose and polymer products, cigarettes, and others (Gharechah et al., 2016). According to reports released by the Statistical Center of Iran (SCI) on urban and rural households, the size of the FMCG market in Iran was 485 trillion Iranian rials in 2020. The statistics indicate a growing trend in the FMCG industry in Iran, with numerous companies entering the market every day. This reflects increasing competitive intensity among rivals (Nejat et al., 2023). Rising competition brings challenges such as cost and quality control, responsiveness to continuous changes in consumer preferences, and attention to environmental issues. Therefore, in a competitive environment where consumer willingness to purchase eco-friendly products is increasing, paying attention to sustainability and the optimal use of resources, along with features like reasonable price and appropriate quality, can play a crucial role in the success of companies operating in the industry. Accordingly, the findings, recommendations, and strategies of this research can serve as a valuable guide for Iranian companies eager to minimize the adverse effects of natural resource exploitation and to gain a competitive advantage in a dynamic market. On this basis, the present study offers an integrated framework grounded in leadership theories, knowledge management, and the FI literature to answer the following questions:

1. Does GKOL affect FI?
2. What role does CPE play in the relationship between GKOL and FI?
3. What role does GKS play in the effect of GKOL on CPE?
4. What role does GKS play in the relationship between CPE and FI?

Literature Review

Theories Supporting the Research Model

The LMX theory states that the quality of the relationship between leaders and employees is formed based on trust, respect, mutual support, and a sense of reciprocal need (Kardoyo et al., 2020). As explained by Graen and Uhl-Bien (1995), the LMX theory posits that members who accept the information, influence, and guidance provided by their leaders, compared to the information and influence received from the outsiders, exhibit certain behaviors shaped by this relationship. The findings of Nguyen (2020) also show that employees' support for organizational policies largely depends on the quality of their relationship with and trust in their leader. Overall, the LMX theory explains that high-quality leader-employee relationships create a dynamic foundation for trust, knowledge exchange, support, and the emergence of creative and innovative behaviors (Graen & Uhl-Bien, 1995). Accordingly, green leadership can lead to FI when employees interact with their leader within a framework grounded in trust, acceptance, and effective knowledge exchange (Khan et al., 2023; Saleem et al., 2024). Positive and supportive relationships between leaders and employees also enhance the sense of value and motivation in employees, thereby strengthening their involvement in creative activities, knowledge sharing, and sustainable actions (Mahmood et al., 2019; Nguyen, 2020).

On the other hand, the componential theory of creativity states that ordinary individuals can produce creative work in any field, provided that the work environment supports the development of creativity and the leader plays a facilitative role (Amabile, 1988; Amabile et al., 1996; Gilson & Shalley, 2004). Amabile (1988) explains that creativity increases when employees strengthen their expertise, experience, and skills, becoming more active in identifying problems and searching for solutions; a process that leads to the generation of innovative ideas and solutions.

Alongside these views, the KBV theory considers knowledge a strategic asset and a key resource for creating competitive advantage (Grant, 1996). When employees share their awareness and experiences related

to green practices, they become capable of offering creative and sustainable solutions (Saleem et al., 2024). When the flow of environmental knowledge within the organization is smooth, employees can generate ideas that create the highest environmental and economic value using the least amount of resources (Anderson et al., 2014).

Frugal Innovation

Originally derived from the Indian concept of *Jugaad*, defined as low-cost solutions designed for the BOP as a setting characterized by extreme resource scarcity, frugal innovation (FI) is increasingly recognized worldwide, even in developed markets (Shirazi & Bakhtiari, 2026). FI, sometimes referred to as “cost-saving engineering”, is an approach to product development and problem-solving that focuses on creating simple, affordable, and effective solutions (Aqmal et al., 2025). Tiwari et al. (2016), through the publication of an article on healthcare in India, were the first to combine the concept of frugality with innovation and to introduce it into the academic literature. Based on more recent definitions, FI is regarded as a novel and practical approach emphasizing the development of products, services, and processes that are low-cost, simple, efficient, sustainable, and accessible at the same time (Aqmal et al., 2025). It represents a distinct manifestation of innovation under constraints, wherein scarcity is not a barrier but a defining condition of the process itself (Bakhtiari et al., 2026). This approach is particularly effective in environments characterized by resource constraints and high levels of need, enabling organizations to generate the greatest possible economic and environmental value by using available resources efficiently (Govindan, 2022).

Hossain (2017) views FI as a response to resource scarcity, arguing that even under financial, technological, or material limitations, FI can provide solutions whose final cost is significantly lower than the existing alternatives, while still maintaining the quality necessary to meet the basic needs

of underserved customers. In a broader definition, FI is described as an improvement in products, processes, or marketing and organizational practices throughout the value chain in such a way that the consumption of material and financial resources is minimized during the stages of development, production, distribution, consumption, and disposal, while an acceptable level of quality is maintained at the same time (Alizadeh Toosi & Jafari Titkanloo, 2025).

By focusing on the use of minimal resources to create maximum value, this approach gives rise to products that rely only on essential functions and avoid unnecessary features. Likewise, in the design and production processes, the primary goal is to reduce costs and optimize resource consumption. Given these characteristics, FI can optimize the entire supply, production, and consumption chain and is, therefore, recognized as an effective strategy for achieving sustainable development (Iqbal et al., 2025).

FI is built upon three fundamental principles: 1) saving resources and decreasing waste, 2) emphasizing essential functionalities, and 3) developing environmentally friendly products. The tendency to emphasize sustainability receives greater attention in FI than it does in mainstream innovations (Hossain, 2018). Based on this perspective, FI overlaps with sustainability-oriented approaches. Moreover, studies such as those by Hossain et al. (2023) have shown that FI can simultaneously generate both economic efficiency and environmental benefits.

Green Knowledge-Oriented Leadership

Leadership is still a concept requiring broader and deeper examination (Kardoyo et al., 2020). In this field, Chen et al. (2014) define green leadership as an individual's ability to influence and mobilize employees to perform environmentally friendly activities. Similarly, Mittal and Dhar (2015) describe green leadership as the charismatic orientation of leaders aimed at encouraging others to engage in pro-environmental behaviors. Accordingly, green leadership can be understood as the

ability of leaders to formulate and guide environmental policies that shape organizational attitudes and practices in support of sustainable actions (Kardoyo et al., 2020).

On the other hand, knowledge-oriented leadership emphasizes guiding employees through learning, creating, and utilizing knowledge. In this sense, leaders are expected to create conditions that enable employees to acquire the necessary knowledge and apply it to achieving the organization's knowledge-related objectives (Salavati et al., 2019). The integration of these two approaches has led to the emergence of a new concept known as green knowledge-oriented leadership (GKOL). This leadership style, which has recently attracted scholarly attention, combines the principles of green leadership and knowledge management to create sustainable transformation within organizations through the management of environmental knowledge. In GKOL, the focus is on the creation, sharing, and application of environmental knowledge in order to channel organizational decision-making toward sustainability (Al Koliby et al., 2025).

GKOL empowers employees with the aim of encouraging them to explore green practices, develop a shared environmental vision, and align organizational values with ecological responsibilities (Khan et al., 2023). The primary advantage of this leadership style over traditional green leadership is that, in addition to strengthening sustainable behaviors, it activates mechanisms for learning and exchanging green knowledge. Within this approach, environmental knowledge is considered a key organizational asset that can facilitate the generation of innovative ideas and the development of cost-effective solutions (Abbas & Khan, 2023).

Creative Process Engagement

Creativity is recognized as the ability to apply knowledge to solve problems and to achieve innovation. This concept is not limited solely to generating entirely new ideas; it can also refer to transferring existing knowledge to new situations and applying it in different contexts (Jones, 2003). In other words,

creativity is the process of producing ideas, methods, and goods that are both novel and useful (Arici & Uysal, 2022). The process of creativity emerges through the interaction between individuals and their environment, with the environment playing a significant role in stimulating and enhancing the creativity of members. In this regard, CPE is described as a cognitive and emotional state in which individuals strive to identify problems, search for information, and generate alternative solutions (Amabile, 1988).

In organizational contexts, creativity generally refers to the generation of novel and useful ideas, whereas innovation involves the implementation of these creative ideas, leading to improvements in processes, methods, and products (Bharadwaj & Menon, 2000). In fact, creativity focuses on idea generation, while innovation emphasizes the realization and implementation of those ideas. For this reason, creativity is often considered the first step in the path toward innovation (Anderson et al., 2014).

From an environmental perspective, the process of CPE refers to employees' participation in identifying and seeking green and innovative solutions, actions, and strategies, leading to the reduction of greenhouse gas (GHG) emissions, the conservation of energy, and the improvement of responsible waste management (Zhang et al., 2020).

Green Knowledge Sharing

Green knowledge management, of which knowledge sharing is a vital component, comprises a set of processes aimed at creating, storing, transferring, and applying environmental knowledge. Through green knowledge-management mechanisms, including knowledge sharing, organizations can enhance their learning capacity, environmental adaptability, and green innovation capability (Abbas & Khan, 2023).

GKS refers to the process of generating, transferring, exchanging, and applying knowledge related to environmental issues and approaches within an organization. This knowledge may include experiences, skills, information, solutions, and work practices that help reduce negative environmental impacts, improve resource efficiency, conserve energy,

and support sustainable actions (Abbas & Khan, 2023).

Knowledge sharing is defined as the degree to which organizational members are willing to exchange, provide, and acquire knowledge, facilitating the connection among different types of organizational knowledge (Ibrahim & Heng, 2015). Within the context of GKS, knowledge exchange is specifically focused on environmental domains and helps employees acquire and apply the knowledge required to reduce greenhouse gas emissions, conserve energy, and enhance responsible waste management (Zhang et al., 2020). The exchange of information, experiences, and skills related to daily tasks, problem-solving, and the generation of innovative ideas is an important outcome of knowledge sharing (Vahidi et al., 2024). Knowledge sharing serves as a tool for transferring specialized knowledge and enhancing the knowledge-based competencies of the organization; this capability allows companies to combine ideas, viewpoints, facts, and information to create new knowledge for innovation (Camelo-Ordaz et al., 2011). Common methods of knowledge sharing among employees include formal and informal training, publication of scientific papers, formal meetings, daily interactions, and documentation of experiences (Maneghi et al., 2024).

Empirical Background and Hypothesis Development

GKOL and FI

Knowledge-oriented leadership is defined as an attitude or action, either observed or attributed, that ultimately leads to changes in intellectual and collective outcomes within an organization. On this basis, knowledge-oriented leadership strengthens the position of knowledge management in the organization and creates the foundation for identifying and exploiting innovative opportunities (Wenger et al., 2000).

According to the research literature, the primary mechanism through which GKOL affects innovation is the quality of the leader-member exchange. By creating appropriate knowledge structures, green knowledge-

oriented leaders facilitate the flow of environmental knowledge and empower employees to develop novel, practical, and low-cost ideas (Aqmala et al., 2025). This leadership style also encourages employees to participate in environmental activities and tasks, a form of participation that contributes to fostering innovation at the organizational level (Ahmeda et al., 2020).

GKOL seeks to transform environmental knowledge into a strategic resource, employing it to reinforce sustainable behaviors and to develop environmentally compatible innovations. Accordingly, such leaders create an environment in which environmental concerns are aligned with improved innovative performance (Al Koliby et al., 2025).

Within a knowledge-based theoretical framework, FI results from the intelligent utilization of knowledge assets and organizational capabilities. Therefore, GKOL can guide the organization toward FI by enhancing knowledge sharing and strengthening the learning capacity (Aqmala et al., 2025). Recent studies confirm that through reinforcing a learning culture and encouraging knowledge interactions, green knowledge-oriented leaders may facilitate the transfer of environmental knowledge, which can later act as a powerful driver for FI (Alizadeh Toosi & Jafari Titkanloo, 2025; Saleem et al., 2024; Shafait & Huang, 2024). Accordingly, the following hypothesis can be proposed:

H1: GKOL affects FI.

The Mediating Role of CPE

Supportive leadership is one of the key factors guiding creative processes in the workplace (Begum et al., 2022). Since creativity is a fundamental prerequisite for developing innovative solutions (Arici & Uysal, 2022), the role of leadership in stimulating creativity becomes particularly important. By creating the motivation needed to go beyond expectations, leaders can help employees boost their self-confidence and contribute to improvements in their intrinsic motivation and outward behaviors (Zhang et al., 2020). Green leadership, through the promotion of ethical

values, encouragement of experimentation, and strengthening of communication, creates a favorable environment for risk-taking, proactivity, and creative activities. Such leaders guide employees to pursue creative processes in order to find new and unique solutions (Begum et al., 2022).

Employee participation in solving organizational problems is influenced by leaders as role models, the organizational climate, and reward-and-punishment mechanisms. In this regard, leader encouragement plays an important role in directing the attention of subordinates toward creative processes (Begum et al., 2022). Moreover, supervisor support is essential for learning and continuous improvement (Bandura, 1989). Numerous studies emphasize that green leadership plays a crucial role in enhancing green creativity and sustainability-related innovation (Mittal & Dhar, 2015). By creating a shared environmental vision, empowering employees, and supporting creative behaviors, these leaders provide a setting in which employees develop greater motivation to present new ideas and environmentally compatible solutions (Ahmeda et al., 2020).

In this context, green knowledge-oriented leaders foster a supportive, participatory, and stimulating environment that increases CPE by employees and provides a platform where new knowledge can be combined with creative ideas (Mahmood et al., 2019). These leaders also encourage employees to engage creatively in environmental activities and adopt strategies to protect natural resources, thereby contributing to the environmental goals of the organization (Zhang et al., 2020). Innovation is defined as an organization's ability to discover and transform creative approaches into solutions for various problems (Awan et al., 2021).

Accordingly, this study proposes that CPE mediates the relationship between GKOL and FI. When organizations face pressure to improve, innovate, and sustain continuous growth, the natural inclination of the employees to participate in creative processes can lead to valuable solutions and enhanced individual and organizational performance. By activating employees in problem identification and information-seeking, CPE

plays a fundamental role in organizational success (Mahmood et al., 2019).

Previous studies have shown that CPE mediates the relationship between green leadership and innovation (Begum et al., 2022), as well as between green leadership and creativity (Zhang et al., 2020). Therefore, in this study, CPE is considered a key mediator in the effect of GKOL on FI. Based on this reasoning, the following hypotheses are proposed:

H2: CPE mediates the effect of GKOL on FI.

H2a: GKOL affects CPE.

H2b: CPE affects FI.

The Moderating Role of GKS

A leader, through the exercise of idealized influence (charisma), strengthens the employees' sense of pride, honor, and loyalty, while emphasizing the importance of a shared sense of mission. In terms of individualized consideration, the leader builds one-on-one relationships with employees, understands their diverse needs, and helps them grow personally and professionally by developing their skills and potential talents. Such leaders broaden the employees' perspectives, encouraging them to rethink old problems and explore innovative solutions. Supporting innovation, granting autonomy, motivating employees, fostering awareness, and enhancing competitiveness are among the effective leadership behaviors in this regard. By encouraging and empowering employees to act in line with the organizational vision, leaders facilitate the formation and development of creative ideas (Gumusluoglu & Ilsev, 2009).

In conjunction with this leadership role, green knowledge management activates the creative capacities of employees and provides the foundation for innovation (Shahzad et al., 2020). GKS enhances problem-solving abilities and enables employees to benefit from the experiences, practices, and approaches that others have used to address environmental challenges. The accumulation of diverse ideas and expertise through this process contributes to the formation of effective and sustainable environmental solutions. Moreover, by encouraging employees to exchange expertise and ideas, a

culture of GKS drives innovation in environmental initiatives, enhances creativity, and strengthens collective commitment to sustainability (Zairbani & Kumar, 2025).

This process aligns with the organizational creativity theory, which posits that incoming knowledge leads to creative output only when it flows within a supportive, interactive, and learning-oriented environment (Amabile et al., 1996). Consequently, green knowledge-oriented leaders should function as knowledge advisors within the organization, helping employees clearly understand how to implement and advance knowledge initiatives. Furthermore, effective communication is essential for such leaders, as it reduces knowledge-related communication barriers and helps steer employees toward achieving the knowledge goals of the organization (Schermerhorn, 2012). Based on this reasoning, the following hypothesis is proposed:

H3: GKS moderates the relationship between GKOL and CPE.

Innovation refers to the implementation of novel ideas derived from creativity. Management scholars often regard innovation as synonymous with invention and view it as the final stage of creativity; the stage in which creative ideas are transformed into tangible products or solutions. In other words, innovation is the transformation of creativity and new ideas into action and results (Wonglimpiyarat, 2004).

In organizations, employees who share their environmental experience and knowledge with others are able to solve complex problems by leveraging collective ideas and to provide solutions that are both economically and environmentally efficient (Zairbani & Kumar, 2025). Employees who contribute creative ideas and sustainability initiatives also show stronger commitment to environmental goals; an effort that not only improves organizational processes but also enhances corporate image and sustainability (Khan et al., 2023).

Such organizations commonly draw on external knowledge resources and integrate them with internal R&D efforts to develop sustainable products. In this context, GKS

fosters a sustainability-oriented culture and enables organizations to innovate with minimal resources. Knowledge sharing not only accelerates innovation but also improves organizational efficiency by stimulating creativity and reducing redundant efforts. Given the global emphasis on sustainability, the role of GKS in promoting FI has become increasingly important. Organizations that prioritize the exchange of environmental knowledge are better prepared to develop cost-efficient and innovative solutions (Saleem et al., 2024).

Moreover, specialized knowledge of sustainability practices helps organizations reduce the time and resources required to develop new technologies or processes and increases their focus on FI (Makhloufi, 2024). Both internal and external knowledge sharing are key drivers of FI, since new knowledge enhances the likelihood of discovering creative solutions. Internal knowledge sharing promotes new ideas and improves individual innovation, whereas external knowledge acquisition facilitates the formation of new stakeholder networks and effective relationships with customers. The combination of these two knowledge sources leads to affordable and innovative solutions (Alizadeh Toosi & Jafari Titkanloo, 2025).

Cross-functional collaboration facilitates knowledge transfer as an essential process for advancing innovation in renewable energy, reducing waste, and cutting costs (Wu, 2023). Knowledge sharing further reduces redundancy, increases accuracy in environmental decision-making, and improves innovation at both process and product levels (Awan et al., 2021). Therefore, organizations that actively engage in GKS are more likely to achieve higher levels of FI (Song et al., 2020).

Previous studies have likewise confirmed the moderating role of GKS in the relationships among environmental variables, emphasizing the need for organizations to recognize and leverage its impact (Ting et al., 2024). Accordingly, the following hypothesis is proposed:

H4: GKS moderates the relationship between CPE and FI.

Based on the discussions above, the proposed research model is illustrated in

Figure 1.

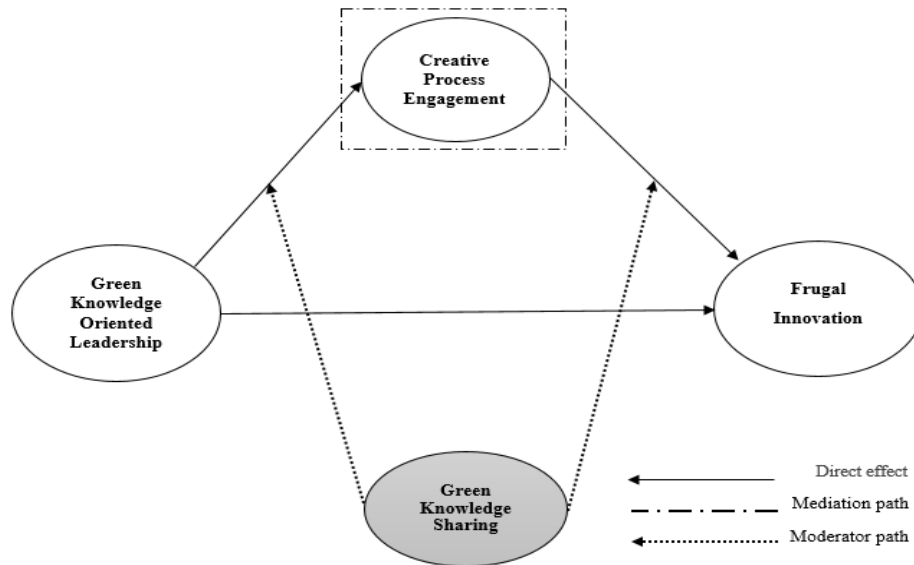


Figure 1. Conceptual Research Model

Research Methodology

This research is grounded in the post-positivist paradigm and employs a quantitative approach to examine the relationships among the research variables. From a purpose-oriented standpoint, the study is classified as applied research, and a survey strategy was

used for data collection. The target population consists of managers of companies operating in the FMCG industry, and the sample size was determined using G*Power software. The data collection instrument was a standardized questionnaire, which was distributed online among the sample members. The structure of the questionnaire is presented in Table 1.

Table 1. Questionnaire Structure

Variables	Role	Items	Summary of Questions	Sources
GKOL	Independent	1–6	Encouraging responsible employee behavior, teamwork, and sustainable environmental practices; tolerating mistakes to achieve environmental goals; learning from experiences related to sustainable environmental practices; using controls to assess progress toward environmental goals; promoting the acquisition of external knowledge on sustainable environmental practices; allocating rewards to employees active in sharing sustainable environmental knowledge.	(Al Koliby et al., 2025)
FI	Dependent	7–11	Considering the impact of product manufacturing on the environment and the world; using data analysis to identify trends; using environmentally friendly materials in new ways; considering different customer segments when producing products; using up-to-date technologies to reduce production costs and increase cost-effectiveness.	(Aqmala et al., 2025)

Variables	Role	Items	Summary of Questions	Sources
CPE	Mediator	12–22	Spending time understanding problems; thinking across different dimensions of environmental issues; breaking down environmental problems into smaller parts; using a wide range of information; using diverse information resources; retaining specialized information for future use; generating new ideas by considering diverse information sources; using varied solutions across different domains; considering alternative solutions; making efforts to devise potential and unconventional solutions; spending time sharing information to generate new ideas.	(Begum et al., 2022)
GKS	Moderator	23–26	Exchange of green knowledge and experience among employees; ability to filter green knowledge; existence of processes for acquiring green knowledge from suppliers; new green knowledge derived from existing knowledge systems.	(Zairbani & Kumar, 2025)

The results of the skewness and kurtosis tests indicated that the data were not normally distributed (see Table 2 in Findings). Therefore, the Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed for data analysis. The analyses were conducted using the SEMinR package in R. In the assessment of the outer (measurement) model, indicator reliability was assessed via factor loadings, and construct reliability via Cronbach's alpha, rho_A, and composite reliability (rho_C) (Table 3). Convergent validity was evaluated using the Average Variance Extracted (AVE) measure (Table 3), while discriminant validity was assessed using the Fornell-Larcker and HTMT criteria (Table 4). For the evaluation of the inner (structural)

model, the analyses focused on examining the path coefficients Beta (β) and their significance levels, effect sizes (Table 5), collinearity, and R squared (R^2) (Table 3). Collectively, these tests enabled an accurate interpretation of the relationships among the variables and an assessment of the overall quality of the theoretical model of the study.

Research Findings

In the first step, the sample size was calculated using the G*Power software. According to Figure 2, the sample size included 312 participants. Following an online survey, the collected data were used as the basis of the analyses.

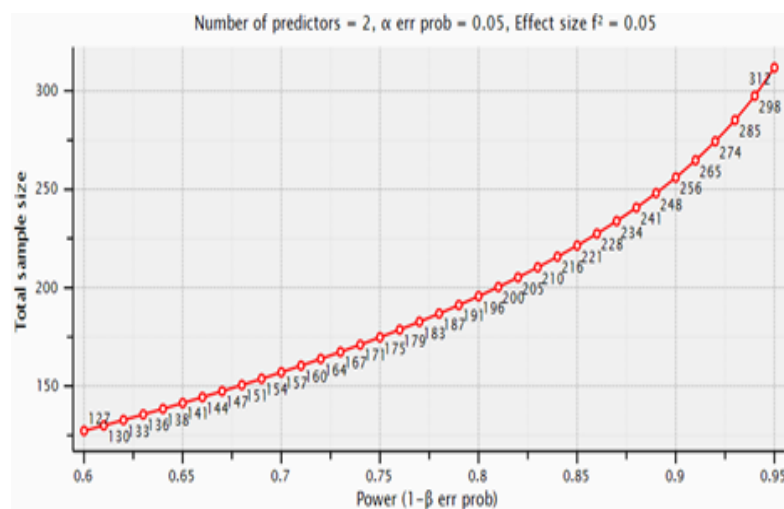


Figure 2. Sample Size Determination Using the G*Power Software.

Test of Data Normality: Skewness and Kurtosis

To determine the appropriate generation of the structural equation modeling to use, the

normality of data distribution was assessed using skewness and kurtosis tests, the results of which are presented in Table 2.

Table 2. Skewness and Kurtosis Test

Construct (Model Label)	Skewness	Kurtosis	Result
Green Knowledge-Oriented Leadership (GKOL)	[-1.34,2.58]	[-0.93,3.63]	Non-normal
Creative Process Engagement (CPE)	[-1.49,3.11]	[-1.87,5.32]	Non-normal
Frugal Innovation (FI)	[-0.86,0.67]	[-0.53,0.82]	Normal
Green Knowledge Sharing (GKS)	[-0.92,0.63]	[-0.71,0.89]	Normal

Given the non-normal distribution of some variables (Demir, 2022), the second generation of structural equation modeling (variance-based) was employed for model testing and data analysis.

Outer (Measurement) Model Evaluation

The evaluation of reflective measurement models in the PLS-SEM approach is conducted through an assessment of reliability and validity.



Figure 3. Systematic Procedure for Evaluating the Outer Model (Hair Jr et al., 2021)

Step 1- Assessment of Indicator Reliability: Factor Loadings

The first step in evaluating reflective outer models is to examine the extent to which the variance of each indicator is explained by its construct, reflecting the reliability of that indicator. To calculate the amount of variance explained, the factor loading must be squared, representing the bivariate correlation between the indicator and its construct. Factor loadings greater than 0.708 are considered adequate, as they indicate that the latent variable explains more than 50% of the indicator's variance (Hair Jr et al., 2021). When indicators have loadings below 0.708, researchers should refrain from immediately deleting them;

instead, they should first examine how removing the indicator would affect other reliability and validity criteria. Generally, indicators with loadings between 0.40 and 0.708 should only be removed if their deletion results in improvements in reliability and convergent validity beyond the recommended thresholds. Consequently, indicators with weaker loadings may sometimes be retained in the model (Hair Jr et al., 2021).

The factor loadings and their significance levels are reported in Table 3. Based on the above guidelines and after model refinement, items CPE7, CPE9, CPE10, and FI4 were removed from the model (their values are still shown in Table 3 for researchers' reference),

and the values for the remaining indicators were recalculated after model modification. Therefore, the results show acceptable unidimensional reliability for each item. Moreover, the significance values of the factor loadings, also reported in Table 3, indicate that all retained items are statistically significant.

Step 2- Assessment of Construct Reliability: Composite Reliability, Cronbach's Alpha, and Rho_A

The second stage in evaluating reflective outer models involves assessing internal consistency, i.e., the extent to which the indicators measuring a construct are correlated with one another. One of the primary criteria used for this purpose is composite reliability (ρ_C) (Jöreskog, 1971). Higher values of this coefficient indicate higher levels of reliability. Values between 0.70 and 0.90 are considered "satisfactory to good". Values above 0.90 (and certainly those exceeding 0.95) are problematic because they indicate item redundancy and reduced construct validity (Diamantopoulos et al., 2012).

Cronbach's alpha is another indicator of internal consistency, with acceptable thresholds similar to those of composite reliability. However, a major limitation of Cronbach's alpha is that it assumes equal indicator loadings in the population. Despite this, researchers have shown that Cronbach's alpha is an acceptable lower-bound estimate of true internal consistency (Trizano-Hermosilla & Alvarado, 2016). While Cronbach's alpha tends to be conservative, composite reliability may be overly optimistic; therefore, the true reliability of a construct is assumed to lie between these two measures (Hair Jr et al., 2021).

As an alternative, recent research has introduced ρ_A as a more precise (or consistent) measure of construct reliability (Dijkstra, 2009; Dijkstra & Henseler, 2015). The ρ_A coefficient typically lies between the conservative estimate of Cronbach's alpha and the optimistic estimate of composite reliability, representing an acceptable compromise between the two (Hair Jr et al.,

2021). Therefore, based on Table 3, construct reliability was confirmed.

Step 3- Assessment of Convergent Validity: Average Variance Extracted (AVE)

The third step involves assessing the convergent validity of each construct. Convergent validity refers to the extent to which a construct converges to explain the variance of its indicators. The metric used for this purpose is the Average Variance Extracted (AVE). AVE is defined as the mean of the squared factor loadings of the indicators associated with a construct (i.e., the sum of the squared loadings divided by the number of indicators). The minimum acceptable AVE value is 0.50. An AVE of 0.50 or higher indicates that the construct explains at least 50% of the variance of the indicators that form the construct (Fornell & Larcker, 1981; Sarstedt et al., 2021). Accordingly, based on the results in Table 3, convergent validity was confirmed for all constructs.

Step 4- Assessment of Discriminant Validity: Fornell-Larcker Criterion and the Heterotrait-Monotrait Ratio (HTMT)

The fourth step involves evaluating discriminant validity, which measures the degree to which a construct is distinct from other constructs in the model. Fornell and Larcker (1981) proposed that discriminant validity is established when the square root of each construct's AVE (reported on the diagonal of the Fornell-Larcker matrix) is greater than the correlations between that construct and other constructs in the model (shown in the lower-left portion of the matrix). However, recent research suggests that this criterion is not always adequate for assessing discriminant validity, especially when indicator loadings within a construct are relatively similar (e.g., all loadings ranging between 0.65 and 0.85). In such cases, the Fornell-Larcker criterion may fail to detect discriminant validity issues and is, therefore, considered unreliable (Hair Jr et al., 2021). Despite these limitations, and due to its widespread familiarity among researchers, the criterion is still reported in this study. As a superior alternative, the Heterotrait-Monotrait Ratio (HTMT) has been recommended.

HTMT is defined as the mean of all heterotrait–heteromethod correlations divided by the mean of all monotrait–heteromethod correlations. Henseler et al. (2015) proposed a conservative threshold of 0.85. Additionally, bootstrapping can be used to assess whether HTMT is significantly below 0.90 or 0.85 (Franke & Sarstedt, 2019; Henseler et al.,

2015). Based on Table 4, discriminant validity was confirmed using both the Fornell-Larcker criterion and the HTMT ratio.

Inner (Structural) Model Evaluation

After confirming the reliability and validity of the outer models, the next step is to evaluate the results of the inner model.

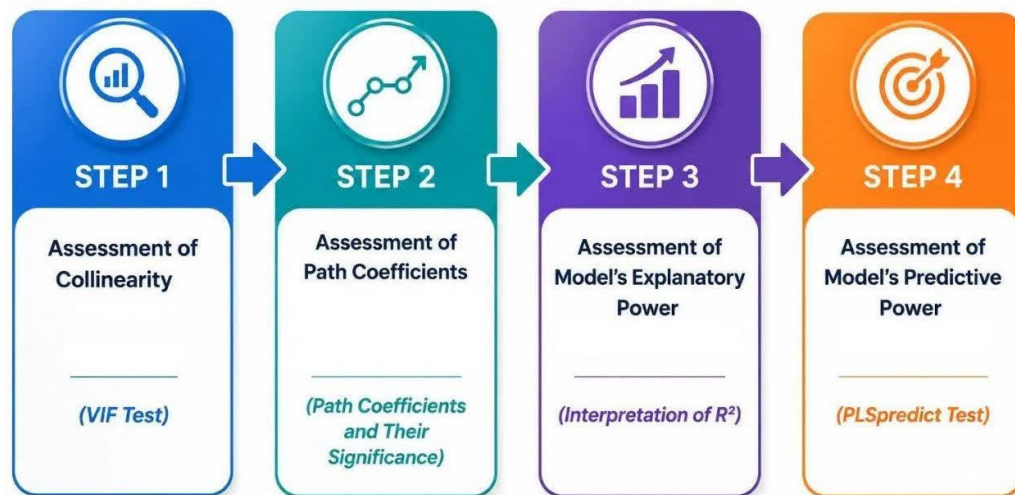


Figure 4. Systematic Procedure for Evaluating the Inner Model (Hair Jr et al., 2021)

Step 1- Collinearity Assessment: VIF Test

The inner model coefficients for the relationships between constructs are obtained from estimating a set of regression equations. It is important to note that point estimates and standard errors can be biased by strong correlations among sets of predictor constructs (Hair Jr et al., 2021). In fact, this process is similar to the evaluation of formative outer models, where combinations of predictor construct coefficients in each regression of the inner model are used to calculate the Variance Inflation Factor (VIF) values. VIF values above 5 indicate potential collinearity among predictor constructs; however, collinearity may also occur at VIF values between 3 and 5 (Becker et al., 2015). Based on Table 3, the absence of collinearity in the causal relationships of the model was confirmed.

Step 2- Path Coefficient Assessment: Beta (B) Coefficients, Bootstrapping, and Effect Size (f^2)

The (direct) path coefficient indicates the change in the values of an endogenous

construct associated with a one-standard-deviation change in a specific predictor construct, while keeping other predictor constructs constant. In terms of interpretation, path coefficients typically range between -1 and $+1$. Coefficients close to -1 indicate strong negative relationships, whereas coefficients close to $+1$ indicate strong positive relationships. Values lower than -1 or higher than $+1$ may technically occur, for example when collinearity exists at very high levels. Therefore, the significance of these coefficients is also important and must be examined (Hair Jr et al., 2021). The values of the path coefficients and their significance are presented in Table 5. According to the results, the effects of GKOL on CPE and CPE on FI are positive, significant, and relatively strong. However, the effect of GKOL on FI is not significant.

In testing the inner model, another criterion examines how the removal of a selected predictor construct affects the coefficient of determination of an endogenous construct. This criterion is the effect size (f^2) and is conceptually similar to the magnitude of path

coefficients (Hair Jr et al., 2021). The results of the effect sizes of the exogenous variables are presented in Table 5. Based on Cohen (1988), it can be concluded that the effects of GKOL on CPE and CPE on FI are substantial (strong). However, the effect size of GKOL on FI is negligible ($f^2 = 0.01$).

Step 3- Assessment of Explanatory Power: R^2

The next step involves examining the coefficient of determination (R^2) of the endogenous variables. The coefficient of determination represents the variance explained in each endogenous variable and serves as a measure of the model's explanatory power, which is also referred to as its in-sample predictive power (Hair Jr et al., 2021). The coefficient of determination is used to evaluate goodness of fit in regression analysis, with values ranging from 0 to 1; the closer the value to 1, the greater the model's explanatory power for the endogenous variable. As a general guideline, R^2 values of 0.66, 0.35, and 0.19 can be considered substantial, moderate, and weak, respectively (Chin, 1998).

One limitation of R^2 is that it tends to rise as the number of predictor variables in the model increases. The adjusted coefficient of determination (Adj. R^2) addresses this issue by adjusting the R^2 value based on the number of predictor variables relative to the sample size. Therefore, it is considered a more conservative estimate of R^2 . However, given the correction factor introduced in its calculation with respect to the data and model size, the adjusted R^2 is not an exact indicator of the variance explained by an endogenous construct (Sarstedt & Mooi, 2014). The relevant results are presented in Table 3. According to the findings, the research model demonstrates a moderate level of explanatory power for the endogenous constructs.

Step 4- Assessment of Predictive Power: PLSpredict

Many researchers interpret the R^2 statistic as an indicator of their model's predictive power. However, this interpretation is not entirely correct, because R^2 only reflects the model's explanatory power within the sample (Hair &

Sarstedt, 2021) and fails to provide information on the model's predictive power, also referred to as out-of-sample predictive power (Hair Jr et al., 2021).

To address this issue, researchers introduced PLSpredict, a method for out-of-sample prediction that indicates the model's ability to predict new or future observations (Shmueli et al., 2019). Two criteria, Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE), have been proposed for this test. In most cases, researchers should use RMSE to assess a model's predictive power. However, if the distribution of prediction errors is highly asymmetric (Danks & Ray, 2018), MAE is considered to be a more appropriate prediction statistic (Shmueli et al., 2019).

To interpret these criteria, the RMSE (or MAE) values of each indicator should be compared with those of a simple linear regression model (LM). The LM benchmark values are obtained by running a linear regression of each indicator of the dependent construct on the indicators of the exogenous constructs in the PLS path model. When comparing RMSE (or MAE) values with those of the LM, the following guidelines apply (Hair Jr et al., 2021):

1. If RMSE (or MAE) values for all indicators are lower than those of the LM benchmark, the model has high predictive power.
2. If the majority (or an equal number) of indicators produce lower prediction errors than the LM, this indicates moderate predictive power.
3. If fewer than half of the indicators produce lower prediction errors than the LM, this indicates low predictive power.
4. If the PLS-SEM analysis does not yield lower prediction errors (in terms of RMSE or MAE) for any indicator compared with the LM, the model has no predictive power.

The results related to the predictive power of the model are presented in Table 3. Based on the distribution of the prediction errors in the research model and the comparison between LM-MAE and PLS-SEM MAE, the

out-of-sample predictive power of the model is evaluated as moderate.

Mediation Analysis

Mediation occurs when a construct, known as a mediator, intervenes between two other related constructs. More specifically, a change in an exogenous construct leads to a change in the mediator construct, which in turn results in a change in the endogenous construct in the PLS path model. In the past, the significance of mediation effects relied on the Sobel test (Sobel, 1982), which is no longer recommended for use (Sarstedt et al., 2021). Instead of using the Sobel test, researchers should bootstrap the sampling distribution of the indirect effect (Hair Jr et al., 2021). Bootstrapping the indirect effect provides higher levels of statistical power compared to the Sobel test (Zhao et al., 2010).

The values related to the mediation path of the model are presented in Table 5. Following the bootstrapping procedure, the indirect effect of GKOL on FI through CPE was found to be significant ($\beta = 0.373$, $t = 10.68$), whereas the direct effect of GKOL on FI was not significant ($\beta = 0.082$, $t = 1.61$). According to the mediation typology proposed by Zhao et al. (2010) and further elaborated by Hair Jr. et al. (2021), when the indirect effect is significant but the direct effect is not, the mediator fully accounts for the relationship between the exogenous and endogenous constructs; a pattern referred to as indirect-only mediation. Therefore, CPE plays an indirect-only mediating role in the relationship between GKOL and FI.

Moderation Analysis

Moderation describes a situation in which the relationship between two constructs is not constant but depends on the value of a third variable, known as the moderator variable. A moderator can strengthen, weaken, or even reverse a relationship (Gardner et al., 2017). The fundamental distinction between mediation and moderation is that in mediation there is a direct effect between the exogenous construct and the mediator construct, whereas a moderator variable is not dependent on the exogenous construct (Memon et al., 2019).

In this study, the two-stage approach was used to calculate the moderating effect (Becker et al., 2018). When interpreting the results of the moderation analysis, the primary focus is on examining the significance of the moderating effect using the bootstrapping method (Hair Jr et al., 2021). If the relationship is statistically significant, the next step is to determine the effect size (f^2) of the moderator (Memon et al., 2019). The f^2 effect size indicates how much the moderation contributes to explaining the endogenous construct. According to Hair Jr. et al. (2021), f^2 values of 0.005, 0.01, and 0.025 should be considered evidence of small, medium, and large effect sizes, respectively.

The path coefficients and significance levels of the moderation analysis of the model are presented in Table 5. Based on the results, GKS strengthens the effect of GKOL on CPE, and this moderating effect is moderate. However, the hypothesis regarding the moderating role of GKS in the relationship between CPE and FI was not supported.

Table 3. Factor Loadings, Reliability, Convergent Validity, Collinearity, R2 and Predictive Power

Construct	Item	FL	t-value	α	Rho_A	Rho_C	AVE	VIF	R ²	R ² adj	LM-MAE	PLS-SEM MAE	Predictive Power
GKOL	GKOL1	0.69	10.37	0.84	0.88	0.88	0.55	1.47	-	-	-	-	-
	GKOL2	0.83	17.97										
	GKOL3	0.79	15.07										
	GKOL4	0.68	9.55										
	GKOL5	0.81	18.4										
	GKOL6	0.62	14.01										
CPE	CPE1	0.77	26	0.84	0.86	0.88	0.51	1.58	0.321	0.316	0.474	0.298	Moderate predictive
	CPE2	0.79	26.99								0.559	0.504	

Construct	Item	FL	t-value	α	Rho_A	Rho_C	AVE	VIF	R ²	R ² adj	LM-MAE	PLS-SEM MAE	Predictive Power
	CPE3	0.64	14.46								0.561	0.532	power
	CPE4	0.82	30.17								0.546	0.518	
	CPE5	0.80	27.87								0.515	0.54	
	CPE6	0.53	7.74								0.965	1.029	
	CPE7	0.46	-								-	-	
	CPE8	0.59	9.76								1.062	1.161	
	CPE9	0.47	-								-	-	
	CPE10	0.49	-								-	-	
	CPE11	0.71	20.41								0.4	0.666	
	GKS1	0.87	49.12								-	-	
	GKS2	0.82	39.61								-	-	
GKS	GKS3	0.74	25.34	0.83	0.84	0.89	0.67	-	-	-	-	-	-
	GKS4	0.83	43.22								-	-	
	FI1	0.76	26.21								0.591	0.406	
	FI2	0.81	38.61								0.629	0.592	
FI	FI3	0.80	32.99	0.81	0.81	0.87	0.64	-	0.513	0.506	0.714	0.723	Moderate predictive power
	FI4	0.31	-								-	-	
	FI5	0.82	23.34								0.645	0.666	

Table 4. Discriminant Validity

	Fornell–Larcker Matrix				HTMT Criterion				Significance of HTMT Criterion			
	GKOL	CPE	GKS	FI	GKOL	CPE	GKS	FI	GKOL	CPE	GKS	FI
GKOL	0.745											
CPE	0.561	0.714			0.531				8.61			
GKS	0.254	0.497	0.819		0.257	0.594			4.04	9.58		
FI	0.455	0.603	0.455	0.804	0.482	0.82	0.546		7.16	23.15	8.97	

Table 5. Path coefficients and hypothesis results

Path	Path Coefficient	Indirect Path Coefficient	Moderating Path Coefficient	T- Value	Hypothesis Results	f ²
H1: GKOL → FI	0.082	-	-	1.61	Rejected	0.01
H2a: GKOL → CPE	0.566	-	-	17.44	Supported	0.47
H2b: CPE → FI	0.658	-	-	15.65	Supported	0.59
H2: GKOL → CPE → FI		0.373	-	10.68	Supported	-
H3: GKOL × GKS → CPE			0.102	2.24	Supported	0.01
H4: CPE × GKS → FI			0.008	-	Rejected	-

Conclusion

The findings of the present study provide a novel perspective on the role of GKOL in the path toward FI. They show that although the direct effect of this relationship is not

particularly strong or significant, an organization led by a green knowledge-oriented leader can move toward FI through its internal organizational mechanisms. The rejection of the first hypothesis, which stated that GKOL directly affects FI, indicates that

merely having a leader with a knowledge-based and environmental orientation is not sufficient to drive employees toward innovative and low-cost behaviors. This finding highlights an important theoretical point: GKOL leads to FI only when it acts as a driving force for the emergence of employees' CPE. This result is consistent with the theoretical literature, which has repeatedly emphasized that innovation—especially FI—depends on processes of creative participation and knowledge interactions and requires the active involvement of employees in problem-solving processes.

The confirmation of H2a and H2b regarding the role of CPE indicates that this variable constitutes the core mechanism through which GKOL is transformed into FI. The high coefficient of the effect of GKOL on CPE, along with the very strong effect of CPE on FI, shows that creativity is a key factor in organizations seeking to generate maximum innovative value with minimal resources. Therefore, any managerial intervention should take into account the fact that FI is not merely the result of managerial instructions or policies, but rather the outcome of the actualization of employees' creative capacities.

On the other hand, the findings confirmed the role of GKS as an important moderator in the stage of transforming GKOL into CPE. This result indicates that the presence of a green knowledge-oriented leader becomes more effective when employees actively participate in the exchange of environmental knowledge. In fact, GKS provides a kind of "knowledge oxygen" for the leader's effective performance, enabling the leader's messages, values, and orientations to be infused into the workplace more rapidly and with higher quality.

However, the rejection of the fourth hypothesis which stated that GKS moderates the relationship between CPE and FI indicates that when employees engage in creative activities, such creativity leads to FI almost regardless of the level of knowledge exchanged. Thus, creativity is an independent and powerful driver of FI, and its effectiveness is not significantly influenced by the intensity of green knowledge flows. Therefore, it can be argued that green knowledge flows only

strengthen FI at the idea-generation stage. These findings provide a clear picture of the necessity of internal organizational dynamics for achieving low-cost innovations and emphasize the importance of knowledge assets and employee creativity. Finally, based on the research model, it can be concluded that FI, contrary to common assumptions, is not a direct product of managerial orientation but rather results from the interaction among knowledge, creativity, and leadership.

Based on the research results, managers of organizations can take a series of strategic actions to increase FI: First, organizations need to develop GKOL as a key capacity. However, it should be noted that this leadership style alone is not enough and managers must create structures and processes that activate employee creativity. Specifically, CPE is the main factor in transforming leadership into innovation. Green creativity training programs, environmental problem-solving sessions, and innovation workshops can strengthen this process.

Second, one of the most important management actions is to create formal and informal mechanisms to strengthen employee CPE. Therefore, managers should provide a space where employees can present new ideas for value creation using minimal resources and not direct the organization's operational focus solely toward cost reduction. Managers can intensify innovative behaviors by providing creativity-based rewards, creating innovation teams, encouraging employees to submit green suggestions, and designing creativity-based promotion paths.

Third, given the proven moderating role of GKS, environmental knowledge management should be pursued as a serious organizational policy. Organizations should develop GKS systems, because they have a reinforcing role in transmitting leaders' messages and increasing their effectiveness. For this purpose, the establishment of intra-organizational green knowledge networks, environmental databases, green experience exchange meetings, and the use of knowledge technologies can strengthen the flow of environmental knowledge and enhance the effect of GKOL.

Fourth, despite the lack of confirmation of the moderating role of knowledge sharing in

the connection between CPE and FI, managers should not neglect the importance of environmental knowledge. Knowledge sharing can improve the quality of creative ideas, even if it does not directly affect the intensity of the effect of creativity on FI. Therefore, combining a culture of creativity and a knowledge culture is the best path to creating FI.

Based on the results and limitations of this study, several directions can be suggested for future research. First, future studies may examine the role of additional mediating variables in the relationship between GKOL and FI. Variables such as organizational learning, green absorptive capacity, environmental commitment, and environmental self-efficacy may provide deeper insights into the mechanisms through which leadership influences innovative outcomes.

Second, future research could explore other leadership styles and compare their effects with GKOL. For example, transformational leadership, servant leadership, and responsible leadership may also influence employees' creativity and FI in different ways. Comparative studies could help clarify which leadership approaches are more effective in promoting sustainable and resource-efficient innovation.

Third, it is recommended that future studies investigate additional moderating variables that may influence the relationships among the main constructs of the model. Factors such as green organizational culture, environmental strategy, organizational support for innovation, and the quality of internal communication may strengthen or weaken these relationships and provide a more

comprehensive understanding of the organizational context.

Fourth, further research should be conducted in different industries and organizational settings to improve the generalizability of the findings. Since the impact of GKOL on FI may vary across industries, future studies could focus particularly on resource-constrained sectors, manufacturing industries, or environmentally sensitive sectors.

Finally, given that GKS did not moderate the relationship between CPE and FI, future studies are encouraged to examine different dimensions and types of knowledge sharing. For instance, researchers may distinguish between tacit and explicit knowledge, technological knowledge and environmental knowledge, or internal and inter-organizational knowledge sharing to determine which forms of knowledge exchange play a more significant role in enhancing FI.

Acknowledgement and Sponsoring Information

The authors would like to express their sincere appreciation to all individuals who contributed to the completion of this research, particularly the participants who generously shared their time and insights. Their cooperation played a valuable role in enabling the successful conduct of this study.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

- Abbas, J., & Khan, S. M. (2023). "Green knowledge management and organizational green culture: an interaction for organizational green innovation and green performance". *Journal of Knowledge Management*, 27(7), 1852-1870. <https://doi.org/10.1108/JKM-03-2022-0156>.
- Ahmeda, U., Mozammelb, S., & Zamanc, F. (2020). "Green HRM and Green Innovation: Can Green Transformational Leadership Moderate: Case of Pharmaceutical Firms in Australia. Syst". *Rev. Pharm*, 11, 616-617. <https://api.semanticscholar.org/CorpusID:235327557>.
- Al Koliby, I. S., Al-Swidi, A. K., Al-Hakimi, M. A., & Farhan, S. A. G. (2025). "How

- green knowledge-oriented leadership drives green innovation in SMEs: the mediating role of environmental strategy and the moderating role of green AI capability". *Cogent Business & Management*, 12(1), 2520914. <https://doi.org/10.1080/23311975.2025.2520914>.
- Alizadeh Toosi, F., & Jafari Titkanloo, S. (2025). "The Effect of Sustainable Leadership Orientation on Frugal Innovation through Diverse Knowledge Sharing by Analyzing the Moderating Role of Entrepreneurial Bricolage (Case study: Technological and Knowledge-Based Agricultural Companies in Khorasan Razavi)". *Journal of Entrepreneurship and Agriculture*, 12(2), 158-172. <http://dx.doi.org/10.61882/jea.2025.446>.
- Amabile, T. M. (1988). "A model of creativity and innovation in organizations". *Research in organizational behavior*, 10(1), 123-167.
- Amabile, T. M., Conti, R., Coon, H., Lazenby, J., & Herron, M. (1996). "Assessing the work environment for creativity". *Academy of management journal*, 39(5), 1154-1184. <https://doi.org/10.5465/256995>
- Anderson, N., Potočník, K., & Zhou, J. (2014). "Innovation and creativity in organizations: A state-of-the-science review, prospective commentary, and guiding framework". *Journal of management*, 40(5), 1297-1333. <https://doi.org/10.1177/0149206314527128>.
- Aqmala, D., Panjaitan, R., Ardyan, E., & Putra, F. I. F. S. (2025). "The role of green blue ocean strategy in enhancing frugal innovation through IoT and AI: A resource-based view perspective". *Journal of Entrepreneurship, Management and Innovation*, 21(2), 56-81. <https://doi.org/10.7341/20252124>.
- Arici, H. E., & Uysal, M. (2022). "Leadership, green innovation, and green creativity: A systematic review". *The Service Industries Journal*, 42(5-6), 280-320. <https://doi.org/10.1080/02642069.2021.1964482>.
- Awan, U., Arnold, M. G., & Gölgeci, I. (2021). "Enhancing green product and process innovation: Towards an integrative framework of knowledge acquisition and environmental investment". *Business Strategy and the Environment*, 30(2), 1283-1295. <https://doi.org/10.1002/bse.2684>.
- Bakhtiari, H., Shirazi, H., Edalatipour, A., & Dabaghiroodsari, M. (2026). "Doing More with Less: A Meta-Analysis of How Frugal Innovation Drives Circular Economy". *Industrial Management Journal*, 18(4), 78-103. [10.22059/imj.2026.413756.1008315](https://doi.org/10.22059/imj.2026.413756.1008315)
- Bandura, A. (1989). "Human agency in social cognitive theory". *American psychologist*, 44(9), 1175-1184. <https://doi.org/10.1037/0003066X.44.9.1175>.
- Becker, J.-M., Ringle, C. M., & Sarstedt, M. (2018). "Estimating Moderating effects in PLS-SEM and PLSc-SEM: interaction term generation* data treatment". *Journal of Applied Structural Equation Modeling*. (2), 1-21. [https://doi.org/10.47263/JASEM.2\(2\)01](https://doi.org/10.47263/JASEM.2(2)01).
- Becker, J.-M., Ringle, C. M., Sarstedt, M., & Völckner, F. (2015). "How collinearity affects mixture regression results". *Marketing letters*, 26, 643-659. <https://doi.org/10.1007/s11002-014-9299-9>.
- Begum, S., Ashfaq, M., Xia, E., & Awan, U. (2022). "Does green transformational leadership lead to green innovation? The role of green thinking and creative process engagement". *Business Strategy and the Environment*, 31(1), 580-597. <https://doi.org/10.1108/JMTM-01-2021-0003>.
- Bharadwaj, S., & Menon, A. (2000). "Making innovation happen in organizations: individual creativity mechanisms, organizational creativity mechanisms or both?". *Journal of Product Innovation Management: An International Publication of the Product Development & Management Association*, 17(6), 424-434. <https://doi.org/10.1111/1540-5885.1760424>.
- Camelo-Ordaz, C., García-Cruz, J., Sousa-Ginel, E., & Valle-Cabrera, R. (2011). "The influence of human resource management on knowledge sharing and innovation in Spain: the mediating role of

- affective commitment". *The international journal of human resource management*, 22(07), 1442-1463. <https://doi.org/10.1080/09585192.2011.561960>.
- Chen, Y., Tang, G., Jin, J., Xie, Q., & Li, J. (2014). "CEO s' transformational leadership and product innovation performance: The roles of corporate entrepreneurship and technology orientation". *Journal of product innovation management*, 31, 2-17. <https://doi.org/10.1111/jpim.12188>.
- Chin, W. W. (1998). "The partial least squares approach to structural equation modeling". *Modern methods for business research*, 295(2), 295-336.
- Cohen, J. (1988). *"Statistical power analysis for the behavioral sciences (2nd ed.)"*. Lawrence Erlbaum Associate.
- Danks, N. P., & Ray, S. (2018). "Predictions from partial least squares models". In *Applying partial least squares in tourism and hospitality research*, (pp. 35-52). Emerald Publishing Limited. <https://doi.org/10.1108/978-1-78756-699-620181003>.
- Demir, S. (2022). "Comparison of normality tests in terms of sample sizes under different skewness and kurtosis coefficients". *International Journal of Assessment Tools in Education*, 9(2), 397-409. <https://doi.org/10.21449/ijate.1101295>.
- Diamantopoulos, A., Sarstedt, M., Fuchs, C., Wilczynski, P., & Kaiser, S. (2012). "Guidelines for choosing between multi-item and single-item scales for construct measurement: a predictive validity perspective". *Journal of the Academy of Marketing Science*, 40, 434-449. <https://doi.org/10.1007/s11747-011-0300-3>.
- Dijkstra, T. K. (2009). "Latent variables and indices: Herman Wold's basic design and partial least squares". In *Handbook of partial least squares: Concepts, methods and applications* (pp. 23-46). Springer. https://doi.org/10.1007/978-3-540-32827-8_2.
- Dijkstra, T. K., & Henseler, J. (2015). "Consistent partial least squares path modeling". *MIS quarterly*, 39(2), 297-316. <https://doi.org/10.25300/MISQ/2015/39.2.02>.
- Fornell, C., & Larcker, D. F. (1981). "Evaluating structural equation models with unobservable variables and measurement error". *Journal of marketing research*, 18(1), 39-50. <https://doi.org/10.2307/3151312>.
- Franke, G., & Sarstedt, M. (2019). "Heuristics versus statistics in discriminant validity testing: a comparison of four procedures". *Internet research*, 29(3), 430-447. <https://doi.org/10.1108/IntR-12-2017-0515>.
- Gardner, R. G., Harris, T. B., Li, N., Kirkman, B. L., & Mathieu, J. E. (2017). "Understanding "it depends" in organizational research: A theory-based taxonomy, review, and future research agenda concerning interactive and quadratic relationships". *Organizational research methods*, 20(4), 610-638. <https://doi.org/10.1177/1094428117708856>.
- Gharechah, M., Roosta, A., Azizi, S., & Javidani, M. (2016). "Identification and explanation of the nature of brand sales strategy in FMCGs based on grounded theory". *New arketing Research Journal*, 6(3), 1-18. <https://doi.org/10.22108/nmrj.2016.21069>. [In Persian]
- Gilson, L. L., & Shalley, C. E. (2004). "A little creativity goes a long way: An examination of teams' engagement in creative processes". *Journal of management*, 30(4), 453-470. <https://doi.org/10.1016/j.jm.2003.07.001>.
- Govindan, K. (2022). "How artificial intelligence drives sustainable frugal innovation: A multitheoretical perspective". *IEEE Transactions on Engineering Management*, 71, 638-655. <https://doi.org/10.1109/TEM.2021.3116187>.
- Graen, G. B., & Uhl-Bien, M. (1995). "Relationship-based approach to leadership: Development of leader-member exchange (LMX) theory of

- leadership over 25 years: Applying a multi-level multi-domain perspective". *The leadership quarterly*, 6(2), 219-247. [https://doi.org/10.1016/1048-9843\(95\)90036-5](https://doi.org/10.1016/1048-9843(95)90036-5).
- Grant, R. M. (1996). "Toward a knowledge-based theory of the firm". *Strategic management journal*, 17(S2), 109-122. <https://doi.org/10.1002/smj.4250171110>
- Gumusluoglu, L., & Ilsev, A. (2009). "Transformational leadership, creativity, and organizational innovation". *Journal of business research*, 62(4), 461-473. <https://doi.org/10.1016/j.jbusres.2007.07.032>.
- Hair, J. F., & Sarstedt, M. (2021). "Explanation plus prediction—The logical focus of project management research". *Project Management Journal*, 52(4), 319-322. <https://doi.org/10.1177/8756972821999945>
- Hair Jr, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., Danks, N. P., & Ray, S. (2021). "Partial least squares structural equation modeling (PLS-SEM) using R: A workbook". Springer Nature. <https://doi.org/10.1007/978-3-030-80519-7>.
- Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). "A new criterion for assessing discriminant validity in variance-based structural equation modeling". *Journal of the Academy of Marketing Science*, 43, 115-135. <https://doi.org/10.1007/s11747-014-0403-8>.
- Hossain, M. (2017). "Mapping the frugal innovation phenomenon". *Technology in Society*, 51, 199-208. <https://doi.org/10.1016/j.techsoc.2017.09.006>
- Hossain, M. (2018). "Frugal innovation: A review and research agenda". *Journal of Cleaner Production*, 182, 926-936. <https://doi.org/10.1016/j.jclepro.2018.02.091>
- Hossain, M., Park, S., & Shahid, S. (2023). "Frugal innovation for sustainable rural development". *Technological Forecasting and Social Change*, 193, 122662. <https://doi.org/10.1016/j.techfore.2023.122662>
- Ibrahim, S., & Heng, L. H. (2015). "The roles of learning in stimulating knowledge sharing at SMEs". *Procedia-Social and Behavioral Sciences*, 172, 230-237. <https://doi.org/10.1016/j.sbspro.2015.01.359>.
- Iqbal, Q., Piwovar-Sulej, K., & Kallmuenzer, A. (2025). "Sustainable development through frugal innovation: the role of leadership, entrepreneurial bricolage and knowledge diversity". *Review of Managerial Science*, 19(2), 573-594. <https://doi.org/10.1007/s11846-024-00764-y>.
- Jones, N. (2003). "Competing after radical technological change: The significance of product line management strategy". *Strategic Management Journal*, 24(13), 1265-1287. <https://doi.org/10.1002/smj.354>.
- Jöreskog, K. G. (1971). "Simultaneous factor analysis in several populations". *Psychometrika*, 36(4), 409-426. <https://doi.org/10.1007/BF02291366>.
- Kardoyo, K., Feriady, M., Farliana, N., & Nurkhin, A. (2020). "Influence of the green leadership toward environmental policies support". *The Journal of Asian Finance, Economics and Business*, 7(11), 459-467. <https://doi.org/10.13106/jafeb.2020.vol7.no11.459>.
- Khan, A., Hussain, S., & Sampene, A. K. (2023). "Investing in green intellectual capital to enhance green corporate image under the Influence of green innovation climate: A Case of Chinese Entrepreneurial SMEs". *Journal of Cleaner Production*, 418, 138177. <https://doi.org/10.1016/j.jclepro.2023.138177>
- Li, L., Patwary, A. K., & Mengxiang, L. (2024). "Measuring green performance in hotel industry through management environmental concern: Mediated by green product and process innovation". *Sage Open*, 14(4), 21582440241255278. <https://doi.org/10.1177/21582440241255278>
- Mahmood, M., Uddin, M. A., & Fan, L. (2019). "The influence of transformational leadership on employees' creative process engagement: A multi-level analysis".

- Management decision*, 57(3), 741-764.
<https://doi.org/10.1108/MD-07-2017-0707>.
- Makhloufi, L. (2024). "Do knowledge sharing and big data analytics capabilities matter for green absorptive capacity and green entrepreneurship orientation? Implications for green innovation". *Industrial Management & Data Systems*, 124(3), 978–1004. <https://doi.org/10.1108/IMDS-07-2023-0508>.
- Maneghi, M., Ahmadi, M., & Boushehri, A. R. (2024). "Presenting a conceptual model of knowledge sharing and networking of knowledge-based companies in the lithium battery value chain". *Strategic Management of Organizational Knowledge*, 7(3), 87-109. <https://doi.org/10.47176/SMOK.2024.1769>. [In Persian]
- Memon, M. A., Cheah, J.-H., Ramayah, T., Ting, H., Chuah, F., & Cham, T. H. (2019). "Moderation analysis: issues and guidelines". *Journal of Applied Structural Equation Modeling*, 3(1), 1-11. [https://doi.org/10.47263/JASEM.3\(1\)01](https://doi.org/10.47263/JASEM.3(1)01).
- Mittal, S., & Dhar, R. L. (2015). "Transformational leadership and employee creativity: Mediating role of creative self-efficacy and moderating role of knowledge sharing". *Management decision*, 53(5), 894-910. <https://doi.org/10.1108/MD-07-2014-0464>.
- Mohammadian, M., Dehdeshti Shahrokh, Z., Khanlari, A., & Zohouri, B. (2016). "Identifying the requirements of social responsibility of fast-moving consumer goods producers in the field of marketing". *Business Management Perspective**, 15(4), 27–43. [In Persian] <https://sid.ir/paper/513088/fa>.
- Nejat, S., Kordnaeij, A., Khodadad Hosseini, S. H., & Shirkhodaie, M. (2023). "Identifying Dimensions of Brand Excellence with Thematic Analysis Approach (Case Study: Fast Moving Consumer Goods Industry)". *Journal of Business Management Perspective*, 22(53), 13-48. [In Persian] <https://doi.org/10.48308/jbmp.2023.103189>.
- Nguyen, T. H. (2020). "Impact of leader-member relationship quality on job satisfaction, innovation and operational performance: A case in Vietnam". *The Journal of Asian Finance, Economics and Business*, 7(6), 449-456. <https://doi.org/10.13106/JAFEB.2020.VO17.NO6.449>.
- Prahalad, C. K., & Hart, S. L. (2002). "The fortune at the bottom of the pyramid". *Strategy and business*, 54-54.
- Salavati, A., Rostami Noroozabad, M., Kamangar, F., & Rahmani Noroozabad, S. (2019). "Systems thinking and implementation of knowledge management". *Journal of strategic management studies*, 5(18), 73-99. [In Persian] <https://dor.isc.ac/dor/20.1001.1.22286853.1393.5.18.4.5>.
- Saleem, F., Pinto, L., & Malik, M. I. (2024). "Green knowledge sharing and the green performance nexus: A moderated mediation model". *Sustainability*, 16(22), 9654. <https://doi.org/10.3390/su16229654>.
- Saleem, M., Qadeer, F., Mahmood, F., Ariza-Montes, A., & Han, H. (2020). "Ethical leadership and employee green behavior: A multilevel moderated mediation analysis". *Sustainability*, 12(8), 3314. <https://doi.org/10.3390/su12083314>.
- Sarstedt, M., & Mooi, E. (2014). "A concise guide to market research". *The Process, Data, and*, 12, 1-7. <https://doi.org/10.1007/978-3-642-53965-7>.
- Sarstedt, M., Ringle, C. M., & Hair, J. F. (2021). "Partial least squares structural equation modeling". In *Handbook of market research* (pp. 587-632). Springer. https://doi.org/10.1007/978-3-319-57413-4_15.
- Schermerhorn, J. R., Jr. (2012). "Management (11th ed.)". John Wiley & Sons.
- Shafait, Z., & Huang, J. (2024). "Examining the impact of sustainable leadership on green knowledge sharing and green learning: Understanding the roles of green innovation and green organisational

- performance'. *Journal of cleaner production*, 457, 142402. <https://doi.org/10.1016/j.jclepro.2024.142402>.
- Shahzad, M., Qu, Y., Zafar, A. U., Rehman, S. U., & Islam, T. (2020). "Exploring the influence of knowledge management process on corporate sustainable performance through green innovation". *Journal of knowledge management*, 24(9), 2079-2106. <https://doi.org/10.1108/JKM-11-2019-0624>
- Shirazi, H., & Bakhtiari, H. (2026). "Turbulence as a Double-Edged Sword: The Moderating Role of I4.0 Technologies in the Frugal Innovation-New Product Development Performance Link". *Knowledge Economy Studies*, e741033. <https://doi.org/10.22034/kes.2026.2091637.1114>
- Shmueli, G., Sarstedt, M., Hair, J. F., Cheah, J.-H., Ting, H., Vaithilingam, S., & Ringle, C. M. (2019). "Predictive model assessment in PLS-SEM: guidelines for using PLSpredict". *European journal of marketing*, 53(11), 2322-2347. <https://doi.org/10.1108/EJM-02-2019-0189>.
- Sobel, M. E. (1982). "Asymptotic confidence intervals for indirect effects in structural equation models". *Sociological methodology*, 13, 290-312. <https://doi.org/10.2307/270723>.
- Song, M., Yang, M. X., Zeng, K. J., & Feng, W. (2020). "Green knowledge sharing, stakeholder pressure, absorptive capacity, and green innovation: Evidence from Chinese manufacturing firms". *Business Strategy and the Environment*, 29(3), 1517-1531. <https://doi.org/10.1002/bse.2450>.
- Ting, C.-W., Li, H.-X., Chen, K.-H., Lee, Y.-S., & Yen, S.-J. (2024). "How can organizational leadership promote environmental behaviors through corporate social responsibility policy adoption? The moderating role of environmental awareness". *Sustainability*, 16(17), 7677. <https://doi.org/10.3390/su16177677>.
- Tiwari, R., Fischer, L., & Kalogerakis, K. (2016). "Frugal innovation in scholarly and social discourse: An assessment of trends and potential societal implications". Working paper/ Technologie-und Innovations management, Technische Universität Hamburg-Harburg= Arbeit papier.
- Trizano-Hermosilla, I., & Alvarado, J. M. (2016). "Best alternatives to Cronbach's alpha reliability in realistic conditions: congeneric and asymmetrical measurements". *Frontiers in psychology*, 7, 769. <https://doi.org/10.3389/fpsyg.2016.00769>.
- Vahidi, H., Danesh, Z., & Shahbazi, S. (2024). Mental patterns of knowledge sharing in generation Z employees in a defense training-research center. <https://doi.org/208945>
- Wenger, E., McDermott, R., & Snyder, W. M. (2000). "A guide to managing knowledge: Cultivating communities of practice". Harvard Business School.
- Wonglimpiyarat, J. (2004). "The use of strategies in managing technological innovation". *European journal of innovation management*, 7(3), 229-250. <https://doi.org/10.1108/14601060410549919>.
- Wu, A. (2023). "Collaborative eco-innovation and green knowledge acquisition: The role of specific investments in Chinese new energy vehicle industry". *Business Strategy and the Environment*, 32(4), 2245-2260. <https://doi.org/10.1002/bse.3246>.
- Zairbani, A., & Kumar, S. (2025). "How Does Green Knowledge Sharing Improve Sustainable Business Performance?". *Knowledge and Process Management*, 32(1), 42-53. <https://doi.org/10.1002/kpm.1796>.
- Zhang, W., Xu, F., & Wang, X. (2020). "How green transformational leadership affects green creativity: Creative process engagement as intermediary bond and green innovation strategy as boundary spanner". *Sustainability*, 12(9), 3841. <https://doi.org/10.3390/su12093841>.
- Zhao, X., Lynch Jr, J. G., & Chen, Q. (2010). "Reconsidering Baron and Kenny: Myths and truths about mediation analysis". *Journal of consumer research*, 37(2), 197-206. <https://doi.org/10.1086/651257>.

COPYRIGHTS



© 2026 by the authors. Licensee PNU, Tehran, Iran. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution 4.0 International (CC BY4.0) (<http://creativecommons.org/licenses/by/4.0>)