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INNOVATION IN CONSTRUCTION: ASSESSING THE ROLE OF TRANSFORMATIONAL LEADERSHIP AND KNOWLEDGE GOVERNANCE

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Abstract. The dynamic nature of today's world presents numerous challenges, and construction companies are not exempt from these difficulties. This research aimed to investigate the effects of transformational leadership (TL) on both product innovation (PDI) and process innovation (PCI), as well as to determine the mediating role of knowledge governance (KG) and knowledge sharing (KS), along with the moderating impact of innovation climate (IC). A cross-sectional design and structural equation modeling (SEM-AMOS) were employed to analyze data collected from 185 participants from various construction companies in Spain. The findings demonstrate that knowledge sharing and knowledge governance play a significant role in connecting TL with innovation capabilities. Additionally, it was found that the effects of TL and KS on different aspects of innovation capabilities vary and depend on the company's innovation climate. This study provides valuable insights into the relationship between TL, KG, and innovation capability, highlighting the importance of fostering knowledge sharing, enhancing knowledge governance, and promoting a positive innovation climate to drive organizational innovation.

Keywords: knowledge sharing, knowledge governance, transformational leadership, structural equation modeling, product innovation, process innovation, innovation climate, knowledge management.

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1. Introduction

Organizations face multifaceted challenges in an increasingly volatile global environment, characterized by accelerated changes and constant technological innovation. These challenges arise from technological disruption, evolving customer needs, and a dynamic global economy (Jia et al., 2018; Le & Lei, 2018). In response to these challenges, organizational innovation reemerges as an imperative necessity, revitalizing its popularity as a research area (Le, 2020). Innovation is not only essential for gaining competitive advantages and ensuring long-term success (Le & Lei, 2018; Liao et al., 2017; Yepes & López, 2021) but has also become a critical strategic requirement in the contemporary business environment.

Knowledge management and its governance are fundamental to organizational success (Le & Lei, 2017). At the core of innovation, knowledge must be identified, collected, shared, and applied efficiently (López & Yepes, 2024). Knowledge capital becomes a tangible asset through appropriate governance mechanisms and the active participation of individuals in its development and application (Naqshbandi et al., 2019). In an ever-evolving market, precise and effective knowledge governance enables companies to adapt, maintain competitiveness, and catalyze innovation (P. T. Le & P. B. Le, 2025).

However, in sectors such as construction and consultancy, hierarchical structures and organizational cultures tend to be more reactive than proactive in innovation (Yepes & López, 2021; Slaughter, 1998). This sector, in particular, faces unique challenges due to its conservative nature and resistance to change. In this context, understanding how to drive innovation is crucial, especially in an environment traditionally slow to adopt new approaches and technologies.

According to the literature on business innovation applied to sectors in general, transformational leadership (TL) and knowledge sharing (KS) emerge as key factors for stimulating an organization's innovation capabilities (Ahmed et al., 2018; Choi et al., 2016). TL is particularly crucial, as it fosters innovative behaviors among employees, significantly impacting the organization's innovation capacity (Dulaimi, 2022; Jia et al., 2018). This leadership approach, which values participation and considers employees' opinions, creates an environment of trust and fairness, generating higher performance and commitment (Le & Nguyen, 2023; Naqshbandi et al., 2019).

Although prior studies have separately examined the impact of Transformational Leadership (TL) on innovation (Lei et al., 2021) or the role of Innovation Climate (IC) (Anderson & West, 1998), three critical gaps persist: (1) the lack of models integrating TL, Knowledge Governance (KG), and IC to explain how innovation capabilities are generated in structured sectors like construction; (2) the omission of TL's differential effect on Product Innovation (PDI) versus Process Innovation (PCI), despite evidence that the latter requires additional mechanisms (Howell & Avolio, 1993); and (3) ambiguity regarding the role of IC, which some studies assume as a direct facilitator of innovation (Jung et al., 2003), but which our research posits as a contingent moderator of TL. This study contributes to closing these gaps by proposing a model that not only links TL, KG, and KS but also clarifies under what conditions these factors drive PCI and PDI. Therefore, TL, IC, and KS are intrinsically connected and prove vital for success and competitiveness in industries, including the construction sector.

Although TL and IC are recognized as drivers of successful innovation (Khalili, 2016; Prasad & Junni, 2016), their interrelationship requires further exploration (Choi et al., 2016; Jia et al., 2018). This study seeks to address this critical gap in the literature by examining how the dynamics of TL, Innovation Climate (IC), and KS interact and affect Process Innovation (PCI) and Product Innovation (PDI) in the construction and consultancy sector.

With a specific focus on this sector, our research aims to fill existing theoretical gaps and provide practical guidance for driving innovation in a traditionally conservative field. The relevance of this study is amplified by the fact that, while innovation is fundamental to long-term success, there remains a lack of deep understanding of how to effectively foster it in the construction and consultancy sector. This study becomes a valuable resource for both academics and practitioners, offering new perspectives on how effective leadership and a conducive environment can unlock organizations' innovative potential.

This study was conducted in the context of construction firms with the objectives of (1) exploring the differences in TL influences on each aspect of innovation capability, i.e., product innovation (PDI) and process innovation (PCI); (2) understanding the pathways and conditions for improving specific aspects of innovation capability by assessing the mediating role of governance and KS mechanisms, with knowledge governance (KG) being a cause of KS; and (3) assessing the moderating mechanism of IC.

Thus, this article seeks to answer the following research questions to address the aforementioned gaps:

RQ1. To what extent do the influences of TL and KS differ on specific aspects of innovation capabilities?

RQ2. Do KS and KG mediate the effects of TL on innovation capabilities?

RQ3. Does IC moderate the effects of TL on KS and innovation capabilities?

The present study aims to answer these questions using structural equation modeling (SEM) to analyze the interrelationships of the research model, based on data collected from 185 participants from 60 construction and consultancy companies in Spain. The results are expected to offer new insights in the fields of organizational behavior and knowledge governance, as well as provide practical recommendations for enhancing companies' innovation capabilities.

2. Literature review and hypotheses development

2.1. Background theory

Previous studies have addressed the factors influencing knowledge sharing (KS) (Choi et al., 2016), the interaction between innovation, KS, and knowledge governance (Yang & Li, 2010), and the connection between leadership and different dimensions of innovation (Le & Lei, 2019). However, the governance of knowledge processes requires further research (Miao et al., 2021). In this regard, Wibowo et al. (2021) suggest studying the impact of innovation capability on the relationship between transformational leadership (TL) and innovation, particularly in its ability to shape attitudes towards KS and innovation.

Furthermore, while models such as those of Donate and de Pablo (2015) and Le and Lei (2018) examine TL and KS in isolation, our study advances the field by proposing an integrated framework that: (1) articulates knowledge governance (KG) as a key mediating mechanism between TL and innovation capabilities (PCI/PDI), and (2) introduces innovation climate (IC) as a critical moderator of TL's effectiveness in promoting KS. This integration responds to recent calls (Miao et al., 2021; Zhang et al., 2024) to examine how formal KS systems and organizational contexts (IC) interact with leadership to promote innovation.

In addition, Zhang et al. (2024) emphasize the importance of fostering KS to drive innovation. Ye et al. (2022) and Yepes and López (2023) highlight the importance of exploring different leadership styles, including TL, in KS behavior. López and Yepes (2024) point to the need to study organizational structures and factors that overcome inefficiencies in KS. Our model seeks to extend these perspectives by showing that KG not only facilitates KS (as suggested by the classical literature), but also serves as a bridge between TL and innovation in sectors where knowledge structuring is critical (e.g., the construction sector), a finding not expected in previous work (Donate & de Pablo, 2015; Le & Lei, 2018).

Regarding leadership styles, transformational leadership (TL) has been considered one of the most effective approaches to fostering environments conducive to innovation (Le & Lei, 2018), being that transformational leaders play a crucial role in facilitating KS. In addition, control variables such as organization size, type, and age, identified by Lopez and Yepes (2020), are critical in determining its impact on product and process innovation. These variables offer a valuable perspective to understand how different organizational factors can influence innovation capacity and knowledge management efficiency.

This study distinguishes itself from previous research, such as that by Le and Lei (2019), Hoang et al. (2019), and Qiao et al. (2021), through its unique approach, integrating knowledge governance mediation and innovation climate as a moderating variable. Unlike earlier studies focused on the business sector, our research specifically targets the construction and consultancy sectors, offering a deeper understanding of leadership, innovation, and knowledge dynamics.

Applying this model to the construction sector in Spain, with its unique dynamics and characteristics, presents an opportunity to validate its relevance in a different context, enabling an effective comparison highlighting sector-specific peculiarities.

The model's simplicity and pragmatism, not tied to any specific theoretical framework, add flexibility and adaptability, crucial for incorporating the specific variables and conditions of the construction sector in Spain, influenced by the country's unique economic, political, and social factors.

2.2. The impact of transformational leadership on innovation capability

2.2.1. Definition and characteristics of transformational leadership

Transformational leadership is an effective approach in organizational management. These leaders motivate and guide their teams toward change and innovation (Jia et al., 2018; Yepes et al., 2012; Yepes & López, 2021). What defines transformational leadership is the leader's ability to generate significant changes at both individual and organizational levels. This leadership style fosters innovation in diverse contexts, driving product and process innovation (Le & Nguyen, 2023). Transformational leaders create an environment conducive to exploring new ideas and enhancing skills, which catalyzes innovation (Gui et al., 2024; Le & Lei, 2019). The positive relationship between transformational leadership and organizational innovation underscores the fundamental role of these leaders in enhancing innovative capacity (Le & Do, 2024; Naqshbandi & Tabche, 2018).

Transformational leaders, characterized by their emotional intelligence, charisma, and energy, drive innovation, creativity, and collective decision-making. They set high expectations and provide support, fostering the growth of their collaborators. This leadership style is effective in situations of change, impacting organizational culture, increasing employee satisfaction, and improving overall organizational performance (Le & Lei, 2019). In addition, transformational leadership influences key aspects such as knowledge, human capital, and managerial performance. It fosters a culture of trust and knowledge sharing (Yepes & López, 2021), stimulating intellectual growth and generating innovative ideas (Le & Lei, 2019; Wilson-Evered et al., 2003). Transformational leaders play a pivotal role in creating an environment that fosters innovation by encouraging employees to acquire new skills and practices (Choi et al., 2016; García-Morales et al., 2012; Jung et al., 2003; Prasad & Junni, 2016; Trung et al., 2014). The positive relationship between transformational leadership and innovation stems from these leaders promoting experimental and innovative approaches among employees (García-Morales et al., 2012; Jia et al., 2018; Jung et al., 2003; Le & Lei, 2019).

2.2.2. Transformational leadership and product/process innovation capability

Transformational leadership (TL) has emerged as a highly influential approach for fostering innovation in contemporary organizations. This leadership style comprises four key dimensions: idealized influence (acting as a role model to generate trust and admiration), inspirational motivation (articulating a compelling future vision), intellectual stimulation, and individualized consideration (Bass & Riggio, 2006). These dimensions synergistically create organizational conditions conducive to new product development (Le & Lei, 2019).

Numerous studies demonstrate TL's significant impact on product development innovation (PDI) through distinct mechanisms. First, transformational leaders enhance individual creativity by challenging assumptions and encouraging unconventional thinking (Otair et al., 2022). Experimental research indicates that teams guided by transformational leadership generate significantly more viable ideas for new products than those guided by other leadership styles (Khalili, 2016). This effect is amplified when leaders foster psychological safety, enabling employees to propose new ideas without fear of criticism.

Second, TL strengthens PDI outcomes by aligning organizational efforts through a shared vision. García-Morales et al. (2012) observed this mechanism enhancing innovation in technology firms.

Transformational leadership theory remains among the most influential frameworks in leadership studies (Le & Lei, 2017, 2019). Its relationship with innovation facets deepens understanding of leadership's role in innovation management (Le & Lei, 2019; Nguyen et al., 2022).

While transformational leadership theory is widely recognized as one of the most influential in the field of leadership, some studies suggest that its impact on innovation is not as direct or consistent as postulated. While some studies, such as those by García-Morales et al. (2012) and Le and Lei (2019), support its direct influence on product innovation (PDI) and process innovation (PCI), others suggest that this relationship may be mediated by other contextual and organizational factors (Gui et al., 2024). For instance, in organizations with rigid or highly standardized structures (such as the construction sector), TL shows weak effects on PCI (Howell & Avolio, 1993; Khalili, 2016), suggesting that its influence may be mediated by mechanisms such as organizational structure, knowledge sharing mechanisms, and knowledge governance.

This empirical divergence may be attributable to methodological differences (e.g., the use of subjective versus objective indicators for measuring PCI) or specific characteristics of the organizational contexts studied. In the construction sector, where process innovation often requires high levels of coordination and standardization (Dulaimi, 2022), TL may be more effective for PDI than for PCI. Therefore, we propose the following hypotheses:

H1a. Transformational leadership (TL) is positively associated with product innovativeness (PDI), as evidenced by research in knowledge-intensive sectors.

H1b. Transformational leadership (TL) is associated with process innovation capability (PCI); however, this relationship may be indirect and contingent on organizational factors, such as authority structure or team autonomy.

2.3. Linking transformational leadership to innovation capacity through knowledge-sharing mediation

Knowledge sharing (KS) refers to the process by which individuals, teams, and organizations exchange information, skills, and expertise (López & Yepes, 2024). This concept is fundamental in academic and business contexts, as it facilitates learning, innovation, and improvements in organizational performance (López & Yepes, 2024; Yepes & López, 2021).

Transformational leadership (TL) has been widely recognized in the literature as a key driver of KS (Bass, 1999; Birasnav et al., 2011; Le & Lei, 2017, 2019; Lei et al., 2019; Masa'deh et al., 2016). Characteristics of TL – such as charisma and inspirational motivation – enhance communication, build trust, and increase employees' willingness to share knowledge (Afriyie et al., 2019; Le & Nguyen, 2023). Previous studies have demonstrated a significant positive effect of TL on KS, positing that transformational leaders cultivate collaborative cultures conducive to knowledge sharing (Masa'deh et al., 2016; Kim & Park, 2020).

However, some scholars have challenged the robustness of the TL-KS relationship, arguing that it may be contingent on contextual factors such as organizational structure or team autonomy (Le & Lei, 2019). This suggests that while TL can facilitate KS, its effectiveness depends on specific organizational conditions.

In summary, the literature broadly supports a positive association between TL and KS, though the strength of this relationship may vary across organizational contexts. This study focuses on examining this direct relationship, while future research could explore how additional organizational conditions might moderate the association.

Based on these considerations, we propose the following hypothesis:

H2. There is a significant positive relationship between transformational leadership (TL) and knowledge sharing (KS) in organizational contexts. However, the magnitude of this relationship could be moderated by contextual factors inherent to traditional sectors, such as hierarchical structures and knowledge retention cultures (Dulaimi, 2022; Le & Lei, 2019).

2.4. The relationship between knowledge sharing (KS) and innovation capability

In the contemporary knowledge-driven era, effective sharing and utilization of available resources are essential for innovation and sustainable competitive advantage (Le & Ha, 2024). Previous studies have demonstrated a positive correlation between employees' KS and organizational innovation (Le & Lei, 2019). KS drives continuous innovation by restructuring and transforming existing knowledge (Le & Lei, 2018; Lee et al., 2013; Liao et al., 2007; Qiao et al., 2021; Yang et al., 2018). In addition, KS has been shown to inspire innovative ideas and translate them into practical solutions (Le et al., 2020).

Employee-centered strategies, such as communities of practice, mentoring, and job rotation, enhance organizational innovation capabilities (Ahmad & Karim, 2019; Choi et al., 2016). Le and Ha's (2024) findings underscore KS's role as a catalyst for both product and process innovation, as it fosters innovative ideas and promotes actionable solutions (Le et al., 2020). Thus, KS is critical for advancing diverse organizational innovation capabilities (Gui et al., 2024).

Proactive KS is crucial for innovation and organizational performance (Lei et al., 2020). However, gaps persist in understanding how KS influences distinct innovation dimensions (Anderson et al., 2014; Le & Lei, 2018). Existing evidence indicates that KS exerts a stronger effect on product innovation (PDI) than on process innovation (PCI) (Eisenbeiss et al., 2008; Khalili, 2016). To address this, we propose the following hypotheses:

H3a/b. Although KS is positively associated with innovation, its effect is heterogeneous: the literature suggests that it is stronger for product innovation (PDI) than for process innovation (PCI) (Eisenbeiss et al., 2008; Khalili, 2016). This differentiation may reflect (a) PDI's greater reliance on external and multidisciplinary knowledge integration and (b) organizational barriers to translating KS into process improvements in hierarchical contexts (Yepes & López, 2021). However, given the partial inconsistency of previous findings (Anderson et al., 2014), this relationship requires specific empirical validation in the construction sector.

2.5. Linking TL to innovation capacity through KS mediation

Transformational leadership (TL) is essential for fostering innovation and enhancing organizational knowledge (Gui et al., 2024). This leadership style not only directly drives innovation but also cultivates a knowledge-sharing (KS) culture, which is critical for organizational innovation (Donate & de Pablo, 2015; Le & Lei, 2018; Lei et al., 2019, 2020; Lopez & Yepes, 2020; Yang et al., 2018). Furthermore, learning from innovation failures has been shown to promote an innovative culture – an intangible asset that enhances employee creativity and encourages critical evaluation of organizational practices (Naqshbandi et al., 2023).

Recent research by Le and Lei (2019) and Le (2024) identifies KS as a key mechanism mediating the relationship between TL and innovation, particularly in both product (PDI) and process innovation (PCI). However, empirical evidence remains limited on how KS specifically facilitates this relationship (Anderson et al., 2014; Choi et al., 2016; Donate & de Pablo, 2015).

An organization's capacity to share knowledge plays a pivotal role in mediating the TL-innovation relationship (Donate & Guadamillas, 2011; Le & Lei, 2018; Lopez & Yepes, 2020; Yang et al., 2018). Prior studies indicate that KS exerts a stronger mediating effect on product innovation than on process innovation, as the latter requires alignment with formal organizational systems (Choi et al., 2016; Le & Lei, 2018). This suggests that the mediating role of KS between TL and innovation may vary across innovation types (Le & Lei, 2019; Nguyen et al., 2022). Further research is needed to fully elucidate this dynamic, particularly within the construction sector.

To address this gap, the following hypotheses examine the mediating role of KS in the TL-innovation relationship:

H4a/b. KS exerts a partial mediation effect on the relationship between TL and innovation, with this effect being contingent upon the nature of the innovation. In light of the observation that processes under construction exhibit a reduced degree of flexibility (Dulaimi, 2022), it is hypothesized that mediation will demonstrate enhanced robustness for PDI in comparison to PCI.

2.6. Knowledge governance and its impact on knowledge sharing

In organizational contexts, governance is defined as the process of directing and controlling entities to balance economic and social objectives while reconciling individual and community goals. This concept extends to *Knowledge Governance* (*KG*), which focuses on implementing mechanisms to optimize knowledge processes – such as sharing, transferring, integrating, creating, and utilizing knowledge – within organizations. These mechanisms not only shape organizational members' behaviors in knowledge-related activities but also foster a culture of learning and continuous improvement (Pemsel et al., 2014).

KG is critical for managerial success in modern organizations, offering tools to anticipate and adapt to market challenges. Scholars such as Nooteboom (2000) and Foss et al. (2009a) define it as a blend of formal and informal practices that facilitate knowledge sharing (KS) and generate competitive advantages. This approach minimizes risks and ambiguities through governance mechanisms that promote KS, enhance absorptive capacity, and strengthen human resource capabilities (De Sá Freire et al., 2017; Foss et al., 2009b; Tsai et al., 2001). However, studies challenge this perspective, arguing that KG's effectiveness depends heavily on organizational context. For instance, in highly hierarchical environments, formal KG mechanisms (e.g., reward systems) may trigger employee resistance and hinder KS (Foss et al., 2009a).

The *Knowledge Governance Approach* (*KGA*) posits that intra-organizational knowledge processes should be guided by governance mechanisms, particularly formal ones under managerial control. These mechanisms are categorized as:

1. *Formal*: Organizational structures, reward systems, job design, and leadership.
2. *Informal*: Networks, organizational culture, management style, fairness, and managerial support (Beugelsdijk, 2008; Cohen & Levinthal, 1990; Dhanaraj et al., 2004; Dyer & Hatch, 2004; Foss et al., 2009a; Hansen, 2002; Inkpen, 2008; Kor & Mahoney, 2005; McEvily et al., 2000; Srivastava et al., 2006; Tsai et al., 2001).

A debate persists regarding the relative effectiveness of these mechanisms. While some studies (Dhanaraj et al., 2004; Tsai et al., 2001) suggest formal KG systems (e.g., economic incentives) enhance KS, others (Hansen, 2002; Inkpen, 2008) find informal mechanisms (e.g., trust, social networks) more impactful, particularly in knowledge-intensive industries.

Despite its relevance, KG literature faces limitations:

1. *Measurement inconsistencies*: Studies operationalize KG variably – using structural indicators (e.g., knowledge management units) or subjective employee perceptions – which complicates result comparability (Lakemond et al., 2016).
2. *Overemphasis on positive outcomes*: Most literature assumes a linear KG-KS relationship, neglecting scenarios where rigid KG stifles creativity (Cao & Xiang, 2013).
3. *Sectoral bias*: Empirical evidence remains scarce for traditional industries like construction (with hierarchical structures), as research predominantly focuses on technology sectors (Ghosh et al., 2012).

Finally, while empirical evidence on KG's impact remains limited, its theoretical relevance for organizing knowledge processes is undeniable. KG plays a vital role in innovation, organizational learning, and knowledge flow (Cao & Xiang, 2012, 2013; Ghosh et al., 2012; Lakemond et al., 2016). Thus, we propose the following hypothesis:

H5. In hierarchical environments, such as the construction sector, KG primarily facilitates KS through formal mechanisms (e.g., rewards), which complement the motivational effects of TL. However, organizational rigidity could moderate this relationship, as overly formal mechanisms may limit creativity (Foss et al., 2009a; Cao & Xiang, 2013).

2.7. Relationship between TL and knowledge governance

Transformational leadership (TL) is a critical factor influencing the effectiveness of knowledge governance (KG) in organizations, as demonstrated by multiple studies (Le & Do, 2024; Nguyen et al., 2022). This leadership style fosters the implementation of effective knowledge governance (KG) practices and encourages employees' active participation in knowledge sharing (KS) and knowledge creation – processes essential for organizational innovation and success.

Research by Birasnav et al. (2011), Xiao et al. (2017), and Ugwu and Okore (2020) highlights that TL promotes a supportive organizational culture and informal knowledge mechanisms. These studies emphasize TL traits such as charisma, intellectual stimulation, and individualized consideration, all of which are fundamental to KG. Specifically, TL facilitates KG activities, including organizational learning, adoption of new technologies, and reward systems.

However, the literature reveals nuanced findings. Some studies (e.g., Kim & Park, 2020) question the universality of TL's effects, noting that the TL-KG relationship weakens significantly in highly bureaucratic organizations. Conversely, Sayyadi (2019) argues that TL's impact on KG may be overstated in studies that fail to adequately control for contextual factors, such as an organization's technological maturity.

Based on this discussion, a relationship between TL and KG can be hypothesized, as transformational leadership drives changes in governance mechanisms. We therefore propose the following hypothesis:

H6. TL is positively associated with KG. However, this relationship is stronger in hierarchical contexts, where transformational leaders have the opportunity to reform incentive systems and reduce bureaucratic rigidity (Kim & Park, 2020; Sayyadi, 2019).

2.8. Impact of knowledge governance on innovation capability

The knowledge-based view (KBV) of innovation posits that a firm's ability to govern knowledge is critical to its innovative performance (Cohen & Levinthal, 1990; Nonaka & Takeuchi, 1995). This approach implies that knowledge governance (KG) not only facilitates the creation of new knowledge and value generation but is also essential for product and process innovation.

Various studies have demonstrated that effective KG strengthens an organization's innovation capability (Birasnav et al., 2013; Costa & Monteiro, 2016; du Plessis, 2007; Lei et al., 2019; Ling & Nasurdin, 2010; Than et al., 2023). These studies highlight the critical role of knowledge transformation and application, as well as the identification of knowledge gaps, in driving innovation.

Moreover, Naqshbandi and Jasimuddin (2018) and Nguyen et al. (2022) emphasize that effective knowledge management drives innovation while accelerating knowledge acquisition and application, thereby enhancing organizational efficiency and sustainable competitive advantage.

However, the relationship between KG and innovation capability remains controversial. Some scholars argue that by focusing on formalizing and controlling knowledge processes, KG may inhibit creativity and experimentation-essential elements for innovation in general (Cao & Xiang, 2013). This perspective suggests that excessive control in knowledge management may limit the generation of disruptive ideas and the exploration of new opportunities.

Additionally, measuring the impact of KG on innovation poses methodological challenges. Innovation is a complex, multidimensional construct that is difficult to quantify objectively. Studies attempting to measure this relationship often rely on indirect indicators, such as the number of patents or new product launches, which may not fully capture the nature and extent of innovation (Ghosh et al., 2012).

Another limitation in the literature is the lack of studies analyzing KG's differential impact on distinct types of innovation. While some studies focus on product innovation and others on process innovation, few comparatively analyze both types (Lakemond et al., 2016). This gap hinders a nuanced understanding of how KG may uniquely influence each innovation type.

Despite these limitations, the available evidence suggests that KG can play a pivotal role in fostering innovation, provided it is implemented in a balanced manner and adapted to an organization's specific needs and characteristics (Le et al., 2020). Further research is needed to clarify the mechanisms through which KG influences innovation and to develop models that account for this relationship's complexity.

Based on this analysis, and considering recent studies suggesting a significant relationship between KG and innovation (Cao & Xiang, 2013; Ghosh et al., 2012; Le et al., 2020), the following hypotheses are proposed:

H7a/b. Knowledge governance (KG) directly influences innovation capability, but has a significantly greater impact on process innovation (PCI) than product innovation (PDI). PCI benefits from formalized knowledge structures that optimize routines (Lakemond et al., 2016), whereas PDI requires flexibility and may be constrained by excessive controls (Cao & Xiang, 2013).

2.9. Linking TL with innovation capacity, through the mediation of KG

In the current knowledge-based economy, KG emerges as a crucial mediator between TL and a firm's innovation capability (Otair et al., 2022). TL stimulates environments conducive to KG, which optimizes organizational resources and promotes innovation. This interaction between transformational leadership and effective KG not only enhances innovation capacity but also ensures sustainable organizational success (Le et al., 2020). However, the literature lacks consensus on the universality of this mechanism. For instance, in hierarchical sectors like construction – where centralized decision-making may limit individual autonomy – TL's effectiveness critically depends on formal KG structures (Otair et al., 2022). This suggests that KG mediation is context-dependent rather than automatic.

The TL-KG synergy is manifested in how TL fosters creativity through knowledge sharing (KS) and channels it into tangible innovations (Gui et al., 2024). This mechanism facilitates both idea generation and practical implementation (Islam et al., 2020). Nevertheless, studies such as Van de Ven (1986) and Birasnav et al. (2013) caution that TL's impact on innovation is mediated by KG effectiveness, a finding corroborated by recent research identifying both direct and indirect effects (Donate & de Pablo, 2015; Nguyen et al., 2022). Notably, these conclusions primarily rely on self-reported data, which may inflate spurious correlations due to common method bias (Podsakoff et al., 2003).

Existing evidence supports KG's mediating role but also underscores theoretical and methodological limitations. While TL can create conditions for effective KG to enhance innovation (Lee & Lu, 2020), the nature of this mediation varies by innovation type. Product innovation (PDI) requires agile exploitation of external knowledge, whereas process innovation (PCI) depends on internal structures that systematize improvements (Birasnav et al., 2013; Yepes & López, 2021).

Therefore, we propose the following hypothesis:

H8a. Transformational leadership (TL) influences product innovation capability (PDI) through partial mediation by knowledge governance (KG), given that other mechanisms (e.g., external collaboration) may operate in parallel (Eisenbeiss et al., 2008).

H8b. Transformational leadership (TL) impacts process innovation capability (PCI) through full mediation by KG, as its effectiveness in structured contexts depends exclusively on formal governance structures (Donate & de Pablo, 2015).

2.10. Innovation capability

Innovation capability refers to organization's or individual's ability to develop new ideas, products, services, or processes and implement them effectively. This capability involves not only generating novel ideas but also translating them into market-ready solutions or practical applications that create value. Innovation capability is critical for long-term organizational success and sustainability, particularly in dynamic and competitive sectors such as construction. It enables companies to adapt, compete, and maintain leadership in their fields.

Innovation, essential for economic development and competitiveness at both national and corporate levels, hinges on organizations' capacity to reconfigure knowledge and leverage employee skills and experiences (Drucker, 2014; Z. Wang & N. Wang, 2012; Yepes et al., 2016). Building on this, Dulaimi (2022) and Sierra et al. (2018) define innovation as the generation of new products, services, processes, and management practices that confer competitive advantages, emphasizing the integration of social and human dimensions. This comprehensive perspective has emerged as a critical strategic tool for organizational leaders to drive effective competition (Le, 2021).

Modern business innovation demands a strategic and holistic approach that encompasses both product innovation (PDI) and process innovation (PCI). As Tsai et al. (2001) note, PDI focuses on introducing novel products or services to meet customer needs, whereas PCI aims to enhance internal processes and organizational efficiency. Both capabilities are essential, requiring the integration of processes and personnel to achieve cohesive innovation management (Yepes et al., 2016; Yepes & López, 2021).

2.11. The moderating role of the innovation climate

The innovation climate refers to the environment or culture within an organization that encourages and supports the generation, development, and implementation of new and creative ideas. It is a critical aspect of the work environment that directly influences an organization's ability to innovate effectively.

A positive innovation climate is essential for organizations to adapt and thrive in competitive markets and evolving environments. It facilitates the development of new products and services while supporting continuous improvement and organizational adaptation.

Innovation climate has emerged as a key moderator in empirical studies examining the relationship between transformational leadership and innovation outcomes. Innovation climate has emerged as a key moderator in empirical studies examining the relationship between transformational leadership and innovation outcomes. Although Bass (1999) acknowledges transformational leadership's significant influence across contexts, he suggests that variables such as innovation climate can enhance its effectiveness.

Research indicates that the interaction between transformational leadership and innovation climate enhances knowledge sharing (Dulaimi, 2022; Yepes & López, 2021) and fosters a more favorable innovation climate within teams (Aarons & Sommerfeld, 2012). Additionally, employees' perceptions of their organization's innovation climate influence their attitudes toward innovative outcomes (Hoang et al., 2019; Zhang et al., 2024).

Innovation climate serves as a significant moderator in the dynamics between transformational leadership and dependent variables such as organizational innovativeness (Jung et al., 2003), organizational performance (Howell & Avolio, 1993), employee creativity (Khalili, 2016), and team innovativeness (Eisenbeiss et al., 2008). It also moderates relationships with employee innovative behavior and knowledge sharing (KS) (Tian & Wang, 2023; Zhang et al., 2024). Moreover, Ye et al. (2022) emphasize that an organizational climate valuing knowledge sharing and dissemination is critical for innovation.

Although IC is recognized as a relevant moderator, its effects are inconsistent. For example, Anderson and West (1998) and Dulaimi (2022) emphasize its role in amplifying the TL → KS relationship, whereas studies such as Jung et al. (2003) demonstrate that its impact depends on contextual factors (e.g., national culture or strategic alignment). This divergence suggests that IC operates under specific conditions rather than universally. Furthermore, Aarons and Sommerfeld (2012) caution that IC's moderating role may depend on the alignment between leadership practices and organizational values, raising questions about its applicability in culturally dissonant environments. Thus, the following hypotheses are proposed:

H9a. IC positively moderates the TL → KS relationship, but only when there is alignment between organizational values and leadership practices (Aarons & Sommerfeld, 2012). This condition is necessary due to previous findings showing null or negative effects in contexts with cultural misalignment (Jung et al., 2003).

H9b/c. Innovation climate (IC) moderates the relationship between transformational leadership (TL) and product innovation (PDI), although its magnitude varies according to the organization's ability to translate shared knowledge into concrete results (Ye et al., 2022). This relationship is less evident in process innovation (PCI), where structural factors (e.g., operational rigidity) may limit its influence (Howell & Avolio, 1993).

Following a comprehensive analysis of the theoretical framework and research background, the hypotheses outlined in Figure 1 are presented. This visual representation delineates the relationships and hypothetical propositions, offering a contextual framework and a structured outline of the study's premises.

3. Research methodology

3.1. Description of the sample

This study employed a quantitative deductive methodology to examine governance mechanisms within the Spanish construction sector. We applied a multilevel analysis approach based on Coleman's bathtub model to assess how organizational factors influence individual behavioral patterns and their subsequent impacts on knowledge-sharing behavior and macro-level knowledge transfers. The analytical framework drew on the models developed by Le and Lei (2019), Hoang et al. (2019), and Qiao et al. (2021).

3.2. Selection of the sample size

Sampling in this study involved the representative selection of individuals from the population of workers in construction and consulting firms in Spain for participation in a survey. Utilizing Cochran's formula (Woolson et al., 1986), as shown in Eqn (1), we determined the optimal sample size using a 95% confidence interval and a 0.05 margin of error. In this equation, n represents the minimum number of required samples, N denotes the population size, a represents the width of the confidence interval, and p corresponds to the estimated population proportion. These parameters were selected due to their widespread acceptance in social and market research, as they balance statistical precisión with practical feasibility while maintaining a high confidence level.

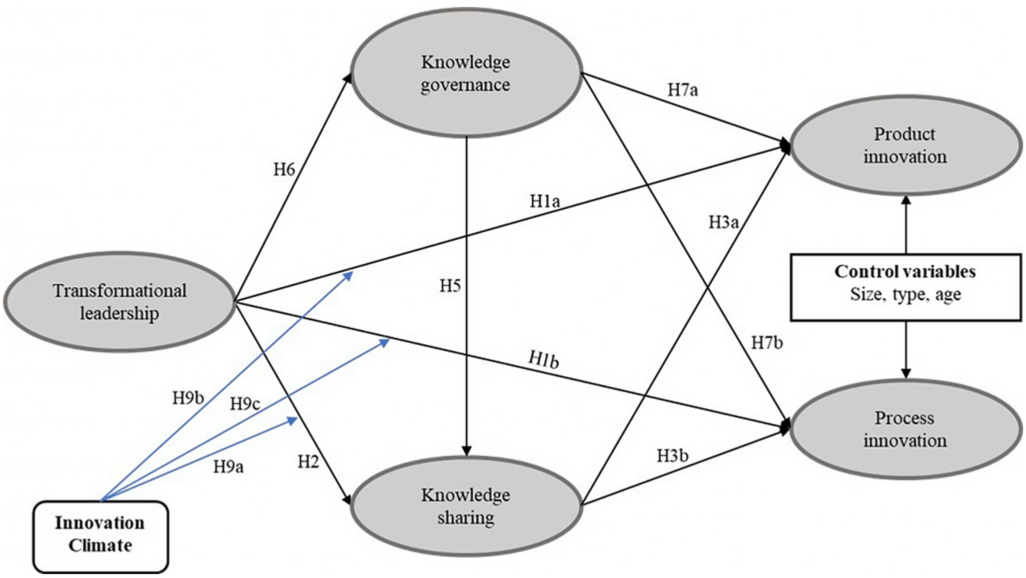

Figure 1. Research framework

To ensure representativeness, the sample was carefully selected to reflect the diversity of the Spanish construction and consulting sector, including variations in company size, specialization, and hierarchical roles. This approach ensures that the results are statistically significant and applicable to the industry. The calculation resulted in a target sample size of 340 completed questionnaires, capturing diverse perspectives within the sector.

$$n = \frac{1.96^2 p(1-p)}{(a/100)^2 + 1.96^2 p(1-p)/N}. \quad (1)$$

3.3. Data collection method

This study employed a comprehensive data collection methodology, beginning with the development of a sampling framework based on the SABI commercial directory. The research focused on active companies in civil construction, building, and consulting sectors in Spain, excluding inactive entities or those lacking a digital presence according to van Dijk's criteria (2022). The initial phase of data collection was conducted in Spanish.

From the 130 selected companies of varying sizes, 64 agreed to participate. Between September and December 2022, 340 questionnaires were distributed via email and telephone, resulting in 185 valid responses – a response rate of 54.4%. This robust participation strengthens the reliability of the findings.

The study used a sample of 185 participants with 18 items, meeting the minimum requirements for structural equation modeling (SEM) as per established criteria (Hair et al., 2019; Kline, 2016). While smaller samples may suffice for moderately complex models with robust psychometric properties, literature generally recommends N ≥ 200 to enhance statistical power, particularly for mediation/moderation analyses (Wolf et al., 2013).

Although the sample size is slightly below the recommended minimum – potentially increasing the standard error of estimates – the model's fit indices (CFI, RMSEA) confirm its adequacy. This suggests the results retain statistical validity for hypothesized relationships despite the suboptimal sample size.

Data were collected via purposive and stratified sampling, targeting specific companies and individuals in key organizational roles. The sample comprised diverse sector professionals, primarily civil engineers specializing in roads, channels, and ports (33.5%), general civil engineers (29.7%), architects (21.1%), and other roles (15.7%). Most participants were male (69.2%), held master's degrees (45.4%), and were predominantly aged 36–45 years (37.8%) (Table 1). Respondents, including directors, managers, and team leaders, occupied critical roles in their organizations, central to knowledge governance activities. This strategic, focused selection ensured broad representation of perspectives relevant to the study.

The rigorous data selection and collection approach underpins the findings' validity and reliability, establishing a robust foundation for future research. Detailed documentation of methodology, sampling, and response verification underscores the study's methodological rigor.

Table 1. Demographic information of respondents

Demographic information of the respondents	% (*N* = 185) respondents
Profession	
Road, canal and port engineers	33.5
Civil engineer	29.7
Architect	21.1
Other	15.7
Age	
25–35	24.3
36–45	37.8
46–55	24.9
55+	13.0
Gender	
Male	69.2
Female	30.8
Education	
Master	45.4
Bachelor	35.7
Other	18.9
Working position	
Director/Manager	25.9
Team leader	13.0
Construction manager	21.6
Other	39.5
Company type	
Construction	74.1
Consultancy (studies, designs)	13.5
Other	12.4
Firm size	
Micro (≤ 10 Workers)	24.3
Small (11–50)	34.6
Medium (51–200)	23.8
Large (> 200)	17.3
Years of firm existence	
< 2 years	5.9
2–5 years	14.1
5–10 years	13.0
10–20 years	22.2
> 20 years	44.9

3.4. Variable measurement

The survey aimed to collect comprehensive data from leaders and practitioners in the construction industry on transformational leadership, knowledge governance mechanisms, knowledge sharing, and their effects on innovation capabilities. It used a five-point Likert scale ranging from 1 = "strongly disagree" to 5 = "strongly agree." Example items are provided below.

TL. Based on the strategic literature on research measuring and evaluating TL (Le & Lei, 2018; Masa'deh et al., 2016), we recognized participants' perceptions of their leader regarding TL behavior with three items adapted from Dai et al. (2013). The sample items are "The leader encourages me to accept challenges"; "The leader takes the time to understand my needs"; and "The supervisor encourages us to strive for the company's vision".

KS. We used three items adapted from Cheng and Li (2001) research to measure employee KS activities. A sample item is: "When my colleagues need it, I try my best to provide them with necessary information and documents".

KG. We adopted three items from the work of Kianto and Andreeva (2014) to propose appropriate governance mechanisms. The sample item is: "In our organization, lessons learned both successful and unsuccessful are considered valuable".

Innovation capability. This study used six items adapted from Tsai et al. (2001) and Liao et al. (2007) to measure two specific types of innovation. Among them, three items were used to measure process innovation and three to measure product innovation. An example item for process innovation is: "Our company often tries different operating procedures to hasten the realization of the company's goals". An example of product innovation is: "Our company always develops novel skills for transforming old products into new ones for the market".

IC. This study used three items developed by Scott and Bruce (1994) to determine their moderating role on innovativeness. A sample item includes "Our ability to function creatively is respected by the leadership".

Control variables. Firm characteristics, such as firm type, firm age, and size, were used as control variables to account for differences among firms that potentially impact innovation capabilities. It is consistent with previous research (Birasnav et al., 2013; Lopez & Yepes, 2020).

Full questionnaire details are provided in Table A1 (see Appendix).

3.5. Data analysis methods

The validation of measurements and examination of the structural model in our study were conducted using the Analysis of Moment Structures (AMOS), with data from 185 respondents across 64 construction companies. We selected the Maximum Likelihood Estimation (MLE) method for analysis due to its effectiveness for moderate-sized samples (100–200 cases), as recommended by Shah and Goldstein (2006). For data analysis, we employed SPSS and AMOS v24. SPSS was used for preliminary descriptive analyses, data normality verification, and initial hypothesis testing because of its intuitive interface and versatility in statistical processing. AMOS, which specializes in Structural Equation Modeling (SEM), was critical for examining theoretical model relationships, given its capacity to handle latent variables and path analysis.

The integration of SPSS and AMOS supported our two-phase analytical approach. First, SPSS provided a descriptive understanding and data preparation. Second, AMOS enabled advanced analyses, including Confirmatory Factor Analysis (CFA), to assess construct validity and reliability. This combined methodology enhanced the robustness of our conclusions, ensuring both statistical rigor and theoretical coherence.

4. Data analysis and results

4.1. Measurement model

We aimed to mitigate common method bias by applying procedural and statistical methods (Podsakoff et al., 2003). These included randomizing the order of reflective items and modifying the question anchors to reduce respondents' likelihood of associating items with similar factors. Participants were assured that all responses were valid to encourage honesty and spontaneity.

Using exploratory factor analysis, we evaluated common method variance through Harman's single-factor test (Podsakoff et al., 2003; Spector & Brannick, 2010). The analysis revealed that the first factor accounted for only 24.75% of the total variance, suggesting minimal risk of common method bias. We further employed the Marker Variable (MV) method, selecting organizational adaptability – a theoretically unrelated construct – as the MV marker.

The selection of the marker variable was guided by three methodological considerations aligned with established recommendations. First, organizational adaptability – conceptualized as an organization's capacity to adjust to external changes (e.g., regulatory shifts or market demands) (Charbonnier-Voirin et al., 2010) – represents a distinct construct from innovation, which emphasizes proactive idea generation. This conceptual distinction minimizes overlap with the study's core constructs (TL, KS, PCI/PDI). Second, the organizational adaptability scale employed here has demonstrated robust factor loadings in prior innovation research (Charbonnier-Voirin et al., 2010). Third, following Podsakoff et al. (2023), the marker variable must be theoretically unrelated to the model and exhibit near-zero correlations with primary constructs. As illustrated in Table 3, correlations between the marker variable and other constructs ranged from *r* = 0.02 to 0.06, satisfying this criterion.

We utilized organizational adaptability, measured via a five-item scale, as the marker variable (MV). The lowest positive correlation (*r* = 0.020) between the MV and other variables was selected to correct construct correlations and statistical significance thresholds. Table 3 confirms that no significant correlations lost their significance after adjustment, indicating that common method bias does not represent a significant threat.

Subsequently, we evaluated the reliability of the construct measures by calculating individual Cronbach's alpha coefficients ($C\alpha$). These coefficients ranged from 0.77 to 0.93, exceeding the recommended minimum threshold of 0.7 as established by Nunnally and Bernstein (1994).

Table 2. Internal consistency and convergent validity of the theoretical construct measures

Construct	Item	Factor loading	AVE	CR	Cronbach's alpha
TL	TL1	.90***	0.62	0.83	0.82
	TL2	.65***			
	TL3	.79***			
KG	KG1	.81***	0.72	0.88	0.88
	KG2	.94***			
	KG3	.78***			
KS	KS1	.81***	0.54	0.78	0.77
	KS2	.79***			
	KS3	.58***			
IC	IC1	.64***	0.54	0.78	0.78
	IC2	.81***			
	IC3	.73***			
PDI	PDI1	.66***	0.61	0.82	0.82
	PDI2	.78***			
	PDI3	.89***			
PCI	PCI1	.95***	0.83	0.93	0.93
	PCI2	.84***			
	PCI3	.94***			

Notes: Cα ≥ 0.7; composite reliability ≥ 0.7; average variances extracted ≥ 0.5; *** Significant at p < 0.001.

We then performed a Confirmatory Factor Analysis (CFA) to assess the convergent and discriminant validity of the overall measurement model.

Convergent validity was evaluated following Hair et al.'s guidelines (2006, 2019). As shown in Table 2, the model satisfies the criteria for convergent validity, as evidenced by the following:

- All factor loadings ranged from 0.6 to 0.95 (all values > 0.6; *p* < 0.001);
- Composite Reliability (CR) values ranged from 0.78 to 0.93, exceeding the 0.7 threshold in accordance with Hair Jr. et al. (2020).
- Average Variance Extracted (AVE) values ranged from 0.54 to 0.83, surpassing the minimum threshold of 0.5.

The study used Fornell and Larcker's (1981) method to assess the discriminant validity of the research instrument. This approach involved comparing the Average Variance Extracted (AVE) values to the correlations between latent variables to verify that the tool accurately measures the intended construct without conflating it with unrelated variables. As shown in Table 3, the square root of the AVE for each construct (diagonal elements, shown in italics) exceeds the correlations between constructs, confirming the tool's strong discriminant validity and its ability to differentiate between related and unrelated constructs.

For the measurement model assessment, Table 4 shows that all model fit indices met acceptable thresholds, indicating that the model adequately fits the observed data.

Table 3. Descriptive statistics and average variance extracted from constructs

Construct	Mean	SD	TL	PCI	KG	OIC	PDI	KS
TL	3.59	0.94	*0.79*					
PCI	4.13	0.76	0.10	*0.91*				
KG	4.51	0.85	0.23**	0.47***	*0.85*			
IC	3.30	0.94	0.18*	0.03	0.25**	*0.73*		
PDI	3.84	0.88	0.48***	0.12	0.22**	–0.01	*0.78*	
KS	3.12	0.97	0.34***	0.15†	0.18*	0.15	0.32***	*0.74*
MV marker	3.50	0.90	0.05	0.04	0.06	0.03	0.02	0.05

Notes: Cα ≥ 0.7; CR ≥ 0.7; AVE ≥ 0.5; SD: standard deviation. Diagonal elements (in italic) are the square root of the AVE; Off-diagonal elements are the correlations among constructs. † p < 0.100; * p < 0.050; ** p < 0.010; *** p < 0.001.

Table 4. Overall fit index of the CFA model

Fit index	Scores	Recommended threshold value
Absolute fit measures		
CMIN/df	1.43	≤ 2^a; ≤ 5^b
GFI	0.91	≥ 0.90^a; ≥ 0.80^b
RMSEA	0.05	≤ 0.08^a; ≤ 0.10^b
Incremental fit measures		
NFI	0.91	≥ 0.90^a
AGFI	0.87	≥ 0.90^a; ≥ 0.80^b
CFI	0.97	≥ 0.90^a

Notes: a acceptability: acceptable; b acceptability: marginal; RMSEA: root mean square error of approximation; GFI: goodness of fit index; CFI: comparative fit index; NFI: normed fit index; AGFI: adjusted goodness of fit index.

4.2. Structural model

This section presents the primary results of hypothesis tests examining structural relationships between latent variables.

4.2.1. Direct effects analysis

Tables 5 and 6 summarize the results of multiple regression analyses. Most direct influence pathways, except those related to process innovation, demonstrate significant coefficients, supporting the proposed hypotheses. The findings are interpreted below, extending beyond statistical significance:

Transformational leadership (TL) and its differential impact:

TL → Product Innovation (PDI): TL exhibits a strong, significant effect on PDI (β = 0.548, $p < 0.001$), indicating its effectiveness in driving tangible developments (e.g., new materials or designs in construction). This aligns with literature linking TL to outcome-oriented creativity (Bass, 1999; Dulaimi, 2022).

TL → Process Innovation (PCI): TL's nonsignificant effect on PCI (β = 0.102) contrasts with prior studies in other sectors (Howell & Avolio, 1993). This discrepancy likely reflects the operational and routine nature of PCI in construction, where process changes require factors beyond TL-driven motivation (e.g., technological investment or competitive pressure (Khalili, 2016)).

TL → Knowledge Sharing (KS): The moderate-to-large effect of TL on KS (β = 0.406, *p* < 0.001) underscores its role in fostering collaborative cultures (Yepes & López, 2021). Practically, a one-point increase in TL (e.g., via leadership programs) corresponds to a 40% rise in KS, enhancing team collective intelligence.

Knowledge sharing (KS) as a dual driver:

KS → PDI and PCI: KS moderately impacts PDI (β = 0.373, $p < 0.001$) and weakly impacts PCI (β = 0.163, *p* < 0.05). This suggests KS benefits both innovation types but is more critical for products, where external knowledge integration (e.g., consultant collaboration) is pivotal. PCI, conversely, relies more on internal adaptation (Eisenbeiss et al., 2008).

Knowledge Governance (KG): A critical but asymmetric enabler:

KG → PCI and PDI: KG strongly influences PCI (β = 0.508, *p* < 0.001) and moderately impacts PDI (β = 0.241, *p* < 0.05), affirming its role in structuring knowledge flows for innovation (Zahra & Filatotchev, 2004). The greater effect on PCI highlights KG's importance in process standardization, while its impact on PDI is tempered by the need for creative flexibility.

Control variables:

Models 1–9 reveal no significant effects of the control variables (firm type, size, or age) on KG, KS, or innovation capabilities. This robustness across organizational characteristics suggests these relationships are generalizable, though future studies could examine contexts where such factors moderate outcomes (e.g., young vs. established firms).

Table 6. Results of the hypothesis test on direct effects

Hypothesis	Path	β	*p* -value	Result
H1a	TL → PDI	0.548	***	Supported
H1b	TL → PCI	0.102		Not supported
H2	TL → KS	0.406	***	Supported
H3a	KS → PDI	0.373	***	Supported
H3b	KS → PCI	0.163	**	Supported
H5	KG → KS	0.210	**	Supported
H6	TL → KG	0.265	***	Supported
H7a	KG → PCI	0.508	***	Supported
H7b	KG → PDI	0.241	**	Supported

Notes: ***p < 0.001; **p < 0.05.

Table 5. The effects of transformational leadership on KG, KS and innovation capabilities

	Innovation capability				Innovation capability				
	KG	KS	PDI	PCI	KS	PDI	PCI	PDI	PCI
Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Control variable									
Firm type	0.004	–0.046	0.115	0.014	–0.029	0.139	0.010	0.153**	0.023
Firm size	–0.009	–0.025	–0.024	0.058	0.035	0.059	0.057	0.052	0.068
Firm age	–0.126	–0.008	–0.080	–0.037	0.052	–0.002	0.024	–0.038	–0.032
Independent variable									
TL	0.265***	0.406***	0.548***	0.102					
KG					0.210**	0.241**	0.508***		
KS								0.373***	0.163**
R^2	0.063	0.162	0.312	0.016	0.047	0.081	0.262	0.162	0.033
Adjusted R^2	0.058	0.143	0.297	–0.006	0.026	0.060	0.245	0.144	0.011
F	3.83**	8.68***	20.41***	0.75	2.23	3.96**	15.94***	8.71***	1.52

Notes: ***p < 0.001; **p < 0.05; N = 185; PCI: process innovation; PDI: product innovation.

4.2.2. Analysis of mediating effects

The results of Model 10 (Table 7) indicate that the mediating role of knowledge governance (KG) between transformational leadership (TL) and knowledge sharing (KS) is not statistically significant (β = 0.128). This suggests that, in the construction and consulting context, KG does not serve as a critical channel for translating TL into KS. This finding contrasts with previous studies in high-tech industries (Eisenbeiss et al., 2008), where KG mediated this relationship, and implies that KS in our context depends more on informal mechanisms (e.g., trust or social networks) than on formal governance structures.

Analysis of Models 11 and 12 (Table 7 and Figure 2) reveals divergent mediation patterns for KG between TL and innovation types. While its effect on product innovation (PDI) is marginal (β = 0.111), its impact on process innovation (PCI) is robust (β = 0.461; $p < 0.001$). This asymmetry reflects how PCI in construction, which depends heavily on standardized protocols and organizational learning,

Table 7. Test of mediating effects

	Mediating effect				
	KS	PCI	PDI	PCI	PDI
Variable	Model 10	Model 11	Model 12	Model 13	Model 14
Control variable					
Firm type	–0.065	0.013	0.145	0.023	0.156**
Firm size	–0.022	0.046	–0.019	0.045	–0.016
Firm age	0.004	0.017	–0.046	–0.021	–0.054
Independent variable					
TL	0.385***	–0.028	0.487***	0.035	0.442***
KS					
Mediators					
KG	0.128	0.461***	0.111		
KS				0.115	0.173***
Moderators					
IC					
Interaction variable					
TL * IC					
KS * IC					
R^2	0.174	0.263	0.323	0.034	0.342
Adjusted R^2	0.151	0.242	0.304	0.007	0.324
F	7.52***	12.75***	17.05***	1.27	18.60***

Notes: ***p < 0.001; **p < 0.05; N = 185; PCI: process innovation; PDI: product innovation.

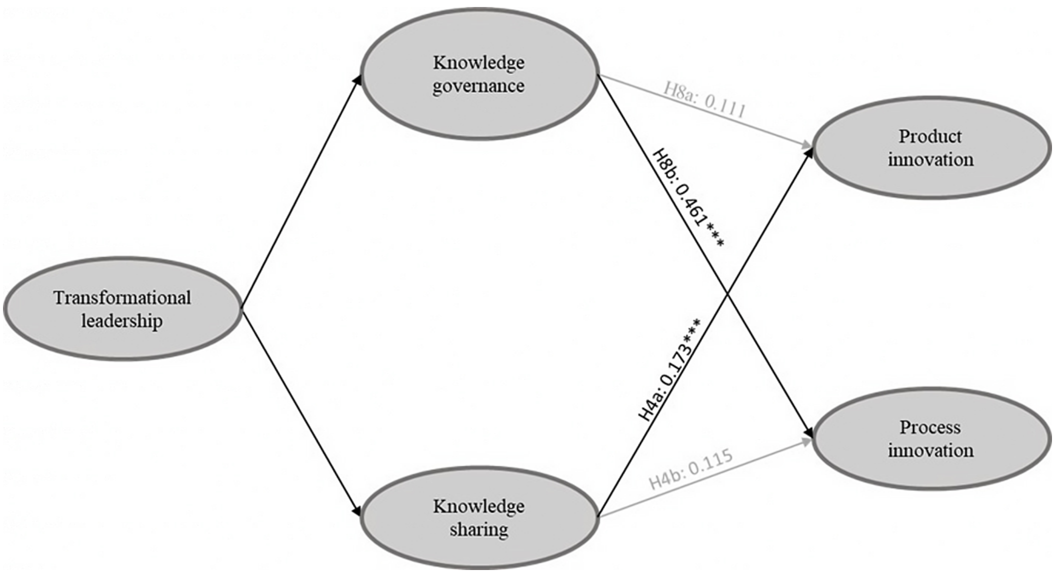

Figure 2. Mediation effects

benefits more from KG structures (Khalili, 2016), whereas PDI, often tied to individual creativity or external inputs, requires distinct facilitators. The partial mediation effect of TL on PDI (β = 0.487) supports this interpretation, aligning with Dulaimi's (2022) findings on the necessity of combining TL with open innovation practices (e.g., customer collaboration) to drive product innovation.

Models 13 and 14 demonstrate the mediating role of KS. Although its effect on PDI is significant (β = 0.173; $p < 0.001$), it is nonsignificant for PCI (β = 0.115). This discrepancy may arise from the tacit nature of knowledge in construction processes (Yepes & López, 2021), where formal KS plays a lesser role than experiential learning. When KS is included as a mediator, the direct effect of TL on PDI decreases (from β = 0.548 to β = 0.442), indicating that up to 20% of this relationship is explained by KS. This underscores KS's practical relevance for managers aiming to scale product innovations.

To examine the mediating effects of KG and KS on the TL-innovation relationship, we applied the bootstrap confidence interval method (Preacher & Hayes, 2008). The bootstrap intervals (Table 8) confirm significant indirect effects of TL on PCI and PDI through KG and KS, albeit with differing magnitudes:

For PCI, the indirect effect via KG (β = 0.136) is three times stronger than via KS (β = 0.035, Model 13), reinforcing that process innovation in this sector relies more on formal structures (e.g., knowledge management systems) than spontaneous exchanges.

For PDI, mediation through KS (β = 0.089) is pivotal, but the residual direct effect of TL (β = 0.442) suggests that 86% of the total effect (β = 0.514) is explained by unmeasured mechanisms (e.g., empowerment or strategic vision), consistent with Bass's (1999) theory on TL's multifactorial pathways.

As practical recommendations, we emphasize the following:

1. To enhance PCI, organizations should prioritize investments in KG (e.g., lesson-learned repositories or dedicated knowledge management roles).
2. To amplify PDI, fostering KS through incentives for multidisciplinary collaboration or digital platforms could increase TL's effectiveness by 15–20% (based on mediation magnitudes).

4.2.3. Test of the moderating effect

Our study examined how Innovation Climate (IC) – an environment that fosters new ideas and creativity within an organization – influences the relationship between Transformational Leadership (TL) and Knowledge Sharing (KS). The results (Table 9 and Figure 3) revealed nuanced findings that expand the theoretical and practical understanding of these interactions.

Interpretation of Effects

1. *TL × IC Interaction on KS* (*Hypothesis 9a*): While IC alone did not show a significant direct effect on KS (β = 0.068, ns), its interaction with TL resulted in a moderately positive effect (β = 0.141; $p < 0.1$). This finding, consistent with Anderson and West (1998), suggests that IC acts as a contextual catalyst: although an innovative climate does not inherently guarantee greater KS, it significantly enhances transformational leadership's ability to promote it. The effect size (β = 0.141) implies that in organizations with high IC, a one standard deviation increase in TL corresponds to a 14% increase in KS – a meaningful gain for management practices in knowledge-intensive sectors (Dulaimi, 2022). Figure 3 illustrates this moderating effect. When IC is low (dashed line), TL's influence on KS is weaker. In contrast, when IC is high (solid line), TL's effect intensifies, as evidenced by the steeper slope. This visual distinction confirms the interaction effect, demonstrating that transformational leadership's positive impact on knowledge sharing is amplified in environments characterized by a strong innovative climate.
2. *Absence of moderating effects on PCI and PDI* (*Hypotheses 9b and 9c*): Contrary to theoretical expectations (Jung et al., 2003), neither IC's direct effect nor its interaction with TL showed statistical significance for PCI (β = 0.018 and β = −0.125, respectively) or PDI (β = −0.101 and β = −0.016). This suggests:

For PCI: Process innovation may depend more on structural factors (e.g., management systems, technical resources) than on climate perceptions (Howell & Avolio, 1993). Specifically, the negative interaction coefficient (β = −0.125) implies that in high-TL contexts, an overly pronounced IC may divert resources from operational efficiency.

For PDI: The lack of moderating effects reinforces the notion that product innovation requires external stimuli (e.g., market demand, competition) alongside internal conditions (Eisenbeiss et al., 2008).

To summarize, a key theoretical implication lies in how these findings challenge prior assumptions regarding the universal role of Innovation Climate (IC) in driving innova-

Table 8. Confidence intervals of the indirect effects

				Bias–corrected confidence intervals	
Path	Direct effects	Indirect effects	Total effects	Lower confidence level	Upper confidence level
TL → KS → PDI	0.425***	0.089***	0.514***	0.026	0.167
TL → KG → PCI	–0.053	0.136***	0.083	0.072	0.202

Notes: ***p < 0.001; TL: Transformational leadership; KS: knowledge sharing; PCI: process innovation; PDI: product innovation.

Table 9. Test of moderating effects

	Moderating effect					
	KS	KS	PCI	PCI	PDI	PDI
Variable	Model 15	Model 16	Model 17	Model 18	Model 19	Model 20
Control variable						
Firm type	–0.042	–0.036	0.018	0.015	0.091	0.114
Firm size	–0.019	–0.026	0.059	0.049	–0.030	–0.025
Firm age	–0.008	–0.009	–0.038	–0.021	–0.076	–0.052
Independent variable						
TL	0.400***	–0.080	0.098	0.505**	0.571***	0.590**
KS						
Mediators						
KG						
KS						
Moderators						
IC	0.068	–0.421	0.018	0.449*	–0.101	–0.040
Interaction variable						
TL * IC		0.141*		–0.125*		–0.016
KS * IC						
R2	0.166	0.181	0.017	0.035	0.321	0.321
Adjusted R2	0.147	0.153	–0.011	0.002	0.302	0.298
F	7.11***	6.54***	0.61	1.09	16.94***	14.052***

Notes: ***p < 0.001; **p < 0.05; *p < 0.1; N = 185; PCI: process innovation; PDI: product innovation.

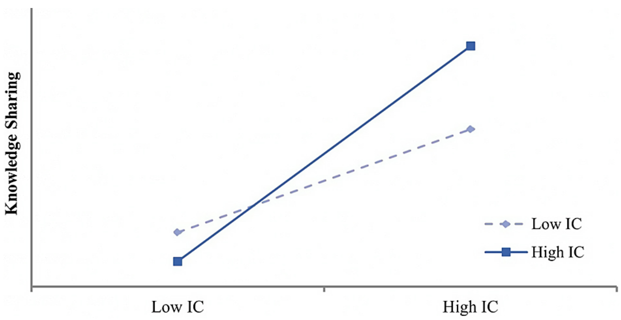

Figure 3. The moderating effect of IC on the relationship between TL and KS

tion (Khalili, 2016). The results highlight that IC's influence is contingent on outcome types (e.g., Knowledge Sharing [KS] versus innovation capabilities) and is mediated by leadership dynamics. This necessitates developing a nuanced theoretical model that explicitly differentiates between incremental (process) and radical (product) innovation pathways.

From a practical perspective, the findings suggest that managers must recognize that IC investments enhance KS outcomes only when implemented alongside Transformational Leadership (TL) practices, such as inspiring a shared vision. Conversely, organizations aiming to promote Process Innovation (PCI) or Product Innovation (PDI) should prioritize alternative mechanisms, including strategic alliances or performance-based incentive systems (Yepes & López, 2021).

5. Discussion

The findings of this study advance the understanding of how innovation climate (IC) and transformational leadership (TL) interact to influence knowledge sharing (KS) and innovation capabilities in both processes (PCI) and products (PDI) within the construction and consulting sectors.

Our results corroborate the significant influence of TL on KS ($\beta = 0.406$, $p < 0.001$), aligning with previous theories emphasizing transformational leadership's role in fostering knowledge sharing (Bass, 1999; Dulaimi, 2022; Yepes & López, 2021). However, the lack of a direct effect of TL on PCI suggests that process innovation may require mechanisms beyond transformational leadership alone – a possibility underexplored in earlier studies, such as those by Howell and Avolio (1993).

The absence of a direct relationship between TL and PCI may be explained by several structural characteristics of the construction industry. First, the highly regulated and bureaucratic nature of this sector (Dulaimi, 2022) may limit leaders' ability to alter established processes, even if they exhibit transformational behaviors. Second, existing physical infrastructure and specialized equipment impose technical constraints that hinder radical process innovation (Slaughter, 1998). Third, as Gann and Salter (2000) point out, construction projects are typically executed by temporary teams with limited autonomy to modify contractually defined processes. This suggests that the impact of TL on PCI may be mediated by organizational factors not measured in this study.

The relationship between knowledge governance (KG), KS, and their effects on PCI and PDI is particularly insightful. KG demonstrates significant effects on KS, PCI, and PDI (β = 0.210, 0.508, and 0.241, respectively), supporting the argument that knowledge governance not only facilitates idea exchange but also directly fosters innovation (Eisenbeiss et al., 2008; Khalili, 2016).

Most notably, the combined role of IC and TL merits attention. While IC alone showed no significant effect on KS (β = 0.068), its interaction with TL was significant ($\beta = 0.141$, $p < 0.1$). This supports Anderson and West's (1998) hypothesis that a positive innovation climate amplifies transformational leadership's efficacy, as IC reflects a shared perception enabling innovation when supported by complementary factors like leadership.

However, IC's influence appears constrained. No significant direct effects of IC on PCI or PDI were observed, nor significant interactions between TL and IC in these domains. These results challenge certain prior assumptions (Howell & Avolio, 1993; Jung et al., 2003), indicating that while IC enhances KS synergistically with TL, its standalone impact on process and product innovation may be marginal.

Our findings should be interpreted considering key contextual factors of the sector. First, project-based work – characteristic of construction/consulting – creates discontinuities in TL-KS relationships (Correa et al., 2007; Giménez Sánchez, 2015). Second, the high level of regulation in Spain limits the adoption of disruptive innovations, which may explain why IC did not show direct effects. Third, the sample consisted mainly of mature firms where processes tend to be highly formalized; these relationships may differ in industry startups. Future research should include these variables as moderators.

5.1. Theoretical contributions

The theoretical contributions of this study offer significant and distinct advances in understanding the dynamics of leadership and innovation, particularly in the Spanish construction sector. These contributions are described in detail below:

1. *Expansion of the TL-KS innovation model in hierarchical contexts*: This study theoretically extends prior work by demonstrating that transformational leadership (TL) operates differently in hierarchical and structured sectors (such as construction), where centralized decision making often limits individual autonomy (Dulaimi, 2022). Contrary to findings in flexible environments (Bass, 1999), our results reveal that:

TL influences product innovation (PDI) primarily through knowledge sharing (KS) ($\beta = 0.406$, $p < 0.001$), supporting the mediation proposed by Eisenbeiss et al. (2008). This finding underscores knowledge as an essential vehicle through which transformational leadership catalyzes product innovation.

However, its effect on process innovation (PCI) is indirect and weak, suggesting that in industries with rigid processes (Howell & Avolio, 1993), innovation additionally requires formal knowledge governance (KG) mechanisms ($\beta = 0.508$, $p < 0.01$). This implies that in environments where processes are highly defined, leadership alone is not sufficient to drive innovation but requires structures that facilitate management and application.

This contribution expands Bass's (1999) classic model by incorporating the moderating role of organizational structure and proposes that the effectiveness of TL depends on the type of innovation (PCI vs. PDI) and the industry context. In doing so, it offers a more nuanced perspective on how transformational leadership can adapt to different organizational environments to maximize its impact.

2. *Synergy between transformational leadership and innovation climate*: While previous studies have examined TL and Innovation Climate (IC) in isolation (Jung et al., 2003), our key finding is that their interaction is critical in industries with a low innovation tradition.

IC enhances the effect of TL on KS ($\beta = 0.141$, $p < 0.1$), but only when explicit policies align individual and collective incentives (Anderson & West, 1998). This suggests that an innovation climate alone is not sufficient; it must be supported by policies that encourage collaboration and reward innovation.

This finding challenges the universalist view of innovation climate (Khalili, 2016) and suggests that its effectiveness depends on transformational leadership. By demonstrating that innovation climate is more effective when combined with transformational leadership, it challenges the notion that a positive climate alone drives innovation.

We propose a contingent model in which the TL-IC combination acts as an "activator" of KS in high-hierarchy contexts, extending the work of Yepes and López (2021) to more traditional environments. This model offers a new way of understanding how leadership and climate interact to promote knowledge sharing in hierarchical organizations.

3. *Differentiation between PCI and PDI*: This study challenges the implicit homogeneity in the innovation literature.

KG influences PDI more than PCI (β = 0.241 vs. 0.210), supporting the thesis that product innovation depends on formal knowledge management structures (Eisenbeiss et al., 2008).

PCI requires additional factors not captured in our model (e.g., resistance to change or technological capabilities), as noted by Dulaimi (2022) in the construction industry. This implies that process innovation is more complex and multifaceted, requiring a combination of factors not fully captured in the current model.

5.2. Practical contributions

1. *Strategic leadership to foster innovation*: The empirical results of this study ($\beta = 0.406$, $p < 0.001$ for the TL → KS relationship; and $\beta = 0.241$ for TL → PDI) confirm that transformational leadership (TL) is

a fundamental driver of innovation, particularly in product development (PDI). To translate these results into concrete actions, the following are recommended:

Implement transformational leadership training programs, focusing on specific skills identified in our study as essential for fostering knowledge sharing and product innovation. For example, in the Spanish construction sector, mentoring programs where leaders exert idealized influence (Bass, 1999) by guiding multidisciplinary teams in the design of product prototypes (PDI), replicating the success observed in companies with high β in TL → PDI (Dulaimi, 2022).

Establish evaluation mechanisms to measure not only the adoption of TL-related practices (e.g., 360-degree surveys) but also their direct impact on innovation metrics (e.g., number of new products patented or implemented annually). Given that our results show that TL influences PDI more than PCI, it is critical to focus efforts on indicators such as the number of new products certified under sustainable regulations (e.g. LEED seals), a priority area in Mediterranean construction (Yepes & López, 2021).

2. *Develop an environment conducive to innovation*: Our finding that the TL × IC interaction significantly enhances KS ($\beta = 0.141$, $p < 0.1$) suggests that organizational policies should be directed toward:

Integrating innovation climate (IC) with TL practices through the following strategies:

Establish reward systems that recognize innovative results and behaviors, e.g., bonuses for sharing lessons learned in geotechnically constrained building projects (PCI), replicating what was observed in Eisenbeiss et al. (2008).

Develop knowledge governance (KG) structures that institutionalize KS. For example, in construction companies with rigid hierarchies, the creation of digital repositories segmented by areas, supported by $\beta = 0.210$ for KG → KS), allows democratizing access to tacit knowledge without challenging formal structures. Additionally, interdepartmental committees (e.g., mixed teams of managers and operators) facilitate knowledge transfer in PCI, such as optimizing prefabrication processes (Khalili, 2016).

5.3. Limitations and directions for future research

This study has several limitations that must be considered when interpreting its results. First, reliance on self-reported data through questionnaires (e.g., Likert scales) introduces well-documented methodological risks, such as social desirability biases (Podsakoff et al., 2023) and perceptual distortions (e.g., overestimation of innovative capabilities). Although statistical controls (Harman's analysis for common method bias) and anonymity were applied to mitigate these biases, their residual influence cannot be entirely ruled out. Future research could incorporate triangulation with objective innovation metrics (e.g., number of patents filed, percentage of revenue from new products, or quantifiable cost savings derived from PCI) to strengthen the external validity of the results (Podsakoff et al., 2023).

Second, the specific geographical context (Spain) limits the generalizability of the results. While the Spanish construction sector shares characteristics with Mediterranean environments (Dulaimi, 2022), cultural factors (e.g., risk aversion, collectivism) or regulatory frameworks (e.g., local regulations) may influence leadership and innovation dynamics. We recommend replicating this study in countries with contrasting organizational cultures (e.g., Nordic countries, which emphasize autonomy, or Asian contexts with collectivist approaches) to test the cross-cultural validity of the proposed model. Additionally, it is critical to acknowledge that this study focuses on the Spanish construction sector, where urban environmental vulnerabilities, associated with challenges such as climate change, social inequality, or inadequate infrastructure, may affect firms' ability to adopt new technologies or develop innovative solutions (Salas & Yepes, 2018). Future research should explore how these contextual variables interact with knowledge governance and leadership mechanisms.

A further limitation is the cross-sectional design, which precludes definitive causal inferences. Longitudinal studies (e.g., annual measurements of KS and innovation) or experimental approaches (e.g., transformational leadership interventions with control groups) could help establish more robust causal relationships between these dynamics. Moreover, while common method bias was statistically controlled, its presence cannot be entirely eliminated due to the cross-sectional nature of the data.

The dynamic nature of the construction industry also presents contextual limitations. For example, the increasing integration of emerging technologies (e.g., Building Information Modeling, artificial intelligence) could alter the studied relationships as these advancements reshape knowledge flows and leadership demands (Dulaimi, 2022). Future work should explore how such technologies moderate the link between TL, KG and innovative performance.

Finally, conceptualizing innovation as perceived capabilities (rather than tangible outcomes) limits comparability with studies using objective metrics (e.g., number of new products launched). Extending the model to include dimensions such as frugal innovation (Zeschky et al., 2011) or second-order constructs (e.g., innovativeness integrating product, process and business model indicators) would enrich the theoretical analysis. Furthermore, in open innovation contexts (Chesbrough, 2003), where interorganizational collaboration is pivotal, the role of KG and TL could vary significantly, opening a promising avenue for research.

6. Conclusions

This study presents findings of considerable importance within leadership, knowledge governance, and innovation, specifically tailored to the construction and consulting sectors. Our research substantiates the hypothesis that an amalgamation of Transformational Leadership (TL), Knowledge Governance (KG), and Knowledge Sharing (KS) markedly enhances both Product and Process Innovations (PDI and PCI) in these industries.

Notably, the study reveals empirical evidence demonstrating the pivotal role of KS and KG as mediators in the relationship between TL and innovation capabilities in construction and consulting. Additionally, it underscores the moderating influence of Innovation Climate (IC) on the efficacy of TL in promoting KS.

These insights are particularly valuable in understanding how TL, KG, and KS interplay to augment innovation capabilities, especially in the context of the construction and consulting sectors. The findings emphasize the necessity of integrating TL with a supportive IC to catalyze KS and thereby amplify a firm's innovation capacity in the long term.

For managers and directors in the construction and consulting fields, these results offer a strategic pathway to foster an environment conducive to KS, thereby significantly boosting their organization's innovation potential. By implementing these findings, leaders can create robust frameworks that facilitate innovation and sustain it over the long term, ensuring that their companies remain competitive and forward-thinking in an ever-evolving industry landscape.

While Knowledge Governance emerges as a potent instrument for spurring innovation and enhancing efficiency in the construction sector, its practical implementation hinges on meticulous planning, fostering a change-embracing organizational culture, and developing strategies to address possible challenges. By navigating these hurdles, construction and consulting firms can optimize KG's full spectrum of benefits, thereby maintaining their competitive edge and driving innovation forward.

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Author contributions

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Disclosure statement

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APPENDIX

Table A1. Measurement items and constructs

Construct	Factor	Dimensions	Measurement items	Source
Transformational leadership	TL	TL1	The leader encourages me to accept challenges.	Adapted from Le and Lei (2018), Masa'deh et al. (2016)
		TL2	The leader takes the time to understand my needs.	
		TL3	The supervisor encourages us to strive for the company's vision.	
Knowledge sharing	KS	KS1	When my colleagues need it, I do my best to provide them with the necessary information and documents	Adapted from Cheng and Li (2001)
		KS2	I am always willing to share my knowledge and experience with others.	
		KS3	I have enough confidence in my leader that I would defend and justify his/her decision if he/she were not present to do so.	
Knowledge governance	KG	KG1	In our organization, lessons learned both successful and unsuccessful are considered valuable.	Adapted from Kianto and Andreeva (2014)
		KG2	Our organization has a clear understanding of our current core knowledge.	
		KG3	Our organization's knowledge and competences are evaluated systematically	
Innovation capability	PDI	PDI-1	Our company always develops novel skills for transforming old products into new ones for the market	Adapted from Tsai et al. (2001), Liao et al. (2007)
		PDI-2	Our company frequently introduces innovations in materials, techniques, or construction services that are well-received.	
		PDI-3	Our company quickly adapts to changing market needs, developing construction products and services that address new challenges and trends.	
	PCI	PCI-1	Our company often tries different operating procedures to hasten the realization of the company's goals.	
		PCI-2	Our company can develop more efficient manufacturing process or operation procedure	
		PCI-3	Our company always acquires new skills or equipment to improve the manufacturing operation or service process	
Innovation climate	IC	IC1	Our ability to function creatively is respected by the leadership.	Adapted from Scott and Bruce (1994)
		IC2	Assistance in developing new ideas is readily available.	
		IC3	There are adequate resources devoted to innovation in this organization.	