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Frugal innovation in the Turkish leather industry: Roles of knowledge management, transformational leadership, and sustainable investment

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ABSTRACT

This study examines the impact of knowledge management, transformational leadership, and investments on frugal innovation in 40 Turkish small and medium-sized leather companies for the year 2024. Quantitative data were collected using a semi-structured questionnaire and analyzed with PLS-SEM. Additionally, interviews with senior managers were categorized and coded for qualitative analysis of frugal innovation and knowledge management practices. The results indicate that transformational leadership, knowledge management, and investments significantly contribute to frugal innovation. Moreover, knowledge management is the strongest predictor of frugal innovation (β=0.421, p<0.001), followed by investments (β=0.313, p=0.042), whereas transformational leadership is the strongest predictor of knowledge management (β=0.521, p<0.001). These findings demonstrate that organizations' intangible capabilities, such as knowledge, skills, and organizational culture, facilitate frugal innovation when operating under resource constraints. The evidence further suggests that effective knowledge management practices can serve as an alternative to additional investments in tangible assets, such as machinery or technology. The results offer valuable insights for managers to align investments with a knowledge-driven strategy and to adopt transformational leadership that promotes knowledge sharing for frugal innovation. From a practical perspective, this research provides managers and policymakers with useful, evidence-based recommendations to enhance competitiveness and sustainability in traditional manufacturing sectors through frugal and knowledge-based innovation approaches.

Contribution/Originality: The study contributes to the literature on the knowledge-based view theory and frugal innovation by providing new evidence for leather manufacturing firms in Turkey. It also examines investments as a mediator, which is an underexplored area in frugal innovation research.

1. INTRODUCTION

In an era of intensifying global competition, frugal innovation has emerged as a vital strategy for small and medium-sized enterprises (SMEs), enabling them to navigate resource constraints more efficiently (Ploeg, Knoben, Vermeulen, & Van Beers, 2021). Unlike conventional innovation that relies on advanced business models and significant investments, frugal innovation focuses on doing more with fewer resources (Radjou & Prabhu, 2014). The core attributes of frugal innovation lie in its capacity to provide a balanced blend of sustainability, affordability, and high performance (Corsini, Dammicco, & Moultrie, 2021; Perera & Badir, 2020). It is characterized by the firm's capacity to engage in iterative processes, flexibly utilize assets, develop sustainable solutions, co-create value, and

establish strategic partnerships (Radjou & Prabhu, 2014). With the ever-changing global landscape, frugal innovation has transformed from a mere low-cost innovation strategy into a powerful approach that enhances competitiveness in resource-constrained environments.

Conceptually, an innovative system is designed to facilitate the development of new ideas and technologies that address changing needs through three key pillars of innovation: knowledge exploration, the creation of new technologies, and the practical application of innovations (Dutta, Lanvin, Leon, & Wunsch-Vincent, 2021). Thus, knowledge management plays a key role in shaping how firms capture, disseminate, and apply knowledge to achieve innovative outcomes (Shehzad et al., 2023). Knowledge management practices enable firms to reallocate their resources effectively, seize emerging opportunities, and make informed decisions in uncertain and dynamic environments (Raisch & Birkinshaw, 2008). However, transforming knowledge into frugal innovation requires a well-designed strategy that integrates investment decisions and transformational leadership. Transformational leaders foster an environment that cultivates learning, sharing, and creativity, while inspiring their teams to align personal aspirations with the firm's innovation goals. Alongside transformative leadership, knowledge-driven strategic investments act as a catalyst for frugal innovation (Li, Chen, & He, 2023).

Within this context, the growing engagement of emerging market firms in the innovation process becomes increasingly vital. Turkey has significant potential to advance frugal innovation, as it faces evolving environmental and resource-related challenges due to economic fluctuations. The exports of Turkish manufacturing companies are highly influenced by factors such as rising production costs and strict environmental regulations (OECD, 2023; United Nations Industrial Development Organization (UNIDO), 2021). These challenges highlight the urgent need to embrace sustainable innovation strategies to remain competitive. Given these dynamics, it is essential to examine how specific industries in Turkey can capitalize on innovation potential despite resource constraints. In this regard, the leather industry presents an interesting case due to its significant potential in exports and skilled craftsmanship.

This study examines the Turkish leather manufacturing industry to explore pathways that accelerate frugal innovation. The resource-intensive, export-oriented leather industry is recognized for producing high-quality goods that stand out internationally due to their unique colors, patterns, and material combinations. In this context, frugal innovation has the potential to be a dominant driver for enhancing the global competitiveness of these firms. Therefore, given its complex production processes, the leather industry plays a key role in advancing sustainable practices, as it faces significant environmental challenges such as waste management (Sharma, Sudhakara, Petru, Singh, & Rajkumar, 2022). Previous studies held in this industry in China, Pakistan, India, Bangladesh, and Iraq have identified similar challenges relating to production-related inefficiencies (Ahmed, Ali, Kousar, & Ahmed, 2022; Alghazali, 2023) environmental concerns (Bhaskaran, 2024; Daddi, Ahmad, & Albano, 2025) limited innovation capacity (Su, Song, Shang, & Fahad, 2023) and adaptation of new technologies (Singh, Singh, & Tripathi, 2024). The industry's reliance on traditional production methods and its dependence on exports increase its sensitivity to market volatility and sustainability challenges. Therefore, the interaction between transformational leadership, knowledge management, frugal innovation, and investments can provide valuable insights into how frugal innovation can be effectively implemented in resource-limited environments. This study employs the Knowledge-Based View (KBV) theory of Grant (1996) and emphasizes that knowledge is a critical resource, highlighting the firm's role in integrating individual knowledge to generate value. This perspective offers a solid foundation for understanding frugal innovation, demonstrating how effective knowledge management can enable firms to overcome resource constraints and financial limitations (Sheikh, Pugh, Wu, & Sarkar, 2024).

Given the increasing global efforts toward sustainability practices, this study provides an alternative strategy for firms operating in resource-limited environments. The operations of the leather industry within the manufacturing sector are highly complex and resource-intensive, necessitating strategic approaches to minimize waste and optimize processes while maintaining sustainable practices. Frugal innovation aims to create "more with less" resources. It also combines the goals of reducing costs, collaborating with third parties, and minimizing environmental waste.

These principles of frugal manufacturing help focus not only on delivering value for companies but also on establishing sustainable practices.

This study contributes to the literature on three-folds. First, unlike prior studies that focus on a single dimension of frugal innovation, this study integrates knowledge management, investment decisions, and transformational leadership as key drivers of frugal innovation, with a specific focus on the leather manufacturing industry in Turkey. This approach offers fresh insights from an emerging market setting. Second, this study highlights the significance of knowledge management systems for frugal innovation alongside reliance on investments in sustainable practices. In this context, it emphasizes the importance of transformational leadership in facilitating knowledge flow within organizations and enriches the literature on both knowledge-driven and leadership-centered innovation, providing valuable insights into how firms can leverage the Knowledge-Based View (KBV) framework to overcome challenges and maintain competitive advantages. Ultimately, this research underscores the mediating role of knowledge management and investments in promoting frugal innovation. In this regard, the study focuses on the following questions.

1. How does knowledge management impact frugal innovation in Turkish leather manufacturing SMEs?
2. How do strategic investment decisions influence the relationship between knowledge management and frugal innovation?
3. How does transformational leadership influence knowledge management and investment decisions to yield frugal innovation?
4. What are the direct and indirect mechanisms through which knowledge, leadership, and investment converge to promote frugal innovation in resource-constrained environments?

The remainder of this paper is organized as follows. Section 2 provides the theoretical and conceptual background and develops the hypotheses. Section 3 presents the data and methodology. Section 4 discusses the empirical findings, and Section 5 interprets the results. Finally, Section 6 outlines the implications of the study and suggests avenues for future research.

2. LITERATURE REVIEW

2.1. Knowledge Driven Frugal Innovation

Knowledge management is a fundamental strategy for companies, and effective knowledge management practices continuously improve operations across industries. In this context, the knowledge-based view (KBV) theory identifies knowledge as the firm's most strategic asset (Grant, 1996) and conceptualizes firms as entities dedicated to generating knowledge, with employees being the primary contributors (Nonaka, Toyama, & Konno, 2000). Tacit knowledge, which encompasses skills, experience, and intuition, is recognized as a key resource alongside explicit knowledge documented in files (Lee & Choi, 2003; Polanyi, 1966). Previous studies have highlighted the importance of converting tacit knowledge into explicit knowledge. Despite these efforts, knowledge-hiding behavior has become a noticeable problem for organizations (Offergelt & Venz, 2023), and recent studies have examined this issue by exploring social reasons behind this behavior (Chen, Liu, Zhu, & Shu, 2023; Qiao, Mahmood, Ahmad, Bashir, & Bari, 2023; Zhang et al., 2023). Knowledge management enables firms to capture, share, and apply explicit and tacit knowledge, thereby improving efficiency, managing risks, and sustaining competitiveness (Fan et al., 2023). Traditional knowledge management models, such as the SECI (socialization, externalization, combination, and internalization) framework (Nonaka & Takeuchi, 1996) and the knowledge lifecycle (Meyer & Zack, 1996), explain how knowledge flows through a process, creating value by fostering innovation. Despite the complexity of knowledge transfer and the risk of miscommunication, effective knowledge management continues to provide the foundation for organizational learning and innovation in dynamic and resource-constrained environments.

In recent years, frugal innovation has gained importance as a strategic response to intensifying global competition, resource constraints, and growing demands for sustainability (Qu, Qin, & Wang, 2023; Radjou & Prabhu,

2014) while challenged with global supply chain disruptions. Centered on the principles of affordability, functionality, sustainability, and efficiency (Corsini, Laurenti, Meinherz, Appio, & Mora, 2019; Perera & Badir, 2020), frugal innovation embodies the power of achieving "more with less". Through simplification and collaborative approaches, it empowers firms to transform complex, high-cost products into streamlined, accessible solutions (Lim & Fujimoto, 2019). It also integrates principles of sustainability and cost-effectiveness, promoting not only market opportunities but also social outcomes (Christensen & Raynor, 2003; Hossain, 2021).

While knowledge management and frugal innovation are conceptually distinct, they complement each other as they mutually support corporate performance. Knowledge management enhances a firm's ability to use resources efficiently by converting tacit knowledge into practical actions. Frugal innovation, in turn, leverages this knowledge to develop simple, cost-effective, and sustainable solutions (Ganguly, Talukdar, & Chatterjee, 2019; López-Cabarcos, Srinivasan, & Vázquez-Rodríguez, 2020). Innovation itself is tacit knowledge-intensive (Leonard & Sensiper, 1998), and the quality of knowledge affects innovation decisions and outcomes (Wang & Wang, 2012). Ultimately, transformational leadership, a collaborative culture, and environmental turbulence often appear as interdependent practices central to sustaining innovation in emerging markets, connecting knowledge management to frugal innovation (Heriyanti, Azizah, Cesna, Santoso, & Sanjaya, 2022).

2.2. Strategic Investments and Frugal Innovation

Investments are crucial in driving organizational performance, especially when aligned with sustainable strategies. Prior studies have shown that strategic investments not only reinforce a firm's competitiveness but also facilitate eco-innovations that cater to the growing demand for environmentally conscious products (Efni, 2017; Lewandowska, Bilan, & Mentel, 2021; Lin, Li, & Miao, 2023). To achieve sustainability, firms must clearly define their objectives and formulate strategies that guide optimal investments. Success in this effort relies on strong managerial capabilities, effective asset management, and a culture of organizational learning (Teece, 2018). Decision models, such as a wiki-based investment knowledge management system (Yu, 2009) and the sustainability investment framework by Buhl, Graf-Drasch, and Wiethe (2023), highlight how structured knowledge can help firms assess opportunities, balance risks, and communicate with stakeholders. Firms develop frugal innovation by investing in R&D, leveraging digital platforms, and motivating teamwork (Teece, 2017). However, the contradiction might arise from the fact that frugality involves minimal resource use, whereas investing more in technological advancements can improve innovation. From a KBV perspective, one may argue that investment is not a critical factor; rather, making informed investments transforms data and expertise into actions that prevent resource waste and strengthen long-term firm value (Feng & Xiao, 2009). In this regard, investments increase risk-taking capacity and financial agility (Li et al., 2023) while frugal innovation focuses on minimizing resource use.

2.3. Transformational Leadership and Frugal Mindset

Transformational leadership has been widely recognized for shaping innovation and enabling firms to align their resources with long-term goals (Teece, 2018). Unlike transactional leaders, transformational leaders focus on motivation, inspiration, and cultivating a shared vision, thereby fostering corporate adaptability and enhancing innovation performance (Lei, Gui, & Le, 2021; Madi, Obeidat, Jaradat, Masa'deh, & Alshurideh, 2023). Transformational leaders are characterized by passion, commitment, and fairness. They motivate employees to exceed expectations and foster behaviors such as environmental citizenship and creativity (Wang, Locatelli, Zhang, Wan, & Chen, 2023). By encouraging openness, collaboration, and knowledge sharing, transformational leadership facilitates the integration of explicit and tacit knowledge, thereby enhancing knowledge management and innovation outcomes.

Transformational leadership plays a crucial role in adopting frugal innovation under resource constraints. Leaders shape organizational culture, drive employee commitment, and create environments conducive to experimentation and change (Lamsam & Charoensukmongkol, 2023). However, these characteristics might contradict

the frugal discipline of minimalism. Therefore, transformational leaders should frame their actions with a frugal mindset and primarily focus on hiring members who share similar interests. This approach will serve as a catalyst for knowledge-based frugality. By connecting knowledge management with frugal innovation, transformational leaders develop routines that foster innovation even when resources are limited, thereby contributing to sustainable competitiveness.

2.4. Hypotheses Development

Grounded in the KBV theory, this study presents an integrated framework encompassing knowledge management, frugal innovation, investment decisions, and transformational leadership. Knowledge management serves as the cornerstone for systematically capturing and utilizing both tacit and explicit knowledge. Frugal innovation translates these insights into cost-effective and sustainable solutions tailored to resource-limited settings. Strategic investments complement this process by aligning financial decisions with innovative objectives, ensuring that firms have the resources and capabilities to support competitiveness. Simultaneously, transformational leadership serves as a catalyst, inspiring individuals, shaping corporate culture, and enabling the conversion of knowledge and investments into innovative practices. In doing so, these constructs constitute a hybrid model for frugal innovation applicable to emerging-market firms. Figure 1 illustrates the research framework.
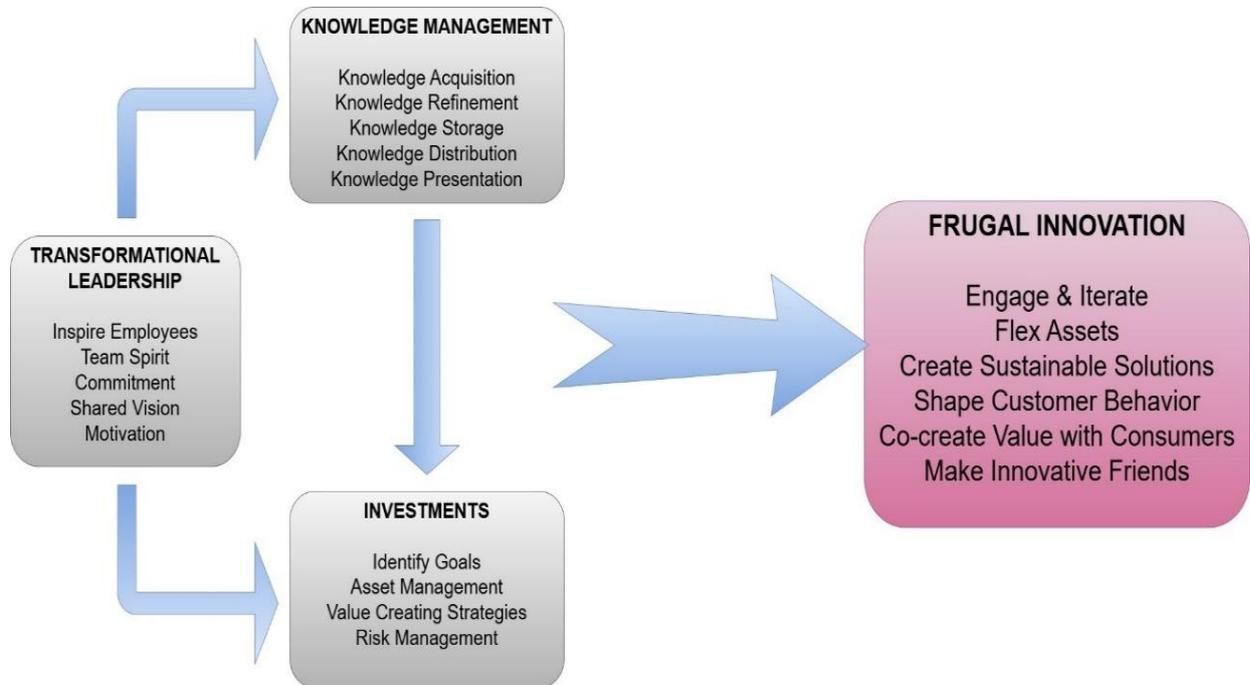
Figure 1. Research framework.

In this study, the proposed model aims to explore the influence of transformational leadership on knowledge management, the effect of knowledge management on frugal innovation and investments, and the impact of investments on frugal innovation. The model also examines the indirect relationships, specifically whether knowledge management (KM) mediates the relationship between transformational leadership (TL) and frugal innovation (FI), as well as between TL and investments (INVs). Furthermore, KM and INV are expected to mediate the relationship between TL and FI in a sequential manner. Table 1 presents the hypotheses.

Table 1. The hypotheses of the study.

Hypothesis	Path/Effect	Hypothesis statement
Direct effects		
H1	KM → FI	Knowledge management positively influences frugal innovation.
H2	INV → FI	Investment decisions positively influence frugal innovation.
H3	TL → KM	Transformational leadership positively influences knowledge management.
H4	KM → INV	Knowledge management positively influences investment decisions.
Indirect effects		
H5	TL → KM → FI	Knowledge management mediates the relationship between transformational leadership and frugal innovation.
H6	TL → KM → INV	Knowledge management mediates the relationship between transformational leadership and investment decisions.
H7	KM → INV → FI	Investment decisions mediate the relationship between knowledge management and frugal innovation.
H8	TL → KM → INV → FI	Knowledge management and investment decisions sequentially mediate the relationship between transformational leadership and frugal innovation.

3. METHODOLOGY

3.1. Data Collection

Our sample includes 55 Turkish leather manufacturing and exporting firms registered with the Istanbul Textile and Apparel Exporters' Association (ITKIB) and the Istanbul Leather and Leather Products Exporters' Association (IDMIB). The leather industry plays a significant role in the Turkish economy, with Istanbul serving as a central hub. In 2022, export revenues from the leather industry exceeded USD 2 billion (Republic of Türkiye – Ministry of Trade, 2024).

Turkish leather companies have exported to more than 180 countries. Among the 55 leather companies targeted in Istanbul, we achieved a response rate of 72.73%. All 40 firms that responded to our survey are members of ITKIB, and 26 of them are also members of IDMIB. Table 2 displays the demographics of the respondent firms.

To complement the quantitative analysis, a series of semi-structured interviews was conducted with the same pool of 40 respondents. A total of 22 senior managers participated in the interviews, representing a 55% participation rate.

Among them, only seven respondents (17.5%) completed all interview questions. The remaining 15 participants (37%) provided partial responses. Table 3 presents the number of respondents for the following interview questions.

1. How would you manage your employees' knowledge to enable them to implement frugal innovation?
2. Do you look for specific traits or capabilities when hiring new team members? Do you check for the existence of a frugal mindset?
3. Does your firm engage in sustainable innovations? If yes, please give examples of reusable resources for innovation.
4. Is your company interested in green finance? Do you consciously participate in or want to participate in green finance for green innovations?
5. How would you describe your leadership style? Do you follow specific patterns or guidelines when working on an innovation project?

Table 2. Demographic characteristics of the respondents.

Demographic characteristics	Frequency	Percentage
Gender		
Female	7	17.50%
Male	33	82.50%
Age		
18-24	0	0%
25-34	3	37.50%
35-44	15	42.50%
45-54	17	12.50%
55 and above	5	7.50%
Title		
Quality Control	1	2.50%
Sales/Operations	8	20.00%
Accounting	9	22.50%
Human Resources	5	12.50%
CEO/Leader	17	42.50%
Education Level		
PhD	0	0.00%
Master's Degree	3	7.50%
Bachelor's Degree	21	52.50%
Associate's degree	16	40.00%
Employment at the firm (Years)		
1 to 5	9	22.50%
6 to 10	6	15.00%
11 to 15	6	15.00%
15 to 20	11	27.50%
20 and above	8	20.00%
Company Affiliation		
ITKIB	40/40	100.00%
IDMIB	26/40	65.00%

Table 3. Participants of the respondents for the interviews.

Interview Participation Status	Number of respondents	Percentage of the sample (N = 40)
Agreed to participate in the interview	22	55.00%
- Completed full interview (5 questions)	7	17.50%
- Partially completed interview	15	37.50%
Declined interview participation	18	45.00%

3.2. Measurement of the Variables

The variables in this study include knowledge management (KM), frugal innovation (FI), investment decisions (INV), and transformational leadership (TL). To analyze their interrelationships, we employed multiple-item measurement approaches. Each item was assessed using a five-point Likert scale, with response options ranging from 1 (never) to 5 (always). Table 4 defines the variables.

Table 4. The definitions of the variables.

Variables	Code	Type of variable	Definition of the variable
Frugal innovation	FI	Dependent variable	Reflects the firm's ability to innovate efficiently and sustainably with limited resources.
Transformational leadership	TL	Independent variable	Describes leadership that inspires, motivates, and challenges employees to achieve shared goals and foster innovation.
Knowledge management	KM	Mediator	Represents how organizations acquire, share, and use knowledge to improve decisions, efficiency, and innovation.
Investments	INV	Mediator	Conscious allocation of financial and material resources to initiatives focused on sustainability and innovation.

The FI questionnaire is a 9-item measure introduced by Rossetto, Borini, Bernardes, and Frankwick (2023) and includes three subsections: core functionalities, cost deduction, and shared sustainability engagement, designed to analyze the firm's frugal innovation objectives. The TL questionnaire, formulated by Dai, Dai, Chen, and Wu (2013), consists of 8 items. The third construct of KM utilizes a 9-item questionnaire proposed by Lei et al. (2021), which covers tacit and explicit knowledge. Finally, the fourth construct, INV, employs a 7-item questionnaire based on the studies of Marin, Martín, and Rubio (2017) and Ahmed et al. (2022). Of the 33 items evaluated, 16 were selected based on their satisfactory discriminant validity and reliability. Figure 2 shows the research model tested by PLS-SEM.
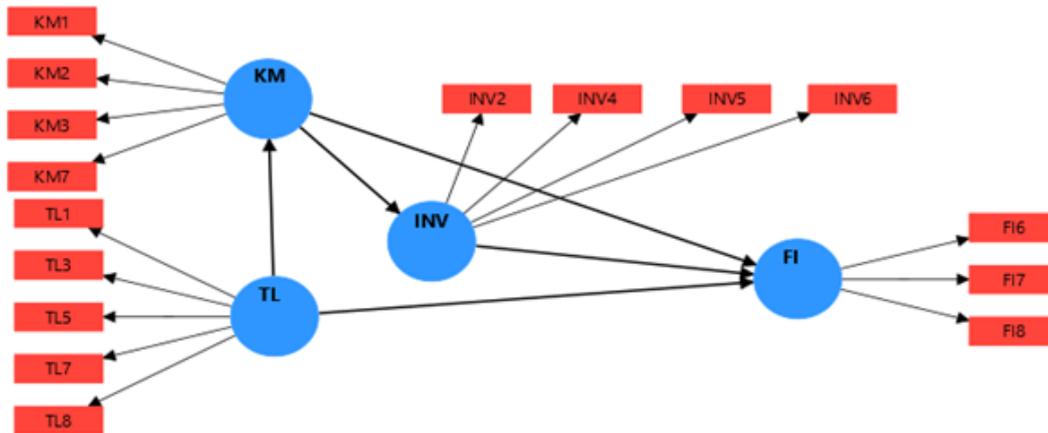

Figure 2. The research model from Smart-PLS output.

4. EMPIRICAL FINDINGS

4.1. Data Preparation

In this study, PLS-SEM is employed to explore how exogenous variables influence the endogenous variable (Hair, Tomas, Hult, Ringle, & Sarstedt, 2022). PLS-SEM is recommended for small sample sizes (Sosik, Kahai, & Piovoso, 2009). The algorithm checks for partial regression relationships in structural models by performing separate ordinary least squares regressions. We use SmartPLS Version 4 to conduct the PLS-SEM analysis. In the measurement model, we assessed the reliability and validity of the variables and their respective indicators. Reliability was evaluated by first reviewing the factor loadings to confirm that each exceeded 0.50. Internal consistency was further assessed using composite reliability (CR) through the Rho_c value, with a threshold greater than 0.70, and Cronbach's alpha, with a threshold greater than 0.60, as suggested by Hair, Ringle, and Sarstedt (2011). Convergent validity was established by ensuring that the average variance extracted (AVE) exceeded 0.50. For discriminant validity, we relied on heterotrait-monotrait (HTMT) ratio values below 0.85 and the Fornell-Larcker Criterion (FLC), which requires that a construct's AVE exceeds all its squared correlations (Henseler, 2017). We also examined cross-loadings for each variable and performed collinearity diagnostics for the constructs by confirming that the variance inflation factor (VIF) ranged from 1 to 5 (Cepeda-Carrion, Cegarra-Navarro, & Cillo, 2019). Satisfying these thresholds confirms the reliability and validity of the model.

4.2. Descriptive Statistics

Table 5 provides the descriptive statistics. The mean values for the items range from 3.175 to 4.325. Specifically, the items related to frugal innovation (FI), transformational leadership (TL), and knowledge management (KM) suggest that respondents are more inclined to practice these concepts. Investments (INV) have slightly lower mean values, indicating that respondents are less likely to be involved in sustainable investments.

The correlation matrix in Table 6 indicates positive correlations among all four constructs. Frugal innovation exhibits the strongest correlation with knowledge management (r=0.624), a moderate correlation with investments (r=0.528), and the weakest correlation with transformational leadership (r=0.481). This suggests that firms focusing

on frugal innovation tend to manage knowledge and investments effectively. Investment shows a small but positive correlation with both knowledge management (r=0.386) and transformational leadership (r=0.335). Additionally, there is a moderate correlation between knowledge management and transformational leadership (r=0.521).

Table 5. Descriptive statistics.

Item	Mean	Std. Dev.	Median	Min.	Max.
FI6	3.675	0.818	4	1	5
FI7	4.000	0.671	4	2	5
FI8	4.325	0.468	4	2	5
INV2	3.875	0.599	4	2	5
INV4	3.875	0.714	4	2	5
INV5	3.175	0.972	3	1	5
INV6	3.400	0.800	3	2	5
KM1	4.300	0.640	4	2	5
KM2	4.275	0.632	4	2	5
KM3	4.250	0.661	4	2	5
KM7	4.100	0.700	4	2	5
TL1	4.150	0.527	4	2	5
TL3	4.250	0.433	4	3	5
TL5	3.975	0.651	4	2	5
TL7	4.100	0.700	4	2	5
TL8	4.225	0.570	4	2	5

Table 6. Correlation matrix.

Constructs	FI	INV	KM	TL
FI	1	0.528	0.624	0.481
INV	0.528	1	0.386	0.335
KM	0.624	0.386	1	0.521
TL	0.481	0.335	0.521	1

4.3. Measurement Model Assessment

Our initial assessment of the measurement model ensures the quality of the constructs, following the steps suggested by Hair et al. (2022). The VIF values were below 3.33 (Kock, 2015) as shown in Table 7, indicating no bias. Next, we checked the AVE, CR, Cronbach's Alpha, and Rho_c values to ensure that these values met the threshold for each construct. We then evaluated the outer loadings and weights to check how each indicator contributed to the model (Purwanto & Sudargini, 2021). The factor loadings range from -1.0 to +1.0; we ensured that none of the items had loadings below 0.50 (Hair, Risher, Sarstedt, & Ringle, 2019). If the required threshold for factor loadings is met, the item is retained in the model; if not, the outer weights are checked next for their significance at p ≤ 0.05. If the threshold for the outer weights is met, the item is retained. If not, the item is deleted from the model. As a result, based on the initial assessment of the measurement model, we conclude that 17 of 33 items were deleted, leaving 16 items in the final model. Table 8 presents the factor loadings, reliability, validity, and the significance of each of these items.

Table 7. The collinearity VIFs of the inner model.

Structural Path	VIF
INV -> FI	1.21
KM -> FI	1.48
KM -> INV	1.00
TL -> FI	1.41
TL -> KM	1.00

Table 8. The factor loadings, reliability, and validity of the final model.

Measurement Items	λ	P values¹	α	CR	AVE	VIF
FI			0.610	0.780	0.550	
FI6	0.801	0.000				1.233
FI7	0.806	0.000				1.213
FI8	0.601	0.000				1.190
KM			0.870	0.890	0.730	
KM1	0.893	0.000				1.353
KM2	0.850	0.000				1.480
KM3	0.922	0.000				2.156
KM7	0.740	0.000				2.153
INV			0.810	0.890	0.720	
INV2	0.704	0.000				4.031
INV4	0.702	0.000				2.479
INV5	0.857	0.000				4.012
INV6	0.824	0.000				1.787
TL			0.860	0.910	0.780	
TL1	0.742	0.000				1.778
TL3	0.792	0.000				2.132
TL5	0.810	0.000				2.172
TL7	0.847	0.000				2.565
TL8	0.892	0.000				2.857

Note: ¹$p \leq 0.05$; two-tailed, Bootstrapped - 10,000 samples

CR is used as a measure of the construct's internal consistency (Hair et al., 2011). The evaluation of the model involves examining both Cronbach's alpha and CR values. As shown in Table 8, all results exceed the thresholds. Hence, the construct reliability is confirmed. Convergent validity is supported, as all AVEs exceed 0.50. The discriminant validity is established using three approaches: cross-loadings, the FLC, where each construct's AVE exceeds its highest squared correlation (Table 9), and the HTMT ratio, which remains below the 0.85 threshold (Table 10). Thus, both convergent and discriminant validity are satisfied.

Table 9. The Fornell-Larcker Criterion (FLC) of the final model.

Constructs	FI	INV	KM	TL
FI	0.742			
INV	0.528	0.775		
KM	0.624	0.386	0.854	
TL	0.481	0.335	0.521	0.818

Table 10. The Heterotrait-Monotrait (HTMT) ratio of the final model.

Constructs	FI	INV	KM	TL
FI				
INV	0.715			
KM	0.796	0.466		
TL	0.630	0.392	0.557	

4.4. Interpretation of the Key Parameters

The parameters used in the measurement model primarily involve verifying whether the items associated with each construct fall within acceptable thresholds. This verification enables a more detailed analysis of the structural model. Descriptive statistics reveal that the mean scores of respondents range from 3.175 to 4.325, indicating a generally positive dispersion across the constructs. All correlations between the constructs are positive, supporting the relationships among them. The internal consistency and convergent validity of the model were further evaluated by meeting the required thresholds for Cronbach's alpha, Composite Reliability (CR), Average Variance Extracted (AVE), Fornell-Larcker Criterion (FLC), and HTMT. Additionally, the Variance Inflation Factor (VIF) values ranged from 1.190 to 4.031, which are within acceptable limits, indicating no issues with multicollinearity. Overall, these

parameters demonstrate that the constructs are appropriate for interpreting the structural model, ensuring the reliability and validity of the analysis.

4.5. Structural Model Assessment

The structural model assessment evaluates the interrelationships among the constructs. Utilizing PLS-SEM bootstrapping with a two-tailed p-value threshold of 0.05 in SmartPLS, the analysis determines whether various factors significantly influence FI in the leather companies. The predictive values (Q^2) were estimated using PLS predictions to assess model reconstruction and predictive relevance. Since all construct values in Table 11 exceed zero, the endogenous variables are considered predictive. Additionally, as reported in Table 11, the R^2 values were 0.503 for FI, 0.149 for INV, and 0.272 for KM.

Table 11. The summary of the predictive analysis.

Construct	Q²predict	RMSE	MAE	R²
FI	0.182	0.971	0.727	0.503
INV	0.073	1.019	0.777	0.149
KM	0.204	0.981	0.692	0.272

To assess the contribution of each exogenous variable, the effect size is examined according to the guidelines of Cohen (1988). The thresholds are categorized as follows: 0.02 is small, 0.15 is medium, and 0.35 is large. Table 12 displays the effect sizes, indicating that transformational leadership exerts a large impact on knowledge management (0.373). This finding confirms transformational leadership as the primary driver of knowledge management. Furthermore, knowledge management has a medium impact on FI (0.242), making it the leading predictor of FI. Investment decisions have a moderate effect on FI (0.163) and are influenced by knowledge management (0.175). Conversely, transformational leadership has a small direct impact on FI (0.035), reaffirming that its primary effect is indirect, acting through knowledge management and, to a lesser extent, investment decisions.

Table 12. The effect size of exogenous variables.

Structural Path	f²
INV -> FI	0.163
KM -> FI	0.242
KM -> INV	0.175
TL -> FI	0.035
TL -> KM	0.373

4.6. The Results of the Structural Model

The proposed model in this study explores the relationships between TL, KM, INV, and FI. The path coefficients and p-values were obtained using the bootstrapping technique, which allows for the evaluation of direct and indirect effects. Table 13 presents the results.

Table 13. The direct and indirect effects results.

Hypothesis	Path / Effect	β	p-value[1]	CI (Lower, Upper)	P-value Sig.	CI Sig.	Final interpretation
H1	KM → FI	0.421	0.000	[0.173, 0.624]	Yes	Yes	Supported
H2	INV → FI	0.313	0.042	[0.009, 0.602]	Yes	Yes	Supported
H3	TL → KM	0.521	0.000	[0.224, 0.746]	Yes	Yes	Supported
H4	KM → INV	0.386	0.002	[0.151, 0.630]	Yes	Yes	Supported
H5	TL → KM → FI	0.219	0.007	[0.066, 0.385]	Yes	Yes	Supported
H6	TL → KM → INV	0.201	0.041	[0.048, 0.422]	Yes	Yes	Supported
H7	KM → INV → FI	0.121[2] 0.201[1]	0.096[2] 0.160[1]	[0.002, 0.283] [2] [-0.000, 0.173] [1]	No[1][2]	Yes[2]	Partially supported[2]
H8	TL → KM → INV → FI	0.063	0.160	[0.000, 0.173]	No	No	Not supported

Note: [1]p < 0.05; two-tailed, [2]p < 0.10, Bootstrapped − 10,000 samples

The results indicate that the proposed model has significant direct and indirect relationships. The analysis reveals reasonable patterns of relationships among the constructs.

The findings support Hypothesis 1, indicating that KM is the strongest predictor of FI (β = 0.421, p = 0.000). Knowledge management has a significant effect on FI, demonstrating that higher levels of knowledge management lead to higher levels of FI. The results also support Hypothesis 2, where INV directly associates with FI (β = 0.313, p = 0.042). Although knowledge management has a stronger direct effect than investments on FI, the outcome remains significant. Therefore, a higher level of investment is also associated with a higher level of FI.

The findings indicate that transformational leadership (TL) strongly predicts knowledge management (KM) (β = 0.521, p = 0.001), supporting Hypothesis 3. The direct effect of transformational leadership on knowledge management is significant, indicating that leadership involvement is positively associated with effective knowledge management practices. The results also support Hypothesis 4. Knowledge management (KM) shows a significant direct impact on INV (β = 0.386, p = 0.002). This finding confirms the role of effective knowledge management in fostering greater investments.

Regarding the mediation effects, the results support Hypothesis 5. Knowledge Management (KM) demonstrates a mediating effect between Transformational Leadership (TL) and Financial Innovation (FI) (β = 0.219, p = 0.007). This indirect effect indicates that transformational leadership primarily influences financial innovation through effective knowledge management practices. The findings also support Hypothesis 6, where KM mediates the relationship between TL and Investment (INV) (β = 0.201, p = 0.041). This suggests that transformational leadership enhances investments via efficient knowledge management. Notably, the mediation pathway of INV between KM and FI, as proposed in Hypothesis 7, shows marginal significance (β = 0.121, p = 0.096), indicating that INV acts as a partial mediator between KM and FI. This result is significant at the 90% confidence level (p = 0.096), implying a weak but noteworthy relationship. Substantively, with a coefficient of β = 0.12, the effect is small but marginal, contributing modestly to the overall pathway.

On the contrary, the sequential mediation path for Hypothesis 8 is not supported (p = 0.160). Substantive significance (β = 0.063) indicates that the contribution is small. Therefore, the impact of transformational leadership on frugal innovation is not effective through this long sequential chain. The results show that KM serves as the primary determinant of FI, whereas TL influences FI indirectly through its impact on KM and INV, as depicted in Figure 3.
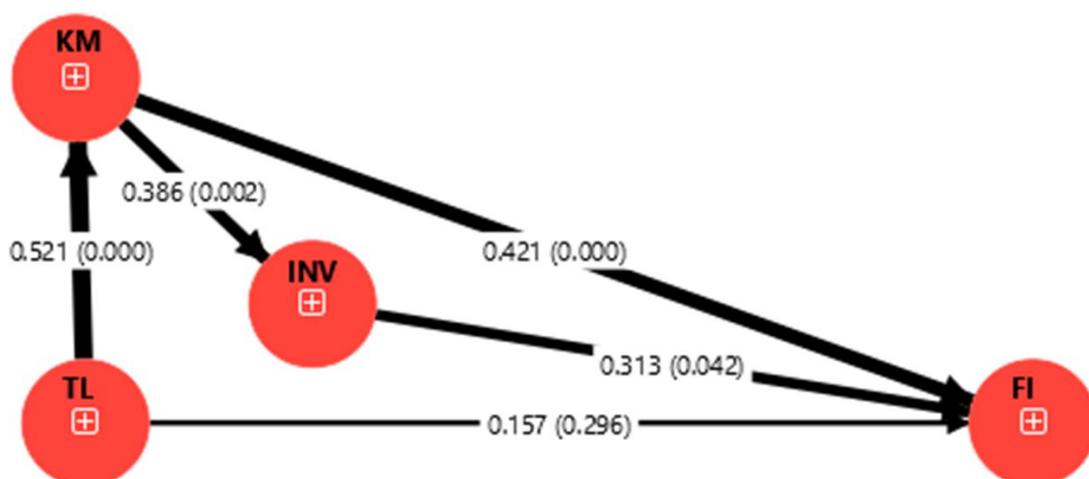

Figure 3. The representation of the path coefficients.

4.7. The Results of the Interviews

The qualitative analysis provides a means to explore complex human experiences. One widely used approach is thematic analysis, which focuses on identifying, analyzing, and interpreting recurring themes and patterns within the

data (Nowell, Norris, White, & Moules, 2017). In addition to the surveys, five interview questions were designed to align with the research framework and address the following factors: TL, FI, INV, and KM. After the interviews, the patterns and themes were identified and categorized using MAXQDA as shown in Table 14. The interpretations were then integrated with the quantitative findings to provide a comprehensive overview.

Table 14. The summary of the thematic analysis.

Main theme	Subtheme	Participant feedback	Total %
Knowledge management	Knowledge Sharing & Communication	Meetings (31.25%)	50%
		Information sharing (12.5%)	
		Opinion (6.25%)	
	Employee Awareness and Engagement	Conscious employees (6.25%)	25%
		Experience (6.25%)	
		Vision (6.25%)	
		Need-oriented (6.25%)	
	Training	Training (6.25%)	12.50%
		Guidance (6.25%)	
	Strategic knowledge allocation	Intellectual knowledge (6.25%)	12.50%
		Distribution channels (6.25%)	
Frugal innovation	Sustainable & efficient practices	Sustainable innovation (35%)	30.27%
		Biodegradable (5%)	
		Zero waste (5%)	
		Avoid overstock (3%)	
		Resourcefulness (4.17%)	
		Work potential/future (4.17%)	
		Perseverance (4.17%)	
	Frugal orientation & mindset	Frugal mindset (29.17%)	39.73%
		Virtues/characteristics (4.17%)	
		Enthusiastic (4.17%)	
		Frugal orientation & innovation mindset (41.68%)	
	Skills & competence	Competence (8.34%)	10.46%
		Certifications (4.17%)	
		Supervision (4.17%)	
		Experience (4.17%)	
	Technological & eco-innovation	Solar energy (11%)	12.04%
		R&D (5%)	
		New technology (5%)	
		Automation (3%)	
	Certification & recognition	Certificates (10%)	5.02%
	Non-engagement	We do not engage (5%)	2.51%
Investments	Green and technological investments	Green finance (47.06%)	64.70%
		Technology innovations (5.88%)	
		More efficient machinery (5.88%)	
		Newer technology (5.88%)	
	Strategic resource allocation	Allocates budget (5.88%)	5.88%
	Lack of participation	Not participating (29.41%)	29.41%
Transformational leadership	Leadership support & direction	Leadership guidelines (33.33%)	50%
		Right direction (8.33%)	
		Straightforward leader (8.33%)	
	Motivational Climate and Team Spirit	Team spirit (16.67%)	41.66%
		Teamwork (8.33%)	
		Like a friend (8.33%)	
		Look up to (8.33%)	
	Innovative leadership	Innovative leader (8.33%)	8.33%

The results reveal that approximately 50% of organizational learning occurs through informal communication and knowledge sharing, highlighting a strong reliance on interpersonal interactions rather than structured systems. Additionally, awareness and engagement (25%) underscore the value of a shared vision and active employee

involvement. Meanwhile, training and knowledge allocation (12%) reflect the firm's ongoing efforts to formalize and disseminate tacit knowledge. As noted by Heriyanti et al. (2022) information sharing and collaboration are fundamental to effective knowledge creation.

Question 1: *How would you manage the knowledge of your employees to enable them to implement frugal innovation?*

Response: *"I would manage it with the goal of increasing the speed of innovation practices by supporting them through regular information sharing, guidance, and training, and by ensuring quality work with more conscious employees."* (Female, Assistant Manager)

The second question asked whether companies adopt a frugal approach when hiring new employees. The results indicate that skills and competence, accounting for 10.46%, remain essential, with particular emphasis on technological and eco-innovation capabilities, which constitute 12.04%. This underscores the central role of human expertise in organizational success. Although not all firms invest equally in frugal innovation, it remains a key element of competitive advantage. Additionally, the presence of non-engagement, at 2.51%, and certification efforts, at 5.02%, highlights varying levels of commitment to frugal innovation across different companies. Employers tend to prioritize candidates who demonstrate both enthusiasm and competence, ensuring meaningful contributions to innovation initiatives.

Question 2: *Do you look for specific traits or capabilities when hiring new team members? Do you check for the existence of a frugal mindset?*

Response: *When recruiting new team members, we focus on their characteristics and virtues, and we seek individuals with a frugal mindset.* (Male, HR Manager)

The third question evaluates the extent to which firms are committed to sustainable innovations and the implementation of frugal practices. The results indicate that 35% of respondents prioritize eco-friendly innovations, while approximately 4.17% place greater emphasis on certifications. The leather industry recognizes the importance of certifications such as OEKO-TEX®, Sanitized®, and the Leather Working Group, which serve to demonstrate the quality of production. According to the findings, firms are increasingly focusing on sustainable development by adopting solar energy generation (11%) and waste-minimization techniques aligned with the principles of frugal innovation.

Question 3: *Does your firm engage in sustainable innovations? If yes, please provide examples of reusable resources used for innovation.*

Response 1: *Our company's participation in sustainable innovations is very high. For example, we use solar panels at our headquarters.* (Male, HR Manager)

Response 2: *"We established a new R&D laboratory. A machine revision was carried out in line with new technology."* (Female, Accountant)

The fourth question aimed to understand companies' participation rates in green innovation. Most firms prioritize technological and sustainability investments, with over 60% of respondents emphasizing green finance and research and development. This result suggests that adopting technological and sustainable practices is essential for maintaining a competitive edge in global markets. However, the limited participation by firms (29.41%) indicates potential barriers to investment, likely stemming from structural and financial constraints that hinder their efforts. A smaller group of respondents (5.88%) highlighted selective budgeting as a significant factor influencing resource allocation. The study also uncovered a notable discrepancy between companies that prioritize green innovations and those that do not.

Investment discussions in the leather industry primarily focused on green financing, reflecting a broader trend among companies that increasingly view environmental preferences and consumption patterns as key indicators of sustainability (Lin et al., 2023). The respondents emphasized the importance of knowledge management in supporting firms' efforts to enhance efficiency and sustainability. It demonstrates how effective knowledge management facilitates information sharing and promotes the development of employees' emotional and intellectual capabilities.

Consequently, it supports the pursuit of frugal innovation and enables more informed financial decisions that contribute to long-term sustainable growth.

Question 4: *Is your company interested in green finance? Do you consciously participate in or want to participate in green finance for green innovations?*

Response 1: *"Yes, we installed solar panels on the roof of the firm and reduced our electricity consumption."* (Male, Accountant)

Response 2: *Our company is interested in green financing and allocates a budget for a livable environment.* (Male, HR Manager)

The final question evaluated whether the leadership style aligned with the characteristics of transformational leadership. Over 50% of managers reported that they provide clear guidance and direction. Additionally, they demonstrated the ability to foster trust within their teams. The findings suggest that transformational leadership in the Turkish leather industry is associated with offering strategic direction and interpersonal support. More than half of the respondents emphasized that effective leaders offer guidance and motivation to their teams. Furthermore, 41.66% of respondents highlighted trust-building as a vital component of leadership, reinforcing the importance of collective commitment and team cohesion in driving innovation (Lei et al., 2021). Interestingly, a small group of participants (8.33%) perceived leadership not just as the ability to generate new ideas but as the skill to guide both investors and employees toward informed decisions. This viewpoint expands the traditional notion of leadership by positioning innovation as a blend of creativity and strategic decision-making that aligns firm goals with market dynamics.

Question 5: *How would you describe your leadership style? Do you follow specific patterns or guidelines when working on an innovation project?*

Response: *"I can define her as an innovative leader who cares about team spirit and provides the right direction by carefully following instructions."* (Female, Manager).
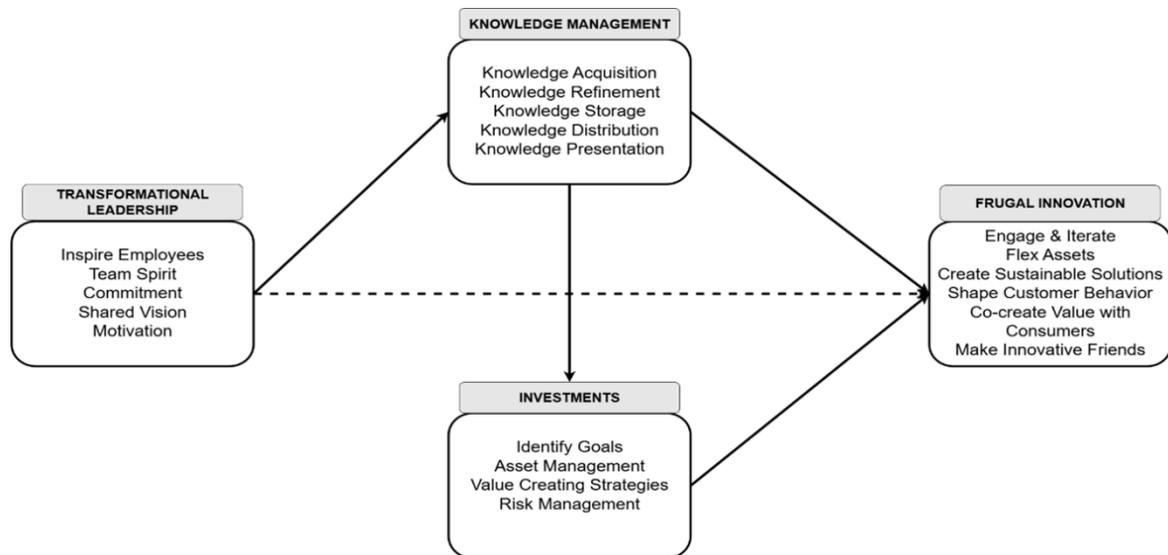

Figure 4. The final proposed model for the Turkish leather firms.

The final model in Figure 4 shows that knowledge management serves as the primary catalyst for frugal innovation, both through its direct effects and by facilitating effective investment decisions. Transformational leadership does not directly impact frugal innovation but rather contributes indirectly by enhancing knowledge management practices, thereby promoting frugal innovation outcomes.

5. DISCUSSIONS

The findings of this study highlight knowledge management as a critical driver of frugal innovation. In line with prior studies (López-Cabarcos et al., 2020; López-Sánchez & Santos-Vijande, 2022; Nonaka & Takeuchi, 1996), the results indicate that knowledge, as a strategic resource, can be effectively leveraged to foster innovation, particularly in resource-constrained environments. Moreover, investments, especially those focused on technological advancements and sustainability further enhance the impact of knowledge management on frugal innovation, underscoring the need for prudent resource allocation to support innovation. The results also suggest that transformational leadership does not directly influence frugal innovation; instead, its effect is mediated by knowledge management and, indirectly, by investments. This finding partially contradicts the results of previous studies (Fan et al., 2023; Madi et al., 2023; Nonaka et al., 2000; G. Wang et al., 2023), where authors argue that knowledge management is the main factor promoting frugal innovation. Hence, leaders should foster a culture of knowledge sharing to facilitate frugal innovation.

For companies that leverage learning to make financial decisions, investing in efficient technologies can help them achieve innovative outcomes. These results align with the findings of prior studies (Lin et al., 2023; Santos, Borini, Oliveira, Rossetto, & Bernardes, 2022), and are particularly important for emerging markets, where firms face rising costs and strict environmental regulations. Ultimately, transformational leaders are recognized for fostering trust and vision, which are crucial for firms to make informed decisions about managing the company's knowledge flow.

6. CONCLUSIONS

The study examines how knowledge management, investment decisions, and transformational leadership facilitate the development of frugal innovation in Turkish manufacturing leather companies. The topic warrants attention as frugal innovation, grounded in the "do more with less" mindset, is relevant to the industry's efforts to balance cost efficiency with sustainability in response to global competition. This research extends the concept of frugal innovation to manufacturing settings, demonstrating that an organizational culture that values knowledge and leadership can help achieve sustainable results in challenging environments. Investments also influence frugal innovation through their role in driving innovation under resource constraints. The impact of transformational leadership on frugal innovation and investment is mediated by knowledge management, highlighting the importance of organizational collaboration over direct leadership influence. Effective knowledge management practices enhance investment and, consequently, frugal innovation. By implementing effective leadership and knowledge-sharing initiatives, firms can improve their ability to align human and financial resources with frugal innovation practices.

6.1. Theoretical Implications

The findings of this study advance the KBV theory by suggesting that effective knowledge management within firms functions as a dynamic mechanism. This mechanism operates through transformational leadership and financial investments, which can be translated into sustainable outcomes via knowledge management practices, thereby empowering frugal innovation. In this context, transformational leadership influences frugal innovation indirectly through knowledge management, rather than directly through investments.

6.2. Practical Implications

The findings offer valuable insights for managers in the leather industry, particularly those in emerging markets. First, leather firms should prioritize establishing robust knowledge management systems. Since knowledge management is a vital component of frugal innovation, targeted investments in these systems can yield substantial returns. This can be achieved by leveraging market intelligence and internal expertise to align financial decisions with a firm's goals. Additionally, investment strategies that prioritize sustainability and eco-friendly operations may

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enhance competitiveness in international markets, as compliance with environmental standards becomes increasingly important. Transformational leaders can foster environments that encourage experimentation, inspiration, and partnership, which align with the principles of frugal innovation. In this context, firms may invest in robust knowledge management systems to ensure the flow of knowledge across departments. They can conduct regular meetings where ideas and concerns are shared, and solutions are stored on digital platforms for easy access.

6.3. Limitations and Future Research Avenues

We acknowledge that this study has certain limitations. Firstly, it exclusively focuses on Turkish leather companies, which restricts the generalizability of the findings. Since the manufacturing industry exhibits distinct operational characteristics across different countries, varying results can be anticipated due to differences in leadership, sustainability, and innovation practices among firms. Therefore, cross-sectoral and cross-country analyses could offer a more comprehensive understanding of how contextual factors influence frugal innovation in other emerging markets. Secondly, the emergence of partial mediation after incorporating investment decisions into the model indicates that future research should consider moderating variables such as market turbulence and policy shifts to produce more robust results. Lastly, the qualitative insights were obtained from the same firms that participated in the survey, which may introduce common-method bias. This issue can be mitigated by employing alternative methods or data sources. Future studies might also explore non-financial factors and technological advancements to deepen the understanding of the research questions.

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