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AI-ENABLED FRUGAL INNOVATION: EXTENDING THE DYNAMIC CAPABILITIES FRAMEWORK FOR SUSTAINABLE DEVELOPMENT

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ABSTRACT

This study examines the drivers of frugal innovation in small and medium-sized enterprises (SMEs) in Jordan, with a focus on artificial intelligence (AI) capability as a digital capability supporting sustainable development within the dynamic capabilities framework. Specifically, it investigates the effects of institutional leverage capability, sustainability orientation, strategic flexibility, and AI capability on frugal innovation. A quantitative research design was applied using data from 389 SMEs across various sectors in Jordan. Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS was used to test the proposed model. Frugal innovation was conceptualized as a second-order construct comprising substantial cost reduction, emphasis on essential functionality, and value optimization. The findings reveal that institutional leverage capability, sustainability orientation, strategic flexibility, and AI capability all have significant positive effects on frugal innovation. Results highlight the importance of organizational and digital capabilities in enabling firms to innovate under resource constraints while supporting sustainable development goals. AI capability emerges as a key digital dynamic capability that enhances opportunity sensing, resource optimization, and process redesign in cost-effective and sustainable ways. This study extends dynamic capabilities theory and offers practical implications for managers and policymakers seeking to promote sustainable and inclusive innovation.

Keywords: *conscious consumption, frugal innovation, institutional leverage capability, strategic flexibility, artificial intelligence capability, sustainable development*

1. INTRODUCTION

Organizations are increasingly expected to remain competitive while addressing sustainability challenges in an era marked by resource scarcity, socioeconomic inequality and environmental pressures (Feng et al., 2023). These challenges are particularly significant for small and medium-sized enterprises (SMEs), which often operate under financial, technological, and institutional constraints (De Massis et al., 2018). In such contexts, frugal innovation has emerged as an important strategic approach, enabling firms to develop cost-effective solutions by emphasizing efficiency, substantial cost reduction, essential functionality, and value optimization while meeting core customer needs (Bag et al., 2025; Fisac-Garcia et al., 2025).

Frugal innovation is increasingly relevant not only in emerging economies but also in developed markets, where inflationary pressures, sustainability regulations, and changing consumption patterns are reshaping demand (Sacanamboy-Trujillo & Escandono-Barbosa, 2025). Beyond cost reduction, however, successful frugal innovation requires organizational capabilities that allow firms to adapt to dynamic environments and reconfigure resources effectively. The dynamic capabilities framework provides a suitable theoretical lens for understanding how firms sense opportunities, seize them through strategic decisions, and transform resources and processes to maintain competitiveness (Mele et al., 2024; Cavusgil & Deligonul, 2025).

Within this framework, institutional leverage capability, sustainability orientation, and strategic flexibility represent important organizational drivers of frugal innovation. Institutional leverage capability enables firms to access external resources such as government programs, industry associations, and regulatory support (Landau et al., 2016; Chatterjee et al., 2024). Sustainability orientation integrates environmental, social, and economic considerations into organizational strategies, promoting responsible and efficient innovation practices (Adiguzel et al., 2024; Iqbal et al., 2025). Strategic flexibility allows firms to reconfigure resources and adapt strategies in response to uncertainty and market changes (Asad & Asif, 2025; Ceptureanu et al., 2025).

At the same time, digital transformation is reshaping organizational decision-making and innovation processes. Artificial intelligence (AI) has emerged as a critical digital capability that enhances data analytics, decision-making quality, operational efficiency, and resource optimization (Borissov & Hristozov, 2024; Adiguzel et al., 2024; AlDhaheri et al., 2025). AI-powered systems enable firms to analyze large volumes of data, reduce waste, optimize resources, and respond more effectively to uncertainty (Jogarao et al., 2024; Ning, 2024). From a dynamic capabilities perspective, AI capability can be conceptualized as a digital dynamic capability supporting firms' sensing, seizing, and transforming activities (De Fano et al., 2025).

Despite these advantages, limited research has examined the role of AI capability in facilitating frugal innovation, particularly in resource-constrained and sustainability-oriented contexts. Existing studies have largely examined frugal innovation, dynamic capabilities, and AI separately, without integrating these constructs into a unified framework. This gap is particularly relevant in emerging economies, where firms face resource limitations while simultaneously pursuing digital transformation and sustainable development.

To address this gap, this study extends the dynamic capabilities framework by incorporating AI capability as a digital enabler of frugal innovation. Specifically, it examines the effects of institutional leverage capability, sustainability orientation, strategic flexibility, and AI capability on frugal innovation among SMEs in Jordan. SMEs provide an appropriate empirical context due to their important role in economic growth, innovation, and employment generation, alongside their significant resource constraints.

Accordingly, this study addresses the following research questions:

RQ_1: What is the effect of institutional leverage capability on frugal innovation in SMEs?

RQ_2: What is the effect of sustainability orientation on frugal innovation in SMEs?

RQ_3: What is the effect of strategic flexibility on frugal innovation in SMEs?

RQ_4: What is the effect of AI capability on frugal innovation in SMEs?

This study has three objectives. First, it examines the effects of institutional leverage capability, sustainability orientation, and strategic flexibility on frugal innovation. Second, it investigates AI capability as a digital dynamic capability supporting frugal innovation. Third, it extends the dynamic capabilities framework by integrating AI capability into the frugal innovation model to provide deeper insight into sustainable innovation under resource-constrained conditions.

This research contributes to the literature in three ways. First, it extends dynamic capabilities theory by conceptualizing AI capability as a digital dynamic capability facilitating frugal innovation. Second, it advances frugal innovation literature by demonstrating that frugal innovation is driven not only by cost reduction but also by the interaction of organizational and digital capabilities. Third, it provides empirical evidence from Jordanian SMEs, offering insights into how institutional, strategic, and digital capabilities can support sustainable development in emerging economies.

The remainder of this paper is organized as follows. Section 2 presents the theoretical framework and hypotheses development. Section 3 describes the research methodology. Section 4 reports the empirical findings. Section 5 discusses the results, theoretical and managerial implications, limitations, and future research directions.

2. LITERATURE REVIEW AND THEORETICAL DEVELOPMENT

2. 1. FRUGAL INNOVATION AND SUSTAINABLE DEVELOPMENT

Sustainable development refers to a development model that balances economic viability, social inclusion, and environmental protection (Al-khatib & Alghababsheh, 2025; Sang & Anh, 2026). With the implementation of the United Nations Sustainable Development Goals (SDGs), organizations face increasing pressure to integrate sustainability principles into their strategic priorities by placing environmental and social concerns at the core of business activities (Nie et al., 2025; Guidi et al., 2025). In this context, innovation has become a critical mechanism through which firms pursue sustainable growth while maintaining competitiveness in dynamic and highly regulated markets (Sathiyaseelan et al., 2024).

Frugal innovation has emerged as a particularly relevant innovation model under these conditions. It refers to the development of products, services, processes, or business models that deliver essential functionality at substantially reduced cost while maintaining acceptable quality standards (Kusumawardhany et al., 2025). Unlike traditional innovation models, which often depend on significant financial resources and advanced technologies, frugal innovation emphasizes simplicity, efficiency, and the creative use of limited resources (Czyżewska-Misztal et al., 2025).

Recent studies identify three core dimensions of frugal innovation: substantial cost reduction, focus on essential functionality, and value creation for low-income or underserved markets (Onsongo & Knorringa, 2025). These dimensions are achieved through lean design, modular architecture, and resource optimization practices (Stjepandic et al., 2025). As a result, frugal innovation enables firms to deliver more affordable solutions, reduce waste, and promote inclusive consumption patterns.

From a sustainability perspective, frugal innovation contributes to economic efficiency, social inclusion, and environmental responsibility by reducing material intensity, limiting unnecessary consumption, and improving access to affordable solutions for broader segments of society (Sacanamboy-Trujillo & Escandón-Barbosa, 2025). Therefore, frugal innovation is increasingly relevant in both emerging and developed economies, where inflationary pressures, regulatory requirements, and sustainability awareness continue to reshape market demand.

2. 2. DYNAMIC CAPABILITIES AS A FOUNDATION FOR FRUGAL INNOVATION

Dynamic Capabilities Theory provides a strong theoretical framework for explaining how firms innovate under uncertain, volatile, and resource-constrained conditions (Agrawal et al., 2025; Naz et al., 2022). While the traditional Resource-Based View emphasizes valuable, rare, inimitable, and non-substitutable resources, it has been criticized for offering limited insight into

how firms adapt to rapidly changing external environments (Naila et al., 2025). Dynamic capabilities address this limitation by focusing on a firm's ability to integrate, build, and reconfigure internal and external competencies in response to environmental change (Joussen et al., 2025).

The theory is commonly conceptualized through three interrelated processes: sensing, seizing, and transforming (Mele et al., 2024; Li et al., 2025). Sensing refers to identifying market opportunities, emerging customer needs, and external threats. Seizing involves mobilizing resources and making strategic decisions to capitalize on identified opportunities. Transforming reflects the continuous renewal of organizational structures, processes and resource configurations to sustain long-term competitiveness (Engelmann, 2024; Soliman et al., 2025; Albannai et al., 2025).

These capabilities are particularly relevant in resource-constrained environments, where firms frequently face institutional voids, market fragmentation, and operational uncertainty. In such settings, innovation depends less on resource abundance and more on managerial agility and organizational responsiveness. Frugal innovation is conceptually aligned with dynamic capabilities, as both emphasize efficiency, flexibility and the creative recombination of scarce resources (Sacanamboy-Trujillo & Escandón-Barbosa, 2025). Firms pursuing frugal innovation must sense unmet needs in underserved markets, seize opportunities by developing cost-effective solutions, and transform internal processes to create value with limited resources. Therefore, frugal innovation should be viewed not merely as an outcome of technical efficiency, but as a strategic outcome enabled by dynamic organizational capabilities.

2. 3. ORGANIZATIONAL CAPABILITIES DRIVING FRUGAL INNOVATION

Based on Dynamic Capabilities Theory, prior research suggests that firms require specific organizational capabilities to innovate effectively under resource constraints. Rather than relying solely on financial or technological abundance, frugal innovation depends on capabilities that enable firms to access external resources, align innovation with sustainability objectives, and respond dynamically to changing market conditions. In this context, institutional leverage capability, sustainability orientation and strategic flexibility emerge as particularly relevant antecedents of frugal innovation.

These capabilities represent complementary mechanisms through which firms sense opportunities, seize market potential, and transform internal processes. Institutional leverage capability facilitates access to external support systems, networks, and legitimacy. Sustainability orientation guides innovation toward the creation of long-term economic, environmental and social value. Strategic flexibility enables rapid resource reallocation and adaptive strategic responses to environmental uncertainty. Collectively, these capabilities form the organizational foundation necessary for the successful implementation of frugal innovation.

2. 3. 1. INSTITUTIONAL LEVERAGE CAPABILITY

Institutional leverage capability refers to a firm's ability to identify, access, and utilize resources embedded within its institutional environment, including government agencies, industry associations, universities, and regulatory systems (Landau et al., 2016). Through these channels, firms can acquire external knowledge, financial support, legitimacy, and strategic networks that help compensate for internal resource limitations (Chatterjee et al., 2024). This capability is particularly important in emerging economies, where institutional frameworks play a critical role in shaping business growth and innovation performance (Luiz et al., 2017). By leveraging institutional resources, firms can reduce uncertainty, improve market access, and strengthen their ability to develop cost-effective solutions that meet quality and affordability requirements (Dai et al., 2025). Therefore, firms with stronger institutional leverage capability are more likely to engage successfully in frugal innovation.

H_1. Institutional leverage capability positively influences frugal innovation.

2. 3. 2. SUSTAINABILITY ORIENTATION

Sustainability orientation reflects the extent to which firms integrate environmental, social, and economic considerations into strategic decision-making. Firms with a strong sustainability orientation typically emphasize long-term value creation, stakeholder responsiveness, and efficient resource utilization. This orientation is closely aligned with frugal innovation, which prioritizes waste reduction, operational efficiency, affordability, and inclusive value creation. Firms with a sustainability-driven mindset are more likely to develop innovations that reduce energy consumption, minimize waste, and balance commercial objectives with broader societal interests (Adiguzel et al., 2024; Iqbal et al., 2025). Consequently, sustainability-oriented firms are more likely to adopt and successfully implement frugal innovation practices.

H_2. A firm's sustainability orientation positively influences frugal innovation.

2. 3. 3. STRATEGIC FLEXIBILITY

Strategic flexibility refers to a firm's ability to adapt its strategies and reallocate resources in response to changes in internal and external environments (Asad & Asif, 2025). Firms with high strategic flexibility can modify operating models, explore alternative innovation pathways, and respond rapidly to environmental shifts. This capability is particularly important for frugal innovation, which often requires experimentation, rapid adaptation, and continuous refinement as customer needs and resource availability evolve (Truong Thi Phuong & Le, 2025). Strategic flexibility also helps firms manage uncertainty and innovation-related risks while maintaining operational efficiency (Mangi et al., 2025). Therefore, firms with greater strategic flexibility are better positioned to successfully implement frugal innovation strategies.

H_3. A firm's strategic flexibility positively influences frugal innovation.

2. 4. ARTIFICIAL INTELLIGENCE AS A DIGITAL DYNAMIC CAPABILITY

Artificial intelligence (AI) has emerged as a transformative capability that enables firms to improve decision-making, enhance operational efficiency, and adapt more effectively to changing market conditions. AI encompasses a broad range of technologies, including machine learning, predictive analytics, intelligent decision-support systems, natural language processing, and process automation (George & Wooden, 2025). As organizations increasingly pursue digital transformation, AI has become a strategic asset for improving responsiveness, operational performance, and innovation outcomes.

Although prior research has extensively examined AI in relation to productivity, digital transformation, and firm performance, its role in frugal innovation remains underexplored (Alzubi, 2025; Saleem et al., 2024). This gap is particularly relevant in resource-constrained environments, where firms must create value efficiently while operating under uncertainty.

From a Dynamic Capabilities Theory perspective, AI capability can be conceptualized as a digital dynamic capability that strengthens firms' sensing, seizing, and transforming processes. First, AI enhances sensing by enabling firms to identify changes in customer preferences, resource availability, and market trends through advanced data analytics. Second, AI supports seizing by improving pricing decisions, resource allocation, forecasting accuracy, and strategic responsiveness (Al-khatib & Alghababsheh, 2025; Khalifeh et al., 2025). Third, AI facilitates transformation by enabling workflow redesign, process automation, and the development of more efficient business models (Mussalam et al., 2025; Qin, 2024).

These capabilities are particularly valuable for frugal innovation. In resource-constrained set-

tings, AI can help firms reduce waste, optimize limited resources, shorten development cycles, and deliver cost-effective solutions aligned with sustainability objectives (Dubey et al., 2022). Additionally, AI strengthens existing organizational capabilities by improving information processing and decision-making under uncertainty (Jayabalan & Dorasamy, 2024). However, empirical research examining AI capability alongside institutional leverage capability, sustainability orientation, and strategic flexibility in explaining frugal innovation remains limited. Therefore, this study proposes the following hypothesis:

H_4. *AI capability positively influences frugal innovation.*

2. 5. RESEARCH GAP AND CONCEPTUAL POSITIONING

Despite growing interest in frugal innovation, the existing literature remains fragmented in several important ways. First, prior studies have typically examined antecedents of frugal innovation in isolation, focusing separately on institutional factors, strategic orientations, or organizational flexibility. Limited attention has been given to how multiple organizational capabilities interact to drive frugal innovation within an integrated theoretical framework.

Second, although artificial intelligence (AI) is increasingly transforming business functions, its role as a strategic asset supporting frugal innovation remains underexplored. Existing research has primarily examined AI in relation to automation, productivity, and digital transformation, rather than as an enabler of cost-efficient and sustainability-oriented innovation.

Third, the relationship between frugal innovation and sustainable development requires further theoretical development, particularly in emerging market contexts characterized by resource constraints, institutional complexity, and market volatility.

To address these gaps, this study develops an integrated model grounded in Dynamic Capabilities Theory. Specifically, it examines the combined effects of institutional leverage capability, sustainability orientation, strategic flexibility, and AI capability on frugal innovation. This study makes three key theoretical contributions. First, it extends Dynamic Capabilities Theory by demonstrating that frugal innovation can be understood as an outcome of synergistic organizational and digital capabilities. Second, it introduces AI capability as a digital dynamic capability within the frugal innovation literature. Third, it contributes to sustainability research by explaining how firms can simultaneously pursue affordability, efficiency, and broader environmental and social objectives through frugal innovation. Accordingly, the proposed framework offers a more comprehensive understanding of how firms can leverage internal and external resources to achieve innovation-driven sustainable development.

3. METHODOLOGY

3. 1. PROCEDURE AND SAMPLING

The study adopted a quantitative research approach to examine frugal innovation among SMEs in Jordan. SMEs represent a vital segment of the Jordanian economy, contributing to innovation, employment generation, and economic development, making them an appropriate empirical context for investigating frugal innovation in resource-constrained environments.

To ensure representativeness, firms were selected from national business registries and commercial databases covering different economic sectors in Jordan (Legate et al., 2023; Loukili et al., 2023). A random sampling procedure was applied, resulting in an initial sample of 403 SMEs actively engaged in innovation-related activities. The sectoral distribution included manufacturing (30%), covering food processing and consumer goods; services (25%), including technical support and consulting; retail (20%), comprising traditional and online

commerce; agriculture (15%), focused on agro-industrial activities; and construction (10%), including commercial and residential projects.

Data were collected in 2025 using a structured questionnaire distributed to innovation managers and senior decision-makers, as they are directly involved in strategic and innovation-related decisions. Respondents assessed the study constructs using a five-point Likert scale, ranging from 1 = strongly disagree to 5 = strongly agree. The questionnaire measured organizational capabilities, sustainability orientation, strategic flexibility, artificial intelligence capability, and frugal innovation practices (Alrifae et al., 2026; Abu-AlSondos, 2025).

After data screening, 389 valid and complete responses were retained for analysis. The high number of valid responses indicates strong participation among Jordanian SMEs and provides a reliable empirical basis for examining frugal innovation under conditions of resource scarcity. The demographic characteristics of the respondents are presented in Table 1.

Table 1. Demographic data

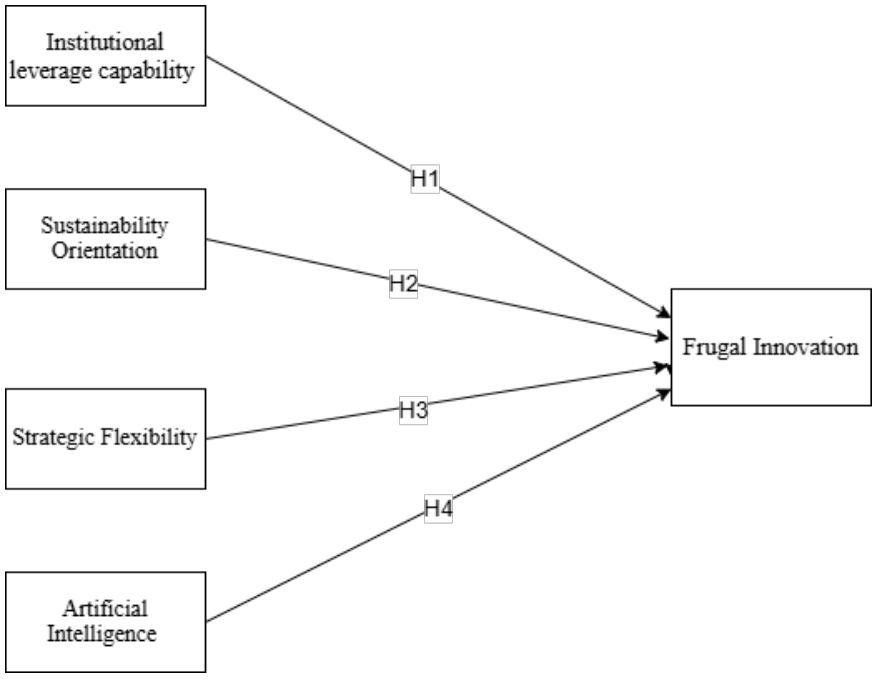
Variable	Description	Number	Percentage
Gender	Female	148	38%
	Male	241	62%
Years of experience in innovation-related positions	< 5 years	78	20%
	5–10 years	136	35%
	> 10 years	175	45%
Firm size (number of employees)	Micro enterprises (1–9)	58	15%
	Small enterprises (10–49)	136	35%
	Medium enterprises (50–250)	195	50%

Source: The Author

3. 2. MEASUREMENTS AND VALIDATION

To measure the constructions that were incorporated in this study, validated and well-known scales that had been used in previous studies were used as shown in the theoretical model in Figure 1.

Figure1. Research model



Source: The Author

In the proposed model, frugal innovation was conceptualized as a second-order construct comprising three key dimensions: significant cost reduction, core functionality, and value proposition. This conceptualization was grounded in the frugal innovation literature, including the seminal and highly cited work of Niroumand et al. (2021), which emphasizes affordability, efficiency, and essential functionality in innovation design for resource-constrained markets.

The core functionality dimension reflects low-cost innovation practices based on simple, efficient, and durable designs that prioritize essential features over non-essential attributes. It captures the extent to which firms develop solutions that effectively meet the basic needs of customers with limited resources while remaining relevant to the target market. The value proposition dimension complements this perspective by emphasizing the delivery of quality solutions at affordable prices, thereby ensuring a favorable cost–benefit ratio for customers.

Previously validated instruments were used to measure the independent variables. Institutional leverage capability was assessed using modified scales developed by Tomatis et al. (2011) and Xu and Song (2021), capturing the extent to which firms use institutional resources and external relationships to enhance innovation capacity. Strategic flexibility was measured using scales developed by Beach et al. (2000) and Combe et al. (2012), reflecting firms' ability to adjust strategic direction and resource allocation in response to changing market conditions. Sustainability orientation was measured using validated scales proposed by Dabija et al. (2017) and Na-Nan et al. (2024), covering environmental, social, and economic sustainability considerations in strategic and operational processes.

Artificial intelligence capability was treated as a first-order construct reflecting firms' ability to adopt and apply AI-based technologies, including data analytics, intelligent decision-support systems, and automation, in organizational practices and managerial decision-making (Alzubi, 2025; Mansour et al., 2023). This construct represents a digital dynamic capability that supports sensing, seizing, and transforming activities in firms pursuing frugal innovation.

To ensure the reliability and validity of the measures, preliminary analyses were conducted using SmartPLS. Descriptive statistics were calculated to summarize respondent and firm characteristics. Convergent validity was confirmed through statistically significant factor loadings exceeding the recommended threshold of 0.50 (Alzuod et al., 2025; J. F. Hair et al., 2019). Discriminant validity was established by confirming that correlations between different constructs were lower than correlations within the same construct. In addition, all constructs reported composite reliability values above 0.70 and average variance extracted values above 0.50, indicating strong reliability and convergent validity (Al-Maaitah et al., 2026; Alrifae, 2025; Atieh et al., 2023).

3. 3. DATA ANALYSIS

To test the research hypotheses, the proposed model was analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) in SmartPLS. PLS-SEM is particularly suitable for studies involving complex models, multiple latent variables, higher-order constructs, and prediction-oriented research objectives. It is also appropriate when the aim is to extend theory rather than solely confirm established theoretical relationships.

The use of PLS-SEM was justified for three main reasons. First, the model includes several antecedents of frugal innovation. Second, frugal innovation was modeled as a second-order construct. Third, the study seeks to explain variations in frugal innovation within a resource-constrained environment. In addition, PLS-SEM does not require multivariate normality, making it suitable for survey-based managerial data.

The analysis was conducted in two stages. First, the measurement model was assessed to establish reliability and validity. Internal consistency reliability was examined using Cronbach's

alpha and composite reliability (CR), while convergent validity was evaluated through indicator loadings and average variance extracted (AVE). Discriminant validity was assessed using the Fornell–Larcker criterion and the heterotrait–monotrait ratio (HTMT).

Second, the structural model was evaluated using path coefficients, the coefficient of determination (R^2), effect size (f^2), and predictive relevance (Q^2). The significance of the structural paths was tested through bootstrapping with 5,000 resamples, generating t-values, p-values, and confidence intervals. Finally, multicollinearity was examined using the variance inflation factor (VIF). All diagnostic indicators were within the recommended thresholds, confirming the adequacy and robustness of the proposed model.

4. RESULTS

4. 1. MEASUREMENT MODEL ASSESSMENT

The measurement model was assessed following the two-step procedure recommended for Partial Least Squares Structural Equation Modeling. Prior to testing the structural relationships, reliability, convergent validity, and discriminant validity were evaluated.

Internal consistency reliability was examined using Cronbach's alpha and composite reliability (CR). All constructs exceeded the recommended threshold of 0.70, indicating acceptable reliability (Abualrejal Ali et al., 2021; Mohammad et al., 2024; Al-Maaitah et al., 2026). Convergent validity was assessed through outer loadings and average variance extracted (AVE). All indicator loadings were statistically significant and above the minimum acceptable value of 0.50, while AVE values exceeded the recommended threshold of 0.50. These findings confirm adequate convergent validity and indicate that the indicators appropriately measure their respective latent constructs.

Table 2. Reliability and Convergent Validity

Construct	Cronbach's α	CR	AVE
Institutional Leverage Capability	0.88	0.91	0.62
Sustainability Orientation	0.86	0.90	0.60
Strategic Flexibility	0.84	0.89	0.58
AI Capability	0.87	0.91	0.63
Frugal Innovation (2nd order)	0.90	0.93	0.65

Source: The Author

4. 2. DISCRIMINANT VALIDITY ASSESSMENT

Discriminant validity was assessed to ensure that each construct was conceptually and empirically distinct from the other constructs in the model. Following established PLS-SEM procedures, discriminant validity was evaluated using the Fornell-Larcker criterion and the heterotrait–monotrait ratio (HTMT) (Hair et al., 2019; Hair & Alamer, 2022). First, the Fornell–Larcker criterion showed that the square root of the average variance extracted (AVE) for each latent construct exceeded its correlations with all other constructs. This indicates that each construct shared more variance with its own indicators than with other constructs in the model, confirming satisfactory discriminant validity. Second, the HTMT ratio was used as an additional and more stringent assessment. All HTMT values were below the conservative threshold of 0.85, indicating adequate differentiation among the constructs and providing further support for discriminant validity. Taken together, these results confirm the conceptual and statistical distinctiveness of the constructs used in this study. Therefore, the measurement model demonstrates adequate discriminant validity and is suitable for subsequent structural model assessment.

Table 3. Fornell-Larcker Criterion

Construct	ILC	SO	SF	AI	FI
Institutional Leverage Capability (ILC)	0.787				
Sustainability Orientation (SO)	0.42	0.775			
Strategic Flexibility (SF)	0.39	0.45	0.762		
AI Capability (AI)	0.41	0.43	0.47	0.794	
Frugal Innovation (FI)	0.56	0.52	0.48	0.54	0.806

Source: The Author

Table 4. HTMT Ratios

Construct Pair	HTMT
ILC – SO	0.61
ILC – SF	0.58
ILC – AI	0.60
ILC – FI	0.73
SO – SF	0.64
SO – AI	0.62
SO – FI	0.71
SF – AI	0.66
SF – FI	0.68
AI – FI	0.74

Source: The Author

4. 3. FACTOR LOADINGS

Outer loadings were examined to further assess indicator reliability and confirm that each measurement item adequately represented its corresponding latent construct. According to Hair et al. (2019), outer loadings above 0.70 indicate strong indicator reliability, while loadings above 0.50 may be acceptable in exploratory research when overall construct reliability and validity are satisfactory. As presented in Table 5, all indicators loaded satisfactorily on their respective constructs, with loading values ranging from 0.76 to 0.88. These results indicate that the observed variables are strongly associated with their underlying latent constructs and contribute meaningfully to construct measurement. Specifically, the loadings for Institutional Leverage Capability ranged from 0.79 to 0.84, while those for Sustainability Orientation ranged from 0.78 to 0.83. Strategic Flexibility items showed loadings between 0.76 and 0.82. Artificial Intelligence Capability indicators ranged from 0.79 to 0.85, whereas Frugal Innovation indicators recorded the highest loadings, ranging from 0.84 to 0.88. Overall, these findings confirm the adequacy of the reflective measurement models and provide additional evidence of satisfactory indicator reliability.

Table 5. Factor Loadings

Construct	Item	Loading
Institutional Leverage Capability	ILC1	0.79
	ILC2	0.82
	ILC3	0.84
Sustainability Orientation	SO1	0.81
	SO2	0.83
	SO3	0.78
Strategic Flexibility	SF1	0.76
	SF2	0.80
	SF3	0.82
AI Capability	AI1	0.83
	AI2	0.85
	AI3	0.79
Frugal Innovation	FI1	0.86
	FI2	0.88
	FI3	0.84

Source: The Author

4. 4. STRUCTURAL MODEL ASSESSMENT

After confirming the adequacy of the measurement model, the structural model was assessed. Prior to hypothesis testing, collinearity diagnostics were examined using the variance inflation factor (VIF). All VIF values were below the recommended threshold of 3.0, indicating that multicollinearity was not a concern.

The model's explanatory power was evaluated using the coefficient of determination (R^2). The results showed strong explanatory power, with the proposed model accounting for 58% of the variance in frugal innovation ($R^2 = 0.58$). Predictive relevance was assessed through the blindfolding procedure, and the Q^2 value for frugal innovation was above zero, confirming the model's predictive relevance.

Finally, bootstrapping with 5,000 resamples was performed to test the significance of the hypothesized relationships. The standardized path coefficients, t-values, and p-values are presented in Table 6.

Table 6. Hypothesis Testing

Hypothesis	Path	β	t-value	p-value	Result
H_1	Institutional Leverage Capability → Frugal Innovation	0.32	6.21	<0.001	Supported
H_2	Sustainability Orientation → Frugal Innovation	0.27	4.98	<0.001	Supported
H_3	Strategic Flexibility → Frugal Innovation	0.21	3.87	<0.001	Supported
H_4	AI Capability → Frugal Innovation	0.29	5.44	<0.001	Supported

Source: The Author

These findings suggest that each of the suggested antecedents has a great impact in a positive direction on frugal innovation. The greatest effect was the institutional leverage capability, then AI capability, then sustainability orientation, and strategic flexibility.

4. 5. EFFECT SIZE, PREDICTIVE RELEVANCE, AND ROBUSTNESS CHECKS

Effect sizes (f^2) were assessed to determine the practical significance of each predictor in addition to statistical significance. In PLS-SEM, the f^2 statistic indicates the extent to which each

exogenous construct contributes to the explained variance of the endogenous construct when included in the model. Following Hair et al. (2019), values of 0.02, 0.15, and 0.35 indicate small, medium, and large effects, respectively.

As presented in Table 7, Institutional Leverage Capability ($f^2 = 0.18$) and Artificial Intelligence Capability ($f^2 = 0.16$) had medium effect sizes on Frugal Innovation. These findings suggest that institutional support and digital capabilities make meaningful contributions to frugal innovation performance. Sustainability Orientation ($f^2 = 0.11$) and Strategic Flexibility ($f^2 = 0.08$) demonstrated small to moderate effects, indicating that although their relative influence is lower, they remain important in supporting adaptive decision-making and responsible resource use.

Predictive relevance was assessed using the blindfolding procedure. The positive Q^2 value for Frugal Innovation confirms that the model has acceptable predictive relevance and can predict the endogenous construct. Additional robustness checks, including collinearity diagnostics and the consistency of bootstrapping results and path estimates, further supported the stability of the model. All VIF values were below the recommended thresholds, and the structural relationships were statistically significant, indicating no multicollinearity concerns.

Overall, these findings demonstrate that the proposed framework provides both explanatory power and predictive relevance for understanding frugal innovation among Jordanian SMEs.

Table 7. Effect Sizes

Path	f^2
Institutional Leverage Capability → FI	0.18
Sustainability Orientation → FI	0.11
Strategic Flexibility → FI	0.08
AI Capability → FI	0.16

Source: The Author

5. DISCUSSION

Sustainable development has become a central concern for both academic researchers and business practitioners, as it requires balancing economic growth, environmental protection, and social equity. In this context, frugal innovation has gained increasing attention as a promising pathway to sustainable development by offering affordable, high-value, and resource-efficient solutions for underserved markets. Accordingly, this study empirically examined the effects of institutional leverage capability, sustainability orientation, strategic flexibility, and artificial intelligence capability on frugal innovation among SMEs in Jordan.

The findings show that institutional leverage capability has a strong positive effect on frugal innovation. This suggests that regulatory incentives, government support schemes, university partnerships, and industry networks help firms overcome internal resource constraints and strengthen their innovation capacity. These results are consistent with Trincanato and Vagnoni (2024), who found that institutional support systems enhance firms' ability to achieve sustainable and cost-effective innovation. They also support broader emerging-market research emphasizing that firms operating in resource-constrained environments often depend on external ecosystems to compensate for limited internal resources. This study extends this literature by demonstrating the particular importance of institutional leverage capability for frugal innovation in Jordanian SMEs.

The results also indicate that sustainability orientation significantly enhances frugal innovation. Firms that integrate environmental, social, and economic objectives into strategic decision-making appear better positioned to develop responsible and affordable innovations.

This finding is consistent with Abbas et al. (2025) and Iqbal et al. (2025), who argued that sustainability-oriented firms are more likely to adopt efficient and socially valuable innovation models. The present results support the view that sustainability should not be seen merely as a cost burden, but rather as an innovation driver, particularly for SMEs seeking competitive differentiation, resource efficiency, and alignment with responsible consumption patterns.

Strategic flexibility was also found to positively influence frugal innovation. This indicates that firms capable of reallocating resources, adjusting strategic priorities, and responding rapidly to environmental changes are better able to innovate under conditions of uncertainty. This result is in line with Ceptureanu et al. (2025) and Mangi et al. (2025), who found that strategic adaptability supports innovative performance in turbulent markets. However, the relatively smaller effect size observed in this study may suggest that flexibility alone is insufficient unless supported by institutional resources and digital capabilities. This provides a more nuanced contribution to the literature by showing that strategic flexibility is most effective when combined with complementary organizational capabilities.

One of the most important findings of this study is the strong positive contribution of artificial intelligence capability to frugal innovation. AI capability improves firms' ability to sense market changes, optimize resource allocation, automate routine processes, and redesign operations in cost-effective ways. These findings are consistent with George and Wooden (2025) and Saleem et al. (2024), who emphasized the role of AI in improving decision quality, operational efficiency, and organizational responsiveness. While previous research has largely focused on digital transformation and productivity outcomes, this study extends the literature by showing that AI capability also functions as a digital dynamic capability that supports frugal innovation in resource-constrained SMEs. In this regard, AI strengthens firms' sensing, seizing, and transforming capabilities, consistent with Dynamic Capabilities Theory.

The findings have several implications for the Jordanian economy. In manufacturing, firms can use institutional support and AI-based analytics to reduce waste, improve supply chain efficiency, and lower production costs. Strategic flexibility can also help manufacturers adapt production processes to changing market conditions. In the service sector, institutional resources such as training programs and digital infrastructure can support affordable and sustainable service models, while AI-based customer analytics and digital platforms can improve service responsiveness and personalization. In retail, cooperation with institutional actors and investment in e-commerce infrastructure can facilitate new business models and market expansion. Sustainability practices, such as eco-friendly packaging and local sourcing, may also strengthen brand reputation among increasingly conscious consumers, while AI-driven demand forecasting and inventory optimization can improve responsiveness to changing consumer demand.

In agriculture, innovation grants, extension services, and other forms of institutional support can accelerate the adoption of cost-effective technologies. AI applications such as precision agriculture and climate analytics can further enhance resource efficiency, resilience, and productivity. In the construction sector, green certification systems, public–private partnerships, modular building techniques, and AI-assisted planning tools can help firms deliver affordable and environmentally sustainable construction solutions.

Overall, the findings suggest that frugal innovation is not merely the result of cost-reduction behavior, but rather an outcome of coordinated organizational, strategic, institutional, and digital capabilities. For resource-constrained SMEs, institutional support, sustainability commitment, strategic adaptability, and AI capability represent a powerful pathway toward innovation-driven sustainable development.

5. 1. THEORETICAL CONTRIBUTIONS

This study offers several theoretical implications for the literature on frugal innovation and Dynamic Capabilities Theory. First, the findings provide empirical evidence that frugal innovation is shaped by a combination of organizational, strategic, institutional, and digital capabilities, rather than being driven solely by cost-reduction motives. This advances the frugal innovation literature by positioning frugal innovation as a capability-based strategic outcome through which firms respond resourcefully to resource scarcity while contributing to sustainable development goals. In this sense, the study deepens understanding of how firms create economic, social, and environmental value through innovation. Second, the results show that institutional leverage capability is a strong enabler of frugal innovation. By effectively using regulatory incentives, government programs, industry associations, and collaborative networks, firms can compensate for limited internal resources and strengthen their innovation capacity. This finding is consistent with prior research emphasizing the role of institutional ecosystems in building competitive advantage, particularly in emerging economies. More importantly, this study extends that view by demonstrating that institutional leverage capability serves as a key facilitator of frugal innovation in resource-constrained contexts. Third, the study provides empirical support for the positive relationship between sustainability orientation and frugal innovation. This suggests that sustainability should not be viewed merely as an outcome of innovation, but as a central strategic driver. Firms that integrate environmental, social, and economic considerations into strategic decision-making are more likely to develop affordable, socially inclusive, and environmentally responsible innovations. This contribution strengthens the growing body of literature linking sustainability orientation with innovation capability. Fourth, the findings confirm the important role of strategic flexibility in supporting frugal innovation. Firms that can reallocate resources, adjust strategic priorities, and respond quickly to environmental changes are better positioned to innovate under uncertainty. This finding contributes to research on adaptability and strategic responsiveness by demonstrating its relevance in the specific context of frugal innovation. Finally, the study extends Dynamic Capabilities Theory by empirically showing that artificial intelligence capability can be conceptualized as a digital dynamic capability that significantly contributes to frugal innovation. AI capability strengthens firms' sensing, seizing, and transforming processes by improving decision-making, resource optimization, and process redesign. By integrating AI capability into the frugal innovation model, this study provides a more contemporary and nuanced explanation of how firms can achieve sustainable innovation in resource-constrained environments.

5. 2. MANAGERIAL IMPLICATIONS

In addition to its theoretical contributions, this study offers several important managerial implications, particularly for managers of resource-constrained SMEs. First, managers should actively develop institutional leverage capability by building relationships with government agencies, industry associations, financial institutions, and research centres. Access to external support systems can reduce innovation costs, improve knowledge acquisition, and enhance competitiveness. In the Jordanian context, national digital transformation initiatives and SME support programs may provide valuable opportunities for firms seeking to strengthen their innovation capacity. Second, sustainability principles should be integrated into strategic planning and operational decision-making. By incorporating environmental, social, and economic considerations into core business strategies, firms are more likely to develop frugal innovations that appeal to increasingly conscious consumers. In this regard, frugal innovation can serve as a source of competitive advantage while also reducing environmental impact, supporting circular economy principles, and strengthening corporate social responsibility. Third, the find-

ings highlight the strategic importance of artificial intelligence capability. Managers should not view AI merely as a technological investment, but as a strategic resource that can improve forecasting accuracy, automate routine processes, optimize resource allocation, and strengthen responsiveness to external changes. Combined with strategic agility, AI can help firms manage uncertainty more effectively and identify innovation opportunities. Fourth, managers should enhance strategic flexibility by promoting adaptive planning, decentralized decision-making, and rapid resource reallocation. Such flexibility enables firms to respond more effectively to changing customer needs, market uncertainty, and supply chain disruptions. Finally, branding and marketing strategies should simultaneously emphasize affordability, sustainability, and innovation. Firms that clearly communicate the value of cost-efficient and environmentally responsible solutions can strengthen consumer trust, loyalty, and long-term market positioning, particularly in price-sensitive markets.

5. 3. LIMITATIONS AND FUTURE RESEARCH

Despite its contributions, this study has several limitations that provide directions for future research. First, the study focused on a selected set of organizational, strategic, institutional, and digital capabilities. Future research could examine additional antecedents of frugal innovation, such as absorptive capacity, inter-organizational collaboration, digital maturity, leadership style, entrepreneurial orientation and technological readiness, to provide a more comprehensive understanding of frugal innovation processes. Second, firm performance outcomes were not explicitly included in the conceptual model. Future studies could extend the model by examining the effects of frugal innovation on financial performance, operational efficiency, market expansion, and sustainability performance. Third, the sample was limited to SMEs in Jordan, which may restrict the generalizability of the findings. Although Jordan provides a relevant emerging-economy context, future comparative studies involving both developed and developing economies would strengthen external validity. Further research on large firms could also clarify how conventional and frugal innovation models coexist within hybrid innovation systems. Fourth, the cross-sectional research design limits the ability to establish long-term causal relationships. Longitudinal studies would provide deeper insight into how frugal innovation and AI-enabled capabilities develop over time. Fifth, the study relied on quantitative self-reported survey data. Future research could adopt mixed-method approaches, including case studies, interviews, or panel data, to gain richer insights into managerial decision-making and implementation processes. In addition, multi-respondent research designs could help reduce potential common-method bias. Overall, future studies can build on these findings by further examining how firms combine organizational and digital capabilities to support innovation-driven sustainable development.

6. CONCLUSION

This paper examined the predictors of frugal innovation among Jordanian SMEs through the lens of Dynamic Capabilities Theory. Specifically, it analysed how institutional leverage capability, sustainability orientation, strategic flexibility, and artificial intelligence capability influence frugal innovation in resource-constrained business environments. The findings reveal that all four capabilities have positive effects on frugal innovation. Institutional leverage capability emerged as the strongest predictor, highlighting the importance of external support systems such as government programs, collaborative networks, and regulatory incentives. Artificial intelligence capability also showed a strong positive effect, indicating that digital intelligence, automation, and data-driven decision-making significantly enhance firms' ability to innovate effectively under resource constraints. Sustainability orientation and strategic flexibility were

also confirmed as important drivers, emphasizing the role of responsible strategic thinking and adaptive organizational behaviours. The study concludes that frugal innovation should not be viewed merely as a low-cost innovation strategy, but rather as a strategic outcome shaped by the interaction of organizational, institutional, strategic, and digital capabilities. The combination of external institutional resources, sustainability commitment, strategic responsiveness, and AI capability provides a viable pathway toward competitiveness and sustainable growth for SMEs in emerging economies. Theoretically, the study extends Dynamic Capabilities Theory by demonstrating the relevance of AI capability as a digital dynamic capability within the frugal innovation framework. Practically, the findings offer useful guidance for managers and policymakers seeking to improve SME resilience, innovation performance, and sustainability outcomes. Overall, the paper emphasizes that innovation-driven sustainable development depends not only on the availability of resources, but also on the intelligent recombination of scarce resources, strategic adaptability, and digitally enabled capabilities.

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