

# How can frugal innovation lead to SMEs resilience? Dual theory perspectives of diffusion of innovation and knowledge-based view

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## Abstract

In the context of limited resources, the ability of SMEs to handle knowledge and its dynamics is the key to successful businesses. Based on the theoretical framework of diffusion of innovation and knowledge-based theory, this research attempted to build the model of how community-based frugal innovation can increase SMEs resilience. A series of mediations of diverse knowledge sharing and knowledge integration were employed to predict this relationship. The research employed a quantitative method of analysis through surveys of 348 fashion and craft SMEs in the special region of Yogyakarta. Besides analysis of the results in general terms, the research employed partial least squares structural modeling to obtain coefficient values between latent variables. The results of the research regarding serial mediations showed that diverse knowledge sharing mediated the relationship between community-based frugal innovation and SMEs resilience. However, knowledge integration is not considered to mediate this relationship because it is not significant to SMEs resilience. The arguments of this research were examined in the discussion and implication section. The findings of this research addressed the unclear research gap in how frugal innovation can affect SMEs resilience through knowledge-based theory. Competitive advantages and resilience of SMEs in resource-poor environments rely on the extent to which SMEs can absorb and apply knowledge.

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**Keywords:** Frugal innovation, Community-based, Diverse knowledge sharing, Knowledge integration, SMEs resilience

## 1. Introduction

In the last few years, frugality has become a major area of interest for innovation researchers due to its general acceptance as a key strategy for organizations to operate in a limited resource environment [1]. The focus on optimal performance and cost-effectiveness through frugal innovation helps organizations to attain success in a limited resource environment [2]. The efficiency of frugal innovation further contributes to the development of a frugal ecosystem, which includes both social [3] and environmental aspects [4]. Previous studies have shown a strong relationship between frugal innovation and sustainability [5], [6]. However, several critical question

need to be answered. Can sustainability be a standalone solution for frugal small and medium-sized enterprises? Should organizations not explore and refine their ideas to determine what innovation strategy is more effective for them? In addition, is mere sustainability a solution for organizations in developing economies? Should they not explore more to navigate the complexities of management? Should they not develop a business mindset that is resilient [7] and willing to learn from failure [8] to move forward? Moreover, empirical evidence reveals that studies on the relationship between frugal innovation and SMEs resilience are limited in number [9].

In a resource-scarce environment, organizational obstacles to innovation are more challenging in comparison to those of large organizations, which have more resources at their disposal [10]. In addition, apart from managerial competence, the ability of the organization to be adaptable becomes essential, as frugal innovations require repetitive processes of trial and error to determine the most viable option [11]. On the other hand, dynamic capabilities help organizations build resilience to respond to the occurrence of extraordinary conditions [12] and return the organization to a state of normalcy after disruptions [8]. In most cases, the dynamics of the environment present unforeseen circumstances, which are beyond the predictive and control capabilities of the organization [13]. Without frugal innovations, the ability of the organization to build resilience becomes compromised, thus reducing the lifespan of the organization [11]. Although the role of frugal innovations as predictors of organizational resilience has not received adequate research attention, there is sufficient evidence of the role of frugality in building the robustness of the organization through the strategic utilization of scarce resources [9]. Fundamentally, frugal innovations compel entrepreneurs to see obstacles as essential components of success, thus the need for organizational resilience.

According to the diffusion of innovation theory, frugality is a non-static construct, since organizations can switch from frugal innovations to other forms of innovations as they grow, depending on the achievements, nature of the business, and the environment [14]. Although the study has largely focused on frugality, the DOI theory provides a good perspective on the role of frugal innovations as entrepreneurs continuously innovate to build organizational resilience [15]. The main processes of the DOI theory include innovation, channels of communication, social systems, and timing of diffusion [16], [17]. In a resource-scarce environment, SMEs rely on the availability of affordable external resources as a strategic input, thus remaining relevant. In the SME environment, social systems provide the basis for mutual benefits, especially through the transfer of knowledge [18]. These interactions help the SME community share experiences, best practices, problem-solving mechanisms, and other forms of knowledge, which are essential components of the diffusion of ideas among the members [19]. Considering the above argument, it is proposed that frugal innovations play a critical role in the sharing of knowledge, thus building the robustness of the organization.

Various arguments can be put forward to support this perspective. First, the DOI theory emphasizes that in a frugal context, knowledge sharing works as an antecedent as well as a consequence of frugal innovation [20]. In this study, knowledge sharing is considered to be an endogenous element in frugality, in which the diffusion process will continue even after successful innovation [21]. This can be particularly noted in environments with resource limitations, in which social exchange, particularly knowledge exchange, plays a vital role in SME communities to compensate for resource limitations [10]. Second, in community-based frugal innovation, knowledge is constantly shared among members to ensure its relevance in the face of changing situations and unexpected events. The community provides a platform in which relational and emotional ties are developed [18], which can create mutual trust and complementarities to enable SMEs to improve their capacity to face uncertainty in an effective manner [22]. Third, in environments with severe limitations, organizations cannot depend entirely on their available resources. In knowledge-driven economies, knowledge is perceived as the main engine for innovation [23]. In this context, diverse knowledge sharing and knowledge integration play a significant role in fostering learning, enhancing organizational efficiency, and strengthening the capacity to overcome possible failures [24].

Knowledge sharing embodies a range of cognitive understandings that provide organizations with access to valuable information resources [25]. According to the knowledge-based view (KBV), organizations achieve a

competitive advantage if they perform better than other organizations in accumulating, transferring, integrating, and applying knowledge [26]. This advantage assumes even greater importance for SMEs since they encounter rising pressures on knowledge resources. The limited internal capacities of the organizations force them to look for cost-effective external sources of support, and knowledge sharing provides a major answer to this problem [27]. Such sharing occurs spontaneously and informally through social interactions within the SME communities [28]. Due to the heterogeneous nature of communities, diverse knowledge sharing reflects the dynamics of knowledge exchange within communities and contributes to building organizational resilience. This practice of knowledge sharing occurs between different knowledge sources within the network [29]. Furthermore, knowledge integration assumes great importance for frugal organizations to improve the quality of the resilience capacities [30]. These processes of knowledge diversity and integration help the organizations to accumulate new knowledge and build correct perspectives to deal with complex challenges and deteriorating conditions of the organizations [20]. These processes not only build capabilities of the organizations but also enhance their effectiveness, enabling SMEs to become more agile, enabled, and resilient in the disruptive environment [8].

This study is based on an explanatory approach to research the direct effect of frugal innovation on SMEs' resilience through serial mediation of diverse knowledge sharing and knowledge integration. Previous studies have ignored frugality as a predictor of business resilience in SME organizations [7], [9]. Consequently, there is a lack of understanding of its potential to achieve positive outcomes. Previous studies have only established the relationship between frugality and value creation [21], sustainable business performance [24], business success, and functional performance in organizations [31]. Based on an extensive review of the existing literature, this study is among the first to explicitly investigate how frugal innovation contributes to SME resilience from a knowledge management perspective. In resource-constrained environments, knowledge emerges as the most critical intangible strategic asset, compensating for the inherent scarcity of internal resources. By optimizing knowledge outputs, frugal SMEs gain distinctive advantages in the form of advanced cognitive capabilities, unconventional problem-solving, and heightened sensitivity to development opportunities that may be overlooked by non-frugal organizations. This perspective highlights a clear research gap and underscores the novelty of this study in explaining resilience-building mechanisms through the interplay of frugal innovation and knowledge management. To bridge the gap in existing literature, we are using DOI and KBV theories to support the conceptual framework of the proposed study. KBV is particularly appropriate for organizations in a resource-constrained environment because SME organizations use knowledge-based resources to compensate for their limited resources and gain a competitive advantage. The rest of the paper includes hypothesis development (Section 2), research methodology (Section 3), results and discussion (Sections 4 and 5), and conclusion of the findings (Section 6).

## **2. Literature review and hypothesis development**

### **2.1. Frugal innovation and SMEs resilience**

Frugal innovation is a product, service, or solution developed in a constrained environment in terms of financial, technological, intellectual, and marketing resources [32]. The outcomes of frugal innovation are based on several key factors, such as product ergonomics, reducing costs, better performance, and sustainable frugality [33]. All these factors mutually influence one another to meet the needs of organizations in a constrained environment, such as SME organizations. Frugal organizations are efficient in using limited resources and time to develop creative solutions to inevitable business problems [21]. SMEs resilience is defined as an organization's ability to face and adapt to unusual changes and bounce back to normal by developing new routines [34]. It helps SME organizations to become more resilient and determined to achieve business success by learning meaningful lessons from business obstacles and failures [6]. Frugal innovation is directly related to business experiments, which help organizations become more resilient and determined to break through business impasses by encouraging adaptive thinking, resourceful decision-making, and practical learning from uncertain market conditions [7].

According to the DOI theory, communication channels and social systems such as SME communities function as vehicles to disseminate the positive mindset of frugality. The essence of this mindset can inspire other members [35] of the community. The key message of the frugal mindset is to seek the most feasible solutions to attain competitive advantage despite limited internal and external capabilities [31]. The dissemination of this mindset makes the organization more capable and dynamic in overcoming obstacles and adapting to unusual situations [36]. SMEs that function in resource-constrained environments have been found to be more competent and dynamic in recombining their capabilities to respond to uncertainty [12]. The agility of SMEs to respond to disruptive environments is mainly dependent on the extent of the organization's innovation capabilities to efficiently and functionally handle input resources [3]. In extremely vulnerable industries such as digital technology, digital transformation is frequently facilitated through the entrepreneurial perseverance of the organization to seize opportunities despite the unsupportive nature of the environment [37]. Thus, the following hypothesis is proposed:

H1: Frugal innovation has a positive and significant influence on SMEs resilience.

## **2.2. Frugal innovation and diverse knowledge sharing**

Within a community setting, frugal innovation promotes constructive associations among community members, which in turn stimulate the exchange of useful knowledge [11]. In a resource-scarcity setting, knowledge sharing is embedded in virtually all social interactions, either in the form of inquiry, discussion, experience-sharing, observation, or role modeling [38]. Such knowledge sharing is both offline and online, including through social media groups, facilitating the wide and timely circulation of knowledge [39]. From the KBV's point of view, where the key driver of competitive advantage is the ability to absorb and generate knowledge, a community of SMEs provides a diverse knowledge base that is freely available to its members [40]. Thus, frugal innovation provides a knowledge-rich environment that is a critical driver of organizational innovation capability [2].

Knowledge-based resources are important for frugal innovation, as business actors cannot rely on resources they do not have because of their inherent limitations. Thus, SMEs rely on the processes, methods, and innovation outcomes of their community as inputs in the value creation and knowledge sharing processes within their respective organizations [41]. Past research indicates the sustained impact of frugal innovation in fostering a knowledge-oriented culture characterized by the intensive exchange of knowledge, information, and business practices [42]. Although the development of innovation capabilities is a function of knowledge sharing, the achievement of innovation does not reduce the frequency of knowledge sharing activities in any way. The study in the service sector of the developing world highlights the critical role of frugality in knowledge creation [22]. The knowledge management literature indicates that knowledge transfer is a critical mechanism in the preservation of cognitive resources and the exploration of new knowledge opportunities [19].

H2: Frugal innovation has a positive and significant influence on diverse knowledge sharing.

## **2.3. Diverse knowledge sharing and SMEs resilience**

Diversity in knowledge sharing activities is characterized by differences in exchange channels, methods of delivery, and knowledge content shared [43]. The use of offline and online media in the community, coupled with information providers whose mode of delivery is commensurate with each organization's nature, provides wider perspectives and encourages improvisation in knowledge resources shared [39]. In KBV theory, knowledge-derived benefits are not restricted to innovation, since they can be extended to cover risk management and adaptation [40]. The resilience capacity of SMEs is defined by how effectively they utilize knowledge resources available to them. Heterogeneous knowledge sharing activities increase the sensitivity of business actors to risks that may affect business outcomes in an adverse manner [43]. Once risks have been effectively mapped, SMEs can prepare to counter possible crises in advance through the development of action plans and solution-based business activities [44]. For this purpose, diverse knowledge sharing can be used to enrich creative ideas and apply them for enhancing accuracy in decision-making processes [45] and for increasing efficiency in operations [46]. Research done by [47] on company managers in China showed that

knowledge sharing activities, as knowledge flow representations, positively correlate with supply chain resilience.

H3: Diverse knowledge sharing has a positive and significant influence on SMEs resilience.

#### **2.4. Frugal innovation and knowledge integration**

In the context of knowledge management, knowledge integration represents a higher stage of knowledge exchange [48]. This process allows organizations to use knowledge resources both within and outside their boundaries [49]. On the other hand, the key driver of knowledge integration is the ability of the organization to innovate, which ensures the continuity of integration processes to establish a cycle of innovation and achieve various aspects of frugality [50]. For resource-constrained organizations, achieving cost efficiency and product functionality requires the reorganization and optimization of internal resources to create business value [25]. On the other hand, the ability to configure resources from the external environment depends on the social systems of business communities. Frugality helps the SMEs to recognize the knowledge that is essential and the information that is not necessary to achieve aspects of frugality and enhance the ability to compete [23]. Various studies have supported the fact that the establishment of frugal ecosystems for the sake of sustainability helps the organizations to efficiently reuse knowledge resources that are deemed necessary [51]. According to [52], the reuse of knowledge resources has been shown to enhance the ability of the organizations to stimulate the creative performance of the business, especially in terms of output optimization with minimal resources. Based on the above discussion, the following hypothesis is proposed:

H4: Frugal innovation has a positive and significant influence on knowledge integration.

#### **2.5. Knowledge integration and SMEs resilience**

Moreover, SMEs' resilience is not limited to the continuity of businesses but is also the ability to learn from changes in the performance of their businesses and to recover well from any challenges that may arise [53]. On the other hand, frugal innovation also contributes to the development and improvement of resource-constrained businesses and their ability to adapt to uncertainties [14]. To resource-constrained businesses, knowledge assets have been seen as a key predictor of their resilience. In this respect, knowledge integration is vital in the development of dynamic capabilities to increase the adaptability of businesses [54]. The constant renewal of knowledge ensures that business actors do not rely on knowledge that is no longer relevant to the market [55]. According to [56], knowledge management practices and resilient supply chains are closely linked in industries such as the maritime industry. Moreover, for SMEs that have adopted global digital platforms, horizontal and vertical knowledge integration has been shown to have a positive influence on crisis adaptation skills and efficiency [57]. Based on the above discussion, the hypothesis is as follows:

H5: Knowledge integration has a positive and significant influence on SMEs resilience.

#### **2.6. Mediating role of diverse knowledge sharing and knowledge integration**

The DOI theory highlights the role of frugal innovation as a catalyst of SMEs resilience. However, the role of frugal innovation as a catalyst of SMEs resilience is influenced by various components, including the channels of communication, social systems, and timing of dissemination, which are consistent with the dynamics of inter-organizational interactions in community networks. The role of frugal innovation as a predictor of SMEs resilience is largely influenced by two variables: the interconnectedness of nodes in social networks [58] and the constraints of the environment, which are inherent in frugal innovation [5]. In this aspect, the role of maintaining existing innovations through the implementation of knowledge management practices is seen as essential for the sustainability of the subsequent outcomes of innovation. In addition, maintaining the existing innovations ensures the development of a knowledge-sufficient environment, which prepares the communities adequately for any unexpected disruptions [41]. Frugal SMEs foster diverse knowledge sharing practices, driven by the need to remain connected, as well as the development of proactive approaches towards any unexpected disruptions [59]. In the same respect, frugal innovation has the ability to trigger the process of knowledge

integration, which strengthens the process of building SMEs resilience, driven by the need to update the knowledge base continuously [60]. The availability of relevant knowledge enables the accuracy of frugal organizations in assessing the risks of the business environment, as well as disruptions from external sources, other than the routine environment [61]. Thus, the following hypotheses can be proposed:

H6: Diverse knowledge sharing acts as a mediator in the positive influence of frugal innovation toward SMEs resilience.

H7: Knowledge integration plays the role of a mediator in the positive influence of frugal innovation toward SMEs resilience.

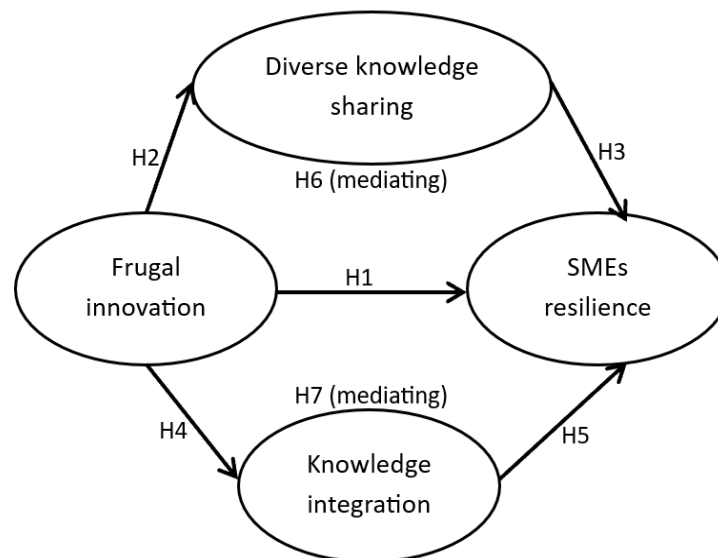


Figure 1. Study model

### 3. Research method

#### 3.1. Sample and data collection procedure

The present study follows a quantitative approach, focusing on data collection and numerical analysis as the essential activities. The findings of the analysis are used to examine the interrelationship of variables, as well as to test the hypotheses (see Figure 1). The empirical context of the present study includes SMEs operating in the fashion industry and the craft industry of the special region of Yogyakarta, which is a prominent tourist hub that plays a vital role in the local economy of Indonesia. However, industry faces several risks. Trade liberalization, as well as the unpreparedness of local businesses, has led to the inflow of foreign products, which are marked by mass production, competitive prices, and superior product quality. These conditions have posed a great challenge to local SMEs, as they struggle to maintain market share. Such conditions, if left unaddressed, may lead to reduced productivity, competitiveness, as well as the risk of business failure [20], [37]. To survive and grow, SMEs operating in these industries must incorporate frugal innovation practices, as well as dynamic social networks, which play the role of a catalyst in building SMEs resilience.

For this purpose, a proportional random sampling method was used in five regencies/cities to ensure proper representation of the population. The population was estimated at around 1,500 officially registered SMEs, and using this figure, the required number was computed using the correct formula [62], which indicated that at least 283 responses would be required at a 95% confidence interval. The data was collected using structured questionnaires, both face-to-face and online using Google Forms and WhatsApp groups. The study was conducted between May and July 2025 and yielded more than the required threshold of 348 responses. Although more responses were recorded at first, only those who were part of officially registered communities under government agencies or independent SME associations were used for the study.

The application of self-reporting and the standardized scale format in this study creates the possibility of common method bias (CMB). In order to mitigate this problem, both statistical and procedural controls were used. Statistically, the presence of CMB was checked by using variance inflation factor (VIF) values, with values below 3 for each of the measure's indicators [63]. The findings show that all 17 indicators have VIF values ranging from 1.461 to 2.602, thus suggesting that there is no need to worry about CMB. On the procedural side, respondents were assured of confidentiality and told there were no right or wrong answers, thus encouraging unbiased and truthful answers [64].

### 3.2. Measurement

In order to ensure the validity and reliability of the measurement tools, a pilot test was carried out with 30 SMEs. The test was conducted in order to eliminate overlapping items. In addition, the design and wording of the tool were reviewed by three subject-matter experts to ensure greater clarity and ease of understanding for the respondents. Frugal innovation (FI) was measured using five items, which measure products, ideas, or solutions developed under resource constraints. The construct comprises different dimensions, including cost efficiency, product ergonomic and functional design, optimal performance, and the frugal ecosystem [33]. Sample items include "focus on cost reduction in operations" and "core product functions are prioritized over additional features." SMEs resilience (SR) was measured using seven items, which measure an organization's capacity to adapt to uncertain situations and bounce back from adversity. These items focus on aspects such as the ability to maintain operations during crises and having structured risk management in place [34]. Some examples of such items are: "providing necessary resources during a crisis" and "ability to take immediate and critical actions in urgent situations." Diverse knowledge sharing (DKS) was also assessed using three items, which focus on aspects of inter-organizational knowledge sharing in community networks [42]. Some examples of items are: "mutually sharing relevant information among SME members" and "collaborating to enhance effective learning." Knowledge integration (KI) was assessed using two items, which focus on aspects of combining heterogeneity in shared knowledge among members to create new perspectives and new innovative solutions for complex issues [48]. The example of an item is: "members exchanging viewpoints to enrich new knowledge."

### 3.3. Data analysis

The data analysis for this study was conducted using partial least squares-structural equation modeling (PLS-SEM) using SmartPLS software version 4. The reason for using variance-based SEM was two-fold: first, the research model was found to be complex in nature, incorporating two mediating variables in the research model, and second, this study also attempted to forecast causal relationships in a research framework supported by limited prior empirical research [65]. The PLS analysis was used to assess the reliability and validity of the reflective measurement model using indicator loadings, internal consistency reliability, convergent validity, and discriminant validity. Later, the structural model was assessed using collinearity tests, coefficient of determination, predictive relevance, and coefficients to assess hypothesis acceptability or rejection. The analysis was conducted following established procedures for PLS-SEM recommended in prior literature [66].

### 3.4. Characteristics of respondents

The following table, Table 1, presents the profile of the respondents, considering some variables. The majority of the businesses have 3-10 years of experience (66.7%), followed by fewer businesses with < 3 years (15.8%) and 11-20 years of experience (10.6%). The fashion and craft SMEs mostly operate in the local (49.4%) and national markets (44.8%), with only a few businesses serving the international market (5.7%). In order to compete with international competitors, the SMEs need to focus on their agility, product quality, and strength to cope with the uncertainties. Moreover, knowledge integration is another vital strategy for the SMEs to access the global market. In terms of the size of the industry, most of the businesses fall under the small and medium industry category, with a greater number of small enterprises. Many of the businesses have  $\leq 4$  employees (39.9%) and 5-19 employees (35.6%). The value of assets is mostly between IDR 51-500 million (45.4%), and the sales volume is mostly between IDR 0-300 million (63.5%).

Table 1. Respondents' profile (n=348)

Description	Frequency	Percentage (%)
Business age (years)		
< 3	55	15.8
3-10	232	66.7
11-20	37	10.6
21-30	16	4.6
> 30	8	2.3
Market		
Local	172	49.4
National	156	44.8
International	20	5.7
Number of employees		
≤ 4	139	39.9
5-19	124	35.6
20-99	67	19.3
≥ 100	18	5.2
Asset (IDR)		
0-50 million	139	39.9
51-500 million	158	45.4
501 million – 10 billion	41	11.8
> 10 billion	10	2.9
Sales volume (IDR/year)		
0-300 million	221	63.5
301 million – 2.5 billion	101	29.0
2.6-50 billion	18	5.2
>50 billion	8	2.3

Source: Data processing by the authors

## 4. Results

### 4.1. Reliability and validity of the constructs

Reliability and validity need to be verified prior to testing the structural model. Factor loadings measure the reliability of the items, and the suggested value should be 0.708 or above [67]. In this study, all constructs exceeded 0.70, with the following exceptions: FI1, 0.673; and FI2, 0.680. These items were retained, as the other conditions were met [68].

Internal consistency was used to evaluate reliability through Cronbach's alpha and composite reliability. All four constructs were found to meet the reliability requirement, as values for Cronbach's alpha and composite reliability were above 0.60. The results are presented in Table 2. Convergent validity was tested with the help

of the average variance extracted (AVE). The AVE value should be greater than 0.50, meaning that the latent variable should explain more than half of the variance in the items used to measure it [69]. The AVE values were 0.577 for FI, 0.786 for DKS, 0.822 for KI, and 0.644 for SR, thus confirming convergent validity.

Table 2. Measurement model evaluation

Variables	Code	Theme	Loadings factor	CA	CR (rho_c)	AVE
Frugal innovation	Fi1	Premium product	0.785	0.816	0.871	0.577
	Fi2	Cost reduction	0.673			
	Fi3	Functionality	0.680			
	Fi4	Ergonomic product	0.816			
	Fi5	Sustainability	0.828			
Diverse knowledge sharing	Dks1	Sharing relevant information	0.895	0.864	0.917	0.786
	Dks2	Collaboration to improve learning	0.883			
	Dks3	Cooperation to enhance knowledge capacity	0.881			
Knowledge integration	Ki1	Blending knowledge to get new perspectives	0.902	0.784	0.903	0.822
	Ki2	Selecting updated and useful knowledge to raise effectiveness	0.912			
SMEs resilience	Sr1	Agile adaptation	0.779	0.907	0.927	0.644
	Sr2	Keep operating amidst crises	0.832			
	Sr3	Risk management	0.839			
	Sr4	Managing resources to solve difficulties	0.829			
	Sr5	Dealing with the unexpected	0.797			
	Sr6	Immediate managerial action	0.796			
	Sr7	Good relationship with partners	0.740			

Note. CA: Cronbach's alpha, CR: composite reliability, AVE: average variance extracted

Source: Data processing by the authors

For this study, discriminant validity is used to assess whether each latent variable in the proposed model is distinct from other latent variables. This is critical in order to maintain unique and meaningful relationships between variables. The Fornell-Larcker criterion was used to assess discriminant validity in this study. This criterion involves comparing the square root of the average variance extracted for each construct and its correlations to other constructs. Discriminant validity is said to exist in this study if the square root of AVE is greater than correlations to other constructs [70]. As shown in Table 3, none of the constructs violated this criterion, thus implying that discriminant validity was achieved. To further support this finding, another test using cross-loading was conducted. All constructs were found to load appropriately on their respective latent variables without significant cross-loadings on other constructs [71]. The findings from both tests are consistent in showing that discriminant validity was satisfactorily established in this study.

Table 3. Discriminant validity (Fornell-Larcker criterion)

	DKS	FI	KI	SR
Diverse knowledge sharing	0.886			
Frugal innovation	0.748	0.759		
Knowledge integration	0.799	0.691	0.907	
SMEs resilience	0.740	0.748	0.660	0.802

Source: Data processing by the authors

#### 4.2. Structural model evaluation

Prior to the analysis of the values of coefficients between the latent constructs, it is vital to ensure that the structural model meets the essential quality requirements, which include the evaluation of the model's collinearity, explanatory power, and prediction power. Collinearity is evaluated using the variance inflation factor (VIF). The value of the VIF is considered significant when it is higher than 5, which indicates a problem of multicollinearity in the model [68]. This implies that the exogenous constructs are not sufficiently differentiated in their impact on the endogenous construct, thus affecting the validity of the model. The values of the VIF in this study ranged from 1.000 to 3.467, thus implying the absence of a significant problem of multicollinearity.

The explanatory power of the model is a measure of the extent to which the dependent variable is influenced by a set of independent variables included in the model, as opposed to the impact of the variables outside the model [69]. The explanatory power is represented by the coefficient of determination, which is a function of the  $R^2$  and  $f^2$  values. From the results presented in Table 4, the  $R^2$  values of the DKS, KI, and SR constructs are 0.559, 0.478, and 0.636, respectively, thus implying a moderate explanatory power of the model. The  $f^2$  is a measure of the effect size of the independent variables on the dependent variables when the independent variables are removed from the model [67]. The effect size is classified as small (0.02), medium (0.15), and large (0.35). The results indicate a large effect size of FI→DKS (1.266) and FI→KI (0.916), a medium effect size of FI→SR (0.208), and a small effect size of DKS→SR (0.103) and KI→SR (0.006).

Predictive relevance is indicated by the  $Q^2$  value. A good fit for the PLS model indicates strong predictive accuracy, where the difference between actual and predictive values is minimized. The  $Q^2$  value includes both in- and out-sample predictive relevance, where values greater than zero indicate good predictive relevance [66]. In this study, the  $Q^2$  value for diverse knowledge sharing was found to be 0.558, for knowledge integration it was 0.475, and for SMEs resilience 0.557. These findings clearly indicate that the PLS model possesses strong predictive accuracy. This proves that the PLS model is well and adequately suited for hypothesis testing.

Table 4. R-Square and f-Square

Independent	Dependent	$R^2$	$R^2$ adjusted	$f^2$
FI	DKS	0.559	0.557	1.266
FI	KI	0.478	0.477	0.916
FI	SR	0.636	0.633	0.208
DKS				0.103
KI				0.006

Note. FI: frugal innovation, SR: SMEs resilience, DKS: diverse knowledge sharing, KI: knowledge integration

### 4.3. Direct relationship

For hypothesis testing in this study, the value of the path coefficient was used at a 95% confidence interval and one-tailed statistics. As indicated in Table 5, FI positively and significantly influences SR ( $B = 0.426$ ,  $t = 7.285$ ,  $p < 0.05$ ), thus validating H1. FI also positively and significantly influences DKS ( $B = 0.748$ ,  $t = 19.390$ ,  $p < 0.05$ ), thus validating H2. DKS positively and significantly influences SR ( $B = 0.360$ ,  $t = 5.644$ ,  $p < 0.05$ ), thus validating H3. FI positively and significantly influences KI ( $B = 0.691$ ,  $t = 14.812$ ,  $p < 0.05$ ), thus validating H4. However, KI does not significantly influence SR ( $B = 0.078$ ,  $t = 1.256$ ,  $p > 0.05$ ), thus rejecting H5.

Table 5. Direct relationship testing

Path	Original sample	Std. deviation	T statistics	P values	Supported?
H1. FI -> SR	0.426	0.058	7.285	0.000	Yes
H2. FI -> DKS	0.748	0.039	19.390	0.000	Yes
H3. DKS -> SR	0.360	0.064	5.644	0.000	Yes
H4. FI -> KI	0.691	0.047	14.812	0.000	Yes
H5. KI -> SR	0.078	0.062	1.256	0.105	No

Note. FI: frugal innovation, SR: SMEs resilience, DKS: diverse knowledge sharing, KI: knowledge integration

Source: Author's own work

### 4.4. Mediation analysis

The results of the mediation analysis are presented in Table 6. The analysis shows that the relationship between FI and SR is mediated by DKS ( $B = 0.269$ ,  $t = 5.552$ ,  $p < 0.05$  [CI: 0.189–0.347]), thus supporting H6. The FI–SR relationship is partially mediated because FI has a significant direct effect on SR. In community networks, frugal organizations build adaptive and resilient capacities through activities of diverse knowledge sharing. The latter is considered one of the main ways through which SMEs can adapt to uncertain business environments. On the other hand, KI does not mediate the FI–SR relationship ( $B = 0.054$ ,  $t = 1.235$ ,  $p > 0.05$  [CI: –0.015–0.128]), thus rejecting H7. Even as FI has a significant influence on KI, this influence is not enough to make KI mediate the FI–SR relationship. Therefore, the FI influence on SR does not have to involve knowledge integration as part of the knowledge management process.

Table 6. Mediation analysis results

Path	Original sample	Std. deviation	T statistics	P values	Percentile bootstrap 95% confidence interval	
					Lower	Upper
H6. FI -> DKS -> SR	0.269	0.048	5.552	0.000*	0.189	0.347
H7. FI -> KI -> SR	0.054	0.044	1.235	0.108	-0.015	0.128

Note. FI: frugal innovation, SR: SMEs resilience, DKS: diverse knowledge sharing, KI: knowledge integration

\* $p < 0.05$

Source: Author's own work

Figure 2 presents the path coefficients of both direct and mediating effects. The figure is presented to help readers understand the research findings in a comprehensive way. Figure 2 is presented below.

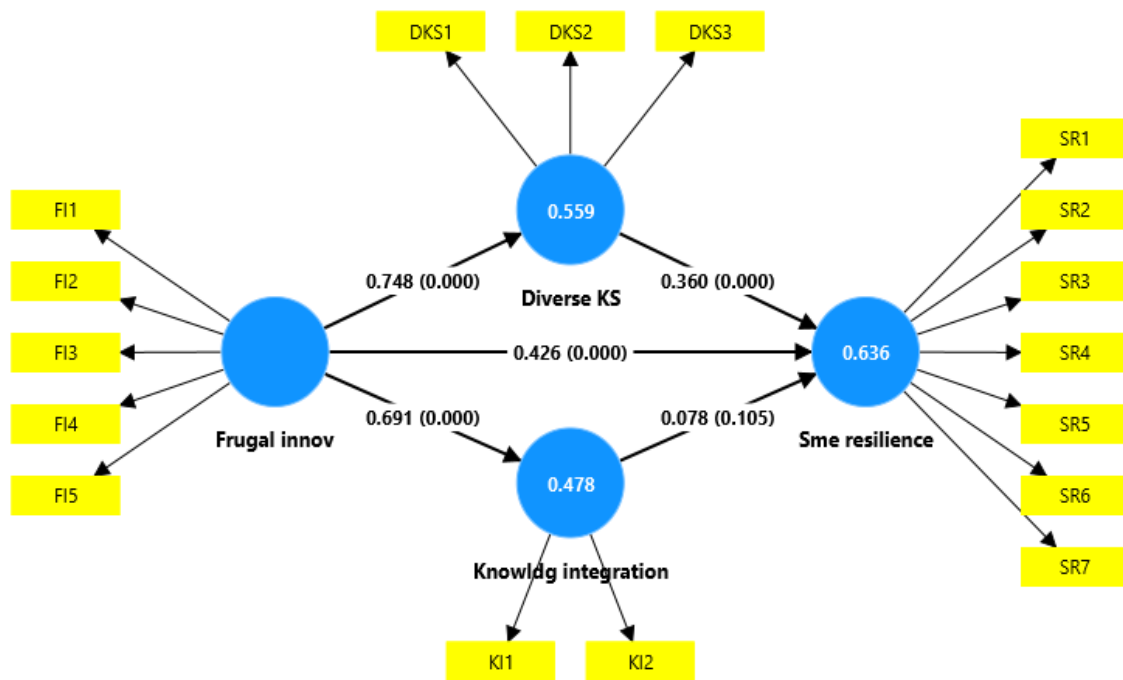


Figure 2. Inner model – bootstrapping

Source: SmartPLS output

## 5. Discussion

### 5.1. Frugal innovation and SMEs resilience

This research aims to examine the influence of frugal innovation on SME's resilience capabilities. The mediating effects of diverse knowledge sharing and knowledge integration within the community-based framework have been explored. The research findings revealed that all the relationships were statistically significant. In addition to this, the indirect effects of the research model revealed that diverse knowledge sharing had a significant mediating influence between frugal innovation and SMEs resilience. However, knowledge integration had no statistically significant mediating influence. When faced with resource scarcity, it becomes imperative to focus on the key areas of the product. To ensure that the product maintains its popularity in the market, frugal SMEs avoid compromising the quality of the product. Therefore, they remove only those features that are felt as non-essential. During such situations, resource scarcity proves to be extremely helpful. It is becoming easier to reduce the operating and acquisition costs of the business. Referring to several studies, the two major advantages of such situations are the enhancement of sustainability and adaptability [72]. By adopting the concept of frugality, SMEs can overcome even the most challenging situations, as they are able to learn from failure, recover from setbacks, and strengthen their resilience over time.

Study [73] further confirms that resilience represents a key outcome of frugality. Creative cognitive capabilities enable organizations to continuously identify and exploit opportunities, even in times of crisis. The habitual pursuit of efficiently delivering superior products encourages SMEs to align market needs with focused and adaptive business strategies. An emphasis on consumer profiles and shifts in customer orientation characterizes frugal organizations, allowing them to implement action-based strategies that are measurable while minimizing risk. Accordingly, resilience in frugal SMEs extends beyond mere elasticity, encompassing disciplined risk awareness, the effectiveness of business actions, and the strategic utilization of limited resources.

### 5.2. Managing knowledge (DKS & KI) and SMEs resilience

The results also reveal the importance of knowledge management for SMEs, which influences the development of organizational resilience. Interactions between communities contribute to the development of a contagion effect, through which knowledge related to innovation and resilience skills is shared. The sharing of knowledge

promotes the generation of new ideas, which provide a basis for coping with critical events. The application of knowledge management helps SMEs to formulate scenarios to act as early warning systems for unexpected disruptions that may affect the organizations [74]. Study [44] on technology-based SMEs suggests that interorganizational collaboration enhances knowledge acquisition, thereby substantially improving risk mitigation performance. Knowledge that is effectively shared and absorbed enables organizations to become more sensitive in identifying alternative business scenarios when adverse conditions are unavoidable. Knowledge exchange through collaborative arrangements enriches the diversity of firms' knowledge stock, which in turn allows SMEs to more agilely explore viable opportunities and execute them effectively.

On the other hand, knowledge integration helps organizations to break free from old knowledge and adopt new knowledge that aligns with the current challenges. As in studies in the context of cross-border SMEs, this helps to enhance the flexibility of the knowledge content, which increases the resilience of the organizations to cope with the dynamics of the environment [57], [73]. Beyond mere absorption, knowledge integration is particularly valuable because it enables firms to distinguish useful and impactful information from knowledge that is less essential for business development. This selectivity allows entrepreneurs to focus on activities that generate positive organizational outcomes rather than becoming overly preoccupied with the knowledge acquisition process itself [53]. Knowledge that is effectively integrated through extensive social relations can further stimulate SMEs' creative problem-solving capabilities. Consequently, the uncertainty inherent in the business environment can be managed more strategically and prudently.

### **5.3. Mediating effect of diverse knowledge sharing**

This study provides a conceptual framework for knowledge management of community-based organizations that operate under resource constraints. The knowledge management framework focuses on two aspects: diverse knowledge sharing and knowledge integration. The results of the study reveal that diverse knowledge sharing has a significant mediating effect on the relationship between frugal practices and organizational resilience, while knowledge integration does not. The sharing of knowledge between the networks helps to enhance the interactions between the communities, which greatly enriches the knowledge base of the organizations [75]. The knowledge shared can be readily applied to solve problems, identify business opportunities, and anticipate market trends [76], [77]. This implies that SMEs can access critical knowledge while engaging in networking, which helps enhance the development of resilience. A study on tourism SMEs facing an occupancy crisis revealed that, to sustain business resilience during difficult times, SMEs must achieve incremental milestones that enhance business robustness [11].

Knowledge content is varied and obtained not only from outside resources such as SMEs' communities but also from frugal knowledge gathered via experiential learning. The term "frugal organization" denotes an organization characterized by its resilience when it encounters inner restrictions and changing outer dynamics. Those SMEs who have implemented the concept of frugality into their operations generate capabilities to produce new products cheaply. Within the scope of community, individuals are motivated to share best practices, which helps them accumulate knowledge, learn together, and implement the knowledge gained among other members. Hence, internalization of knowledge content becomes a base for SMEs to achieve innovations during uncertainty. Consistent with previous studies [74], diverse knowledge content increases the ability of companies to find solutions under challenging circumstances. Diverse knowledge generates a variety of ideas and helps firms remain competitive in their market sectors and stay alive in the long term.

### **5.4. Mediating effect of knowledge integration**

In contrast to how knowledge integration is often understood, this study shows that knowledge integration requires more than knowledge acquisition; it also requires aligning acquired knowledge with the organization's capacity to effectively implement it. This requires cognitive effort from the organization to integrate both internal and external knowledge sources [78]. SMEs must assess whether knowledge integration is possible and beneficial for organizational development and performance. This is particularly daunting for resource-

constrained environments. Previous studies suggest that adopting a reactive cognitive approach to market dynamics is insufficient to facilitate knowledge coupling for building resilience in organizations [79]. Knowledge, for it to be valuable in adverse market environments, must be easily applicable without cognitive processing, as this can hinder an organization's adaptability, particularly for frugal organizations.

In addition to considerations about potential misalignments between firm profiles and acquired knowledge, another plausible reason for discarding knowledge integration as a mediating variable is related to variations in absorptive capacity across firms. The point is that absorptive capacity is essential when assessing how knowledge integration contributes to increasing resilience within frugal organizations through adversities. This is because absorptive capacity not only affects the quality of information that may be assimilated, but is also relevant for the cognitive capacity of SMEs to process knowledge and, more importantly, for their ability to exploit knowledge for business purposes. There are also empirical results that suggest that higher absorptive capacity is associated with the ability to create effective knowledge infrastructure among French SMEs, thus contributing to better implementation of business processes [80].

### **5.5. Implications of the study**

The study contributes to the extension of diffusion of innovation theory in resource-constrained environments, as it reveals how frugality affects building resilience in organizations in community-based environments [15]. In resource-constrained environments, frugal organizations rely on knowledge exchange as one of the main means for diffusing innovation through social systems, thus facilitating knowledge acquisition for the organization [81]. This enables organizations to recognize opportunities, resolve disruptive issues, and fulfill market demands. Social systems encourage diversity in content, experience, and cognition, thus enhancing adaptability and resilience in uncertain environments. Knowledge exchange from diverse sources further enhances organizational efficiency, thus equipping organizations with the power to overcome adversities [82]. The empirical link between frugality and resilience, though still in its infancy, can be understood in relation to diffusion of innovation theory and knowledge-based theory.

In practice, this study underscores the need for the development of a knowledge-based economy to enhance organizational resilience in difficult situations. This is because knowledge, as a non-physical element, is inexhaustible and constantly relevant for the creation of novel and viable solutions. Community engagement practices serve as a continuous source of knowledge that helps firms achieve competitive advantage [83]. Resilience is not a random phenomenon. In a resource-scarce environment, it occurs as a result of the interaction of the social system, the creation of adequate knowledge, and the culture of experimentation facilitated by frugal organizations [84]. This synergy enables SMEs to innovate and be resilient under all circumstances.

## **6. Conclusions**

This study offers a unique point of view on the subject. It does this by considering frugal innovation as a major driver of resilience using the diffusion of innovation theory and the knowledge-based view. Within the context of the interaction of the community, frugal organizations play a critical role in the sustenance of knowledge sharing practices until the achievement of strategic knowledge. This knowledge empowers SMEs to innovate constantly, to analyze situations better, to come up with viable solutions, to make precise decisions, and to seize opportunities to enhance the growth of the firm. As a result, the organizations are able to innovate under all circumstances and even to be more resilient than before when confronted with unforeseen situations. Frugal organizations engage in experimentation to come up with viable ideas and solutions, even if the process does not bear the expected fruits. Through persistence, frugal organizations can build resilience capacities to enable SMEs to be agile, robust, and unwavering in the face of difficult situations.

Although this study provides significant insights, there are certain limitations that can be addressed in further studies. First, all data collection tools are based on self-reporting methods, which might lead to biases. In further studies, secondary data can be employed to measure the ability of organizations to innovate in a state of resource

constraints. In addition, dyadic data collection can be employed to measure knowledge distribution in community networks. Second, demographic factors such as business size and business age can be taken into consideration as control variables in further studies [22]. In addition, the incorporation of situational factors such as environmental factors and government relations, as well as organizational factors including leader behavior and creative climate, into the model will provide a more comprehensive understanding of community networks.

The current research proves that the logic behind the proposed framework is justified by DOI theory and KBV concept. Future studies aiming at deepening understanding of frugality can consider the association between frugal innovations and organizational resilience using the theoretical background of social learning theory. Although knowledge acquisition and learning are similar activities, their outcomes can be used as measures of effective knowledge integration obtained as a result of organizational interactions within the social setting. In addition, the creation of practical learning theories can be relevant when talking about frugality-related ideas because such learning practices can be applied by resource-limited companies to utilize innovative yet unusual solutions. Moreover, collaborative learning is consistent with the community setting of SMEs since knowledge and experience are socially constructed through the exchange of information.

### **Declaration of competing interests**

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

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### **Author contributions**

The contribution to the paper is as follows: Handrio Adhi Pradana: writing – original draft, visualization, methodology, formal analysis, conceptualization; Noermijati Noermijati: writing – review & editing, supervision, and conceptualization; Wahdiyati Moko, Atim Djazuli: validation, supervision, and conceptualization. All authors approved the final version of the manuscript.

### **Ethical approval statement**

This research was conducted in accordance with established ethical guidelines and received formal approval from the Department of Cooperatives and Small and Medium Enterprises (Dinkop UKM), Regional Government of the Special Region of Yogyakarta (Approval No. B/00.9/2223/D2, dated March 17, 2025).

### **Informed consent**

Informed consent for the publication of personal data contained in the article has been obtained from all the participants. The participants were willing to take the survey when they responded to the initial question. It has also been ascertained that the data collected from the participants would remain confidential and anonymous and would not be disclosed at all.

### **Declaration of Generative AI and AI-assisted technologies in the writing process**

During the preparation of this work the author(s) used Microsoft Copilot and Grammarly to improve language and readability. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

## References

- [1] S. Singh, P. Jain, S. Singh, and A. Sharma, "Mapping the enablers of frugal innovation and firm performance of indigenous innovation in emerging economies," *IEEE Engineering Management Review*, vol. 53, no. 5, pp. 177–192, Oct. 2025, <https://doi.org/10.1109/EMR.2024.3508821>.
- [2] S. Girija, B. Banerji, N. Batra, M. Paruchuru, and T. Yeediballi, "Making frugal innovations inclusive: a gendered approach," *J. Clean. Prod.*, vol. 434, p. 140182, Jan. 2024, <https://doi.org/10.1016/j.jclepro.2023.140182>.
- [3] J. Abbas, S. Bresciani, G. Subhani, and P. De Bernardi, "Nexus of ambidexterity and frugal innovation for enhanced ESG performance of entrepreneurial firms. The role of organizational capabilities," *International Entrepreneurship and Management Journal*, vol. 21, no. 1, p. 47, Dec. 2025, <https://doi.org/10.1007/s11365-024-01062-5>.
- [4] C. Escudero-Cipriani, J. García-del Junco, R. Chafloque-Céspedes, and A. Alvarez-Risco, "Frugal innovation in the business environment: a literature review and future perspectives," *Front. Artif. Intell.*, vol. 7, p. 1385522, Dec. 2024, <https://doi.org/10.3389/frai.2024.1385522>.
- [5] M. Albert, "Sustainable frugal innovation - the connection between frugal innovation and sustainability," *J. Clean. Prod.*, vol. 237, p. 117747, Nov. 2019, <https://doi.org/10.1016/j.jclepro.2019.117747>.
- [6] R. Dubey, D. J. Bryde, C. Foropon, M. Tiwari, and A. Gunasekaran, "How frugal innovation shape global sustainable supply chains during the pandemic crisis: lessons from the COVID-19," *Supply Chain Management: An International Journal*, vol. 27, no. 2, pp. 295–311, Feb. 2022, <https://doi.org/10.1108/SCM-02-2021-0071>.
- [7] B. Karroumi and A. Sedqui, "Resilient supply chain built on frugal innovations, and how this relation can be created?" in 2022 14th International Colloquium of Logistics and Supply Chain Management (LOGISTIQUA), May 2022, pp. 1–6, <https://doi.org/10.1109/LOGISTIQUA55056.2022.9938033>.
- [8] K. K. Ledi, "Surviving black swan: competitive intelligence and frugal innovation as panaceas to SME value creation during crisis," *Cogent Business & Management*, vol. 11, no. 1, p. 2405056, Dec. 2024, <https://doi.org/10.1080/23311975.2024.2405056>.
- [9] K. Al Omoush, C. Lassala, and S. Ribeiro-Navarrete, "The role of digital business transformation in frugal innovation and SMEs' resilience in emerging markets," *International Journal of Emerging Markets*, vol. 20, no. 1, pp. 366–386, Jan. 2025, <https://doi.org/10.1108/IJOEM-12-2022-1937>.
- [10] A. Bencsik, R. Machová, and Z. Tóth, "Cheap and clever – symbiosis of frugal innovation and knowledge management," *Problems and Perspectives in Management*, vol. 14, no. 1, pp. 85–93, Mar. 2016, [https://doi.org/10.21511/ppm.14\(1\).2016.10](https://doi.org/10.21511/ppm.14(1).2016.10).
- [11] Suherman *et al.*, "Resilience in tourism-based SMEs driven by initiatives and strategies through share value relational capital viewed from a resource-based theory perspective," *Humanit. Soc. Sci. Commun.*, vol. 11, no. 1, p. 1128, Sep. 2024, <https://doi.org/10.1057/s41599-024-03607-z>.
- [12] S. Weaven, S. Quach, P. Thaichon, L. Frazer, K. Billot, and D. Grace, "Surviving an economic downturn: dynamic capabilities of SMEs," *J. Bus. Res.*, vol. 128, pp. 109–123, May 2021, <https://doi.org/10.1016/j.jbusres.2021.02.009>.
- [13] F. O. Socorro Márquez, G. E. Reyes Ortiz, and H. Torrez Meruvia, "The frugal scalability paradox in emerging innovation ecosystems," *Adm. Sci.*, vol. 15, no. 11, p. 455, Nov. 2025, <https://doi.org/10.3390/admsci15110455>.
- [14] C. N. Hindocha, G. Antonacci, J. Barlow, and M. Harris, "Defining frugal innovation: a critical review," *BMJ Innov.*, vol. 7, no. 4, pp. 647–656, Oct. 2021, <https://doi.org/10.1136/bmjinnov-2021-000830>.
- [15] X. Zhang, "Frugal innovation and the digital divide: developing an extended model of the diffusion of innovations," *International Journal of Innovation Studies*, vol. 2, no. 2, pp. 53–64, Jun. 2018, <https://doi.org/10.1016/j.ijis.2018.06.001>.
- [16] J. MacVaugh and F. Schiavone, "Limits to the diffusion of innovation," *European Journal of Innovation Management*, vol. 13, no. 2, pp. 197–221, Apr. 2010, <https://doi.org/10.1108/14601061011040258>.
- [17] M. Hossain, H. Simula, and M. Halme, "Can frugal go global? Diffusion patterns of frugal innovations," *Technol. Soc.*, vol. 46, pp. 132–139, Aug. 2016, <https://doi.org/10.1016/j.techsoc.2016.04.005>.

- [18] M. Hossain, S. Park, and S. Shahid, “Frugal innovation for sustainable rural development,” *Technol. Forecast. Soc. Change*, vol. 193, p. 122662, Aug. 2023, <https://doi.org/10.1016/j.techfore.2023.122662>.
- [19] G. H. Mengesha, R. T. Watson, and S. Negash, “Frugal knowledge sharing for frugal innovation diffusion in Africa,” *Journal of Global Information Management*, vol. 29, no. 6, pp. 1–23, Oct. 2021, <https://doi.org/10.4018/JGIM.289221>.
- [20] S. Afriyie, J. Du, and A.-A. I. Musah, “Innovation and knowledge sharing of SME in an emerging economy; the moderating effect of transformational leadership style,” *International Journal of Innovation Management*, vol. 24, no. 04, p. 2050034, May 2020, <https://doi.org/10.1142/S1363919620500346>.
- [21] Z. Yousaf, M. Panait, U. Tanveer, A. Cretu, A. Hrebenciuc, and S. M. Zahid, “Value creation through frugal innovation, innovation capability and knowledge sharing in a circular economy,” *Sustainability*, vol. 14, no. 14, p. 8504, Jul. 2022, <https://doi.org/10.3390/su14148504>.
- [22] P. B. Le, “Determinants of frugal innovation for firms in emerging markets: the roles of leadership, knowledge sharing and collaborative culture,” *International Journal of Emerging Markets*, vol. 18, no. 9, pp. 3334–3353, Nov. 2023, <https://doi.org/10.1108/IJOEM-02-2021-0258>.
- [23] Y.-T. Tu, “The role of green social behavior in frugal innovation and entrepreneurial success: the moderating impact of knowledge management,” *Journal of Innovation & Knowledge*, vol. 9, no. 4, p. 100566, Oct. 2024, <https://doi.org/10.1016/j.jik.2024.100566>.
- [24] F. Achmad and I. Inrawan Wiratmadja, “Driving sustainable performance in SMEs through frugal innovation: the nexus of sustainable leadership, knowledge management, and dynamic capabilities,” *IEEE Access*, vol. 12, pp. 103329–103347, 2024, <https://doi.org/10.1109/ACCESS.2024.3433474>.
- [25] A. Bazayar, M. Abbasi, and S. Naghdi Khanachah, “Investigating the moderating role of technology turbulence and innovation capabilities in servant leadership, knowledge management and frugal innovation,” *Journal of Science and Technology Policy Management*, Aug. 2024, <https://doi.org/10.1108/JSTPM-10-2023-0168>.
- [26] J. C. Lang, “Managing in knowledge-based competition,” *Journal of Organizational Change Management*, vol. 14, no. 6, pp. 539–553, Dec. 2001, <https://doi.org/10.1108/EUM000000006145>.
- [27] N.-L. Sum and B. Jessop, “Competitiveness, the knowledge-based economy and higher education,” *Journal of the Knowledge Economy*, vol. 4, no. 1, pp. 24–44, Mar. 2013, <https://doi.org/10.1007/s13132-012-0121-8>.
- [28] K. Trivedi and K. B. L. Srivastava, “The role of knowledge management processes in leveraging competitive strategies to achieve firm innovativeness,” *The Bottom Line*, vol. 35, no. 2/3, pp. 53–72, Aug. 2022, <https://doi.org/10.1108/BL-06-2021-0071>.
- [29] P. B. Le, L. T. Phong, and K. D. Vu, “Leadership practices for pursuing frugal innovation in hotels and restaurants: the roles of knowledge sharing and information technology utilization,” *Journal of Hospitality and Tourism Insights*, vol. 8, no. 6, pp. 2099–2116, Nov. 2025, <https://doi.org/10.1108/JHTI-07-2024-0703>.
- [30] S. A. Soomro, S. A. Soomro, K. Prasai, and F. Muhammad, “Frugal innovation and sustainable leadership in resource constrained environments: the role of tacit and explicit knowledge sharing,” *Journal of Economic and Administrative Sciences*, May 2025, <https://doi.org/10.1108/JEAS-02-2025-0085>.
- [31] E. Rosca, M. Arnold, and J. C. Bendul, “Business models for sustainable innovation – an empirical analysis of frugal products and services,” *J. Clean. Prod.*, vol. 162, pp. S133–S145, Sep. 2017, <https://doi.org/10.1016/j.jclepro.2016.02.050>.
- [32] A. Pisoni, L. Michelini, and G. Martignoni, “Frugal approach to innovation: State of the art and future perspectives,” *J. Clean. Prod.*, vol. 171, pp. 107–126, Jan. 2018, <https://doi.org/10.1016/j.jclepro.2017.09.248>.
- [33] T. Weyrauch and C. Herstatt, “What is frugal innovation? Three defining criteria,” *Journal of Frugal Innovation*, vol. 2, no. 1, p. 1, Jan. 2017, <https://doi.org/10.1186/s40669-016-0005-y>.
- [34] D. Kantur and A. İşeri-Say, “Organizational resilience: a conceptual integrative framework,” *Journal of Management & Organization*, vol. 18, no. 6, pp. 762–773, Nov. 2012, <https://doi.org/10.5172/jmo.2012.18.6.762>.
- [35] J. W. Dearing, “Applying diffusion of innovation theory to intervention development,” *Res. Soc. Work Pract.*, vol. 19, no. 5, pp. 503–518, Sep. 2009, <https://doi.org/10.1177/1049731509335569>.

- [36] M. Dabić, T. Obradović, B. Vlačić, S. Sahasranamam, and J. Paul, “Frugal innovations: a multidisciplinary review & agenda for future research,” *J. Bus. Res.*, vol. 142, pp. 914–929, Mar. 2022, <https://doi.org/10.1016/j.jbusres.2022.01.032>.
- [37] M. Christofi, H. Khan, N. Zahoor, E. Hadjielias, and S. Tarba, “Digital transformation of SMEs: the role of entrepreneurial persistence and market sensing dynamic capability,” *IEEE Trans. Eng. Manag.*, vol. 71, pp. 13598–13615, 2024, <https://doi.org/10.1109/TEM.2022.3230248>.
- [38] A. Ganguly, A. Talukdar, and D. Chatterjee, “Evaluating the role of social capital, tacit knowledge sharing, knowledge quality and reciprocity in determining innovation capability of an organization,” *Journal of Knowledge Management*, vol. 23, no. 6, pp. 1105–1135, Aug. 2019, <https://doi.org/10.1108/JKM-03-2018-0190>.
- [39] E. H. Hwang, P. V. Singh, and L. Argote, “Knowledge sharing in online communities: learning to cross geographic and hierarchical boundaries,” *Organization Science*, vol. 26, no. 6, pp. 1593–1611, Dec. 2015, <https://doi.org/10.1287/orsc.2015.1009>.
- [40] S. C. Cooper, V. Pereira, D. Vrontis, and Y. Liu, “Extending the resource and knowledge based view: insights from new contexts of analysis,” *J. Bus. Res.*, vol. 156, p. 113523, Feb. 2023, <https://doi.org/10.1016/j.jbusres.2022.113523>.
- [41] C. Mason, T. Castleman, and C. Parker, “Communities of enterprise: developing regional SMEs in the knowledge economy,” *Journal of Enterprise Information Management*, vol. 21, no. 6, pp. 571–584, Oct. 2008, <https://doi.org/10.1108/17410390810911186>.
- [42] Q. Iqbal and K. Piwowar-Sulej, “Sustainable leadership and heterogeneous knowledge sharing: the model for frugal innovation,” *European Journal of Innovation Management*, vol. 26, no. 7, pp. 655–673, Dec. 2023, <https://doi.org/10.1108/EJIM-03-2022-0144>.
- [43] J. Lauring and J. Selmer, “Knowledge sharing in diverse organisations,” *Human Resource Management Journal*, vol. 22, no. 1, pp. 89–105, Jan. 2012, <https://doi.org/10.1111/j.1748-8583.2010.00158.x>.
- [44] S. Ghobadi and L. Mathiassen, “Risks to effective knowledge sharing in agile software teams: a model for assessing and mitigating risks,” *Information Systems Journal*, vol. 27, no. 6, pp. 699–731, Nov. 2017, <https://doi.org/10.1111/isj.12117>.
- [45] P. E. Arduin, M. Grundstein, and C. R. Sabroux, “From knowledge sharing to collaborative decision making,” *International Journal of Information and Decision Sciences*, vol. 5, no. 3, p. 295, 2013, <https://doi.org/10.1504/IJIDS.2013.055927>.
- [46] M. Al Yami, M. M. Ajmal, and S. Balasubramanian, “Does size matter? The effects of public sector organizational size’ on knowledge management processes and operational efficiency,” *VINE Journal of Information and Knowledge Management Systems*, vol. 52, no. 5, pp. 670–700, Oct. 2022, <https://doi.org/10.1108/VJIKMS-07-2020-0123>.
- [47] Y. Tu, H. Li, J. Dong, J. Zhou, and L. Hu, “Impacts of intellectual capital, supply chain knowledge sharing on supply chain resilience: evidence from China,” *Journal of Intellectual Capital*, vol. 26, no. 4, pp. 1013–1035, Jul. 2025, <https://doi.org/10.1108/JIC-01-2025-0013>.
- [48] Z. Y. Wu, X. G. Ming, L. N. He, M. Li, and X. Z. Li, “Knowledge integration and sharing for complex product development,” *Int. J. Prod. Res.*, vol. 52, no. 21, pp. 6296–6313, Nov. 2014, <https://doi.org/10.1080/00207543.2014.923121>.
- [49] M. Kodama, “Boundaries innovation and knowledge integration in the Japanese firm,” *Long Range Plann.*, vol. 42, no. 4, pp. 463–494, Aug. 2009, <https://doi.org/10.1016/j.lrp.2009.08.001>.
- [50] A. C. Edmondson and J.-F. Harvey, “Cross-boundary teaming for innovation: integrating research on teams and knowledge in organizations,” *Human Resource Management Review*, vol. 28, no. 4, pp. 347–360, Dec. 2018, <https://doi.org/10.1016/j.hrmr.2017.03.002>.
- [51] J. Á. López-Sánchez and M. L. Santos-Vijande, “Key capabilities for frugal innovation in developed economies: insights into the current transition towards sustainability,” *Sustain. Sci.*, vol. 17, no. 1, pp. 191–207, Jan. 2022, <https://doi.org/10.1007/s11625-021-01071-1>.
- [52] L. Giustiniano, S. Lombardi, and V. Cavaliere, “How knowledge collecting fosters organizational creativity,” *Management Decision*, vol. 54, no. 6, pp. 1464–1496, Jul. 2016, <https://doi.org/10.1108/MD-04-2015-0111>.

- [53] E. Daniels, S. Bharwani, Å. G. Swartling, G. Vulturius, and K. Brandon, "Refocusing the climate services lens: introducing a framework for co-designing 'transdisciplinary knowledge integration processes' to build climate resilience," *Clim. Serv.*, vol. 19, p. 100181, Aug. 2020, <https://doi.org/10.1016/j.cliser.2020.100181>.
- [54] R. MacIntosh, N. Beech, E. Antonacopoulou, and D. Sims, "Practising and knowing management: a dialogic perspective," *Manag. Learn.*, vol. 43, no. 4, pp. 373–383, Sep. 2012, <https://doi.org/10.1177/1350507612452521>.
- [55] Y. Zhao, Y. Lu, and X. Wang, "Organizational unlearning and organizational relearning: a dynamic process of knowledge management," *Journal of Knowledge Management*, vol. 17, no. 6, pp. 902–912, Oct. 2013, <https://doi.org/10.1108/JKM-06-2013-0242>.
- [56] S. K. Patil and R. Kant, "A fuzzy ANP-based approach for selection of knowledge management strategies to build resilient supply chain: an empirical case study," *International Journal of Integrated Supply Management*, vol. 10, no. 2, p. 173, 2016, <https://doi.org/10.1504/IJISM.2016.077074>.
- [57] Y. Guo, Y. Chen, A. Usai, L. Wu, and W. Qin, "Knowledge integration for resilience among multinational SMEs amid the COVID-19: from the view of global digital platforms," *Journal of Knowledge Management*, vol. 27, no. 1, pp. 84–104, Jan. 2023, <https://doi.org/10.1108/JKM-02-2022-0138>.
- [58] R. Khan and H. Melkas, "The social dimension of frugal innovation," *International Journal of Technology Management*, vol. 83, no. 1–3, p. 160, 2020, <https://doi.org/10.1504/IJTM.2020.109234>.
- [59] O. Mishra, "Principles of frugal innovation and its application by social entrepreneurs in times of adversity: an inductive single-case approach," *Journal of Entrepreneurship in Emerging Economies*, vol. 13, no. 4, pp. 547–574, Sep. 2021, <https://doi.org/10.1108/JEEE-07-2020-0247>.
- [60] S. Suriyankietkaew, K. Krittayaruangroj, and N. Iamsawan, "Sustainable leadership practices and competencies of SMEs for sustainability and resilience: a community-based social enterprise study," *Sustainability*, vol. 14, no. 10, p. 5762, May 2022, <https://doi.org/10.3390/su14105762>.
- [61] M. Dost and M. S. Khan, "Influence of risk-taking and proactivity behaviours on frugal product innovation: the moderating role of external sources of knowledge," *International Journal of Innovation Management*, vol. 25, no. 08, Oct. 2021, <https://doi.org/10.1142/S1363919621500870>.
- [62] R. V. Krejcie and D. W. Morgan, "Determining sample size for research activities," *Educ. Psychol. Meas.*, vol. 30, no. 3, pp. 607–610, Sep. 1970, <https://doi.org/10.1177/001316447003000308>.
- [63] N. Kock, "Common Method Bias: A Full Collinearity Assessment Method for PLS-SEM," in *Partial Least Squares Path Modeling*, H. Latan and R. Noonan, Eds. Cham, Switzerland: Springer International Publishing, 2017, ch. 11, pp. 245–257, [https://doi.org/10.1007/978-3-319-64069-3\\_11](https://doi.org/10.1007/978-3-319-64069-3_11).
- [64] P. M. Podsakoff, S. B. MacKenzie, J.-Y. Lee, and N. P. Podsakoff, "Common method biases in behavioral research: a critical review of the literature and recommended remedies," *Journal of Applied Psychology*, vol. 88, no. 5, pp. 879–903, Oct. 2003, Accessed: Dec. 30, 2025. [Online]. Available: <https://psycnet.apa.org/buy/2003-08045-010>
- [65] J. F. Hair Jr., L. M. Matthews, R. L. Matthews, and M. Sarstedt, "PLS-SEM or CB-SEM: updated guidelines on which method to use," *International Journal of Multivariate Data Analysis*, vol. 1, no. 2, p. 107, 2017, <https://doi.org/10.1504/IJMDA.2017.087624>.
- [66] J. F. Hair, J. J. Risher, M. Sarstedt, and C. M. Ringle, "When to use and how to report the results of PLS-SEM," *European Business Review*, vol. 31, no. 1, pp. 2–24, Jan. 2019, <https://doi.org/10.1108/EBR-11-2018-0203>.
- [67] J. F. Hair Jr., M. Sarstedt, L. Hopkins, and V. G. Kuppelwieser, "Partial least squares structural equation modeling (PLS-SEM)," *European Business Review*, vol. 26, no. 2, pp. 106–121, Mar. 2014, <https://doi.org/10.1108/EBR-10-2013-0128>.
- [68] C. M. Ringle, M. Sarstedt, R. Mitchell, and S. P. Gudergan, "Partial least squares structural equation modeling in HRM research," *The International Journal of Human Resource Management*, vol. 31, no. 12, pp. 1617–1643, Jul. 2020, <https://doi.org/10.1080/09585192.2017.1416655>.
- [69] M. Sarstedt, J. F. Hair, M. Pick, B. D. Liengaard, L. Radomir, and C. M. Ringle, "Progress in partial least squares structural equation modeling use in marketing research in the last decade," *Psychol. Mark.*, vol. 39, no. 5, pp. 1035–1064, May 2022, <https://doi.org/10.1002/mar.21640>.

- [70] C. Fornell and D. F. Larcker, “Evaluating structural equation models with unobservable variables and measurement error,” *Journal of Marketing Research*, vol. 18, no. 1, pp. 39–50, Feb. 1981, <https://doi.org/10.1177/002224378101800104>.
- [71] C. M. Voorhees, M. K. Brady, R. Calantone, and E. Ramirez, “Discriminant validity testing in marketing: an analysis, causes for concern, and proposed remedies,” *J. Acad. Mark. Sci.*, vol. 44, no. 1, pp. 119–134, Jan. 2016, <https://doi.org/10.1007/s11747-015-0455-4>.
- [72] S. Anim-Yeboah, R. Boateng, R. Odoom, and E. A. Kolog, “Digital transformation process and the capability and capacity implications for small and medium enterprises,” *International Journal of E-Entrepreneurship and Innovation*, vol. 10, no. 2, pp. 26–44, Jul. 2020, <https://doi.org/10.4018/IJEEI.2020070102>.
- [73] E. Elkhidir, S. Mannakkara, T. F. P. Henning, and S. Wilkinson, “Knowledge types and knowledge transfer mechanisms for effective resilience knowledge sharing between cities – A case study of New Zealand,” *International Journal of Disaster Risk Reduction*, vol. 70, p. 102790, Feb. 2022, <https://doi.org/10.1016/j.ijdr.2022.102790>.
- [74] B. J. S. Mariano, W. Dagli, and G. T. Cirella, “Adaptive knowledge sharing in turbulent times: urban disaster risk and knowledge management,” in *Human Settlements. Advances in 21st Century Human Settlements*, G. T. Cirella, Ed. Singapore: Springer, 2022, ch. 2, pp. 29–42, [https://doi.org/10.1007/978-981-16-4031-5\\_2](https://doi.org/10.1007/978-981-16-4031-5_2).
- [75] F. Ahmad, “Knowledge-sharing networks: language diversity, its causes, and consequences,” *Knowledge and Process Management*, vol. 24, no. 2, pp. 139–151, Apr. 2017, <https://doi.org/10.1002/kpm.1539>.
- [76] M. T. Hansen, M. L. Mors, and B. Løvås, “Knowledge sharing in organizations: multiple networks, multiple phases,” *Academy of Management Journal*, vol. 48, no. 5, pp. 776–793, Oct. 2005, <https://doi.org/10.5465/amj.2005.18803922>.
- [77] A. A. Bodla, N. Tang, W. Jiang, and L. Tian, “Diversity and creativity in cross-national teams: the role of team knowledge sharing and inclusive climate,” *Journal of Management & Organization*, vol. 24, no. 5, pp. 711–729, Sep. 2018, <https://doi.org/10.1017/jmo.2016.34>.
- [78] B. R. Bhardwaj, “Influence of knowledge management on product innovation by intrapreneurial firms,” *Global Knowledge, Memory and Communication*, vol. 69, no. 1–2, pp. 38–57, Aug. 2019, <https://doi.org/10.1108/GKMC-03-2019-0039>.
- [79] D. Wu, T. Liu, W. Yang, and X. Cui, “Knowledge coupling and organizational resilience: the moderating effect of market orientation,” *Science, Technology and Society*, vol. 28, no. 3, pp. 444–462, Sep. 2023, <https://doi.org/10.1177/09717218231178343>.
- [80] S. M. Jasimuddin and M. M. Naqshbandi, “Knowledge infrastructure capability, absorptive capacity and inbound open innovation: evidence from SMEs in France,” *Production Planning & Control*, vol. 30, no. 10–12, pp. 893–906, Sep. 2019, <https://doi.org/10.1080/09537287.2019.1582097>.
- [81] K. Motohashi, D.-R. Lee, Y.-W. Sawng, and S.-H. Kim, “Innovative converged service and its adoption, use and diffusion: a holistic approach to diffusion of innovations, combining adoption-diffusion and use-diffusion paradigms,” *Journal of Business Economics and Management*, vol. 13, no. 2, pp. 334–343, Apr. 2012, <https://doi.org/10.3846/16111699.2011.620147>.
- [82] D. Kocsis and J. Xiong, “A divide quantified—exploring the relationship between ICT infrastructure diffusion and income inequality,” *Journal of Electronic Business & Digital Economics*, vol. 1, no. 1–2, pp. 34–49, Dec. 2022. <https://doi.org/10.1108/JEBDE-09-2022-0033>.
- [83] F. Berkes and N. J. Turner, “Knowledge, learning and the evolution of conservation practice for social-ecological system resilience,” *Hum. Ecol.*, vol. 34, no. 4, pp. 479–494, Oct. 2006, <https://doi.org/10.1007/s10745-006-9008-2>.
- [84] T. Hahn, L. Schultz, C. Folke, and P. Olsson, “Social networks as sources of resilience in social-ecological systems,” in *Complexity Theory for a Sustainable Future*, J. Norberg and G. S. Cumming, Eds. New York, NY, USA: Columbia University Press, 2008, ch. 4. Accessed: Jan. 05, 2026. [Online]. Available: [https://www.researchgate.net/profile/Thomas-Hahn-5/publication/285840082\\_Social\\_networks\\_as\\_sources\\_of\\_resilience-in-social-ecological\\_systems/links/56e9c53d08ae95bd2a19f6/Social-networks-as-sources-of-resilience-in-social-ecological-systems.pdf](https://www.researchgate.net/profile/Thomas-Hahn-5/publication/285840082_Social_networks_as_sources_of_resilience-in-social-ecological_systems/links/56e9c53d08ae95bd2a19f6/Social-networks-as-sources-of-resilience-in-social-ecological-systems.pdf)