

“Motivational factors influencing the adoption of frugal innovation among agrifood SMEs in Surakarta, Indonesia”

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ARTICLE INFO	Nuning Setyowati, Emi Widiyanti and Fanny Widadie (2026). Motivational factors influencing the adoption of frugal innovation among agrifood SMEs in Surakarta, Indonesia. <i>Problems and Perspectives in Management</i> , 24(4), 143–159. doi: 10.21511/ppm.24(4).2026.10
DOI	http://dx.doi.org/10.21511/ppm.24(4).2026.10
RELEASED ON	Wednesday, 21 October 2026
RECEIVED ON	Monday, 02 March 2026
ACCEPTED ON	Thursday, 01 October 2026
LICENSE	 This work is licensed under a Creative Commons Attribution 4.0 International License
JOURNAL	"Problems and Perspectives in Management"
ISSN PRINT	1727-7051
ISSN ONLINE	1810-5467
PUBLISHER	LLC “Consulting Publishing Company “Business Perspectives”
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”



NUMBER OF REFERENCES

50



NUMBER OF FIGURES

2



NUMBER OF TABLES

10

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BUSINESS PERSPECTIVES



LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10,
Sumy, 40022, Ukraine
www.businessperspectives.org

Type of the article: Research Article

Received on: 2nd of March, 2026Accepted on: 1st of October, 2026Published on: 21st of October, 2026

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Fanny Widadie, 2026

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Conflict of interest statement:

Author(s) reported no conflict of interest

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MOTIVATIONAL FACTORS INFLUENCING THE ADOPTION OF FRUGAL INNOVATION AMONG AGRIFOOD SMEs IN SURAKARTA, INDONESIA

Abstract

Agrifood SMEs play a vital role in producing high-value-added processed products, enhancing the potential of local agricultural commodities, and supporting food availability and diversity. However, these SMEs face various challenges, including limited resources and capital, the need to adapt to rapid innovation and shifting consumer preferences, and volatile purchasing power amid economic fluctuations. This study aims to analyze the motivational factors influencing the adoption of frugal innovation among agrifood SMEs in Surakarta City, Indonesia. A quantitative method was employed, involving a sample of 150 agrifood SMEs in Surakarta. Data were collected through surveys and direct interviews between April and June 2025. The data were analyzed using structural equation modeling (SEM) with partial least squares (PLS) in SmartPLS 4. The majority of respondents' businesses have been operating for less than 10 years and generate monthly revenue ranging from IDR 5,000,000 to IDR 40,000,000. The findings reveal that compatibility ($\beta = 0.191, p < 0.05$), low-cost manufacturing ($\beta = 0.220, p < 0.05$), digital platforms ($\beta = 0.258, p < 0.05$), sustainable leadership ($\beta = 0.160, p < 0.05$), technology turbulence ($\beta = 0.188, p < 0.05$), and external sources of knowledge ($\beta = 0.172, p < 0.05$) significantly encourage the adoption of frugal innovation. Moreover, external knowledge sources partially mediate the influence of sustainable leadership on the adoption of frugal innovation.

Keywords

agrifood, SMEs, adoption, compatibility, frugal
innovation

JEL Classification

O32, O33, L26, Q13

INTRODUCTION

Agrifood SMEs are among the most promising sectors for producing high-value-added products, enhancing the potential of local agricultural commodities, and supporting food availability and diversity. The agrifood sector undergoes a significant transformation as society experiences economic development. Conversely, the evolution of the food sector also plays a vital role in shaping economic growth (Rosalina et al., 2023). Agrifood SMEs facilitate public access to food, meet nutritional needs, create employment opportunities, and may enhance the economic well-being of local communities (Putri et al., 2024). However, the agrifood sector faces challenges, with minimal adoption of technology and innovation (Adana et al., 2023).

Surakarta City, Indonesia, has significant potential to develop agrifood SMEs across the food and beverage sectors. According to BPS (2025), Surakarta has 1,449 agrifood SMEs. A wide variety of food products are produced, including culinary delicacies, souvenir foods, traditional snacks, traditional beverages, healthy drinks,

and coffee, which is a local food product in Surakarta. Agrifood SMEs in Surakarta have accessed social media-based online marketing, with the majority of platforms used being Instagram, TikTok, and WhatsApp (Pramono & Ardiyansah, 2026). Agrifood SMEs face multiple challenges, including inadequate resources, the need to adapt to rapid innovation, changing consumer preferences, and unstable purchasing power resulting from economic shocks (Agarwal et al., 2017; Hossain, 2021). Agrifood SMEs in Surakarta also face increasingly fierce competition, limited mastery of production technology and information, and suboptimal human resource capacity. These issues are a focus of the local government's strategies for developing SMEs (DINKOPUKM, 2025). Agrifood SMEs must quickly align their strategies with these environmental dynamics. One practical approach is to adopt frugal innovation (Cuevas-Vargas & Parga-Montoya, 2021; Hossain, 2021).

Frugal innovation is an innovation concept that emphasizes cost minimization, focuses on a product's core functions, and may enhance overall business performance (Rossetto et al., 2017). It prioritizes simplicity, affordability, quality (Cuevas-Vargas et al., 2023; Weyrauch & Herstatt, 2017), sustainability, and simplicity despite financial and technological constraints (Hossain, 2020; Von Janda et al., 2020; Zeschky et al., 2014). This concept emerged in response to the need to serve low-income market segments with affordable yet functional products (Tiwari & Bergmann, 2018). Agrifood SMEs can identify areas within their business processes that can be optimized through frugal innovation across various aspects, from product development and production technology to marketing strategies. The Surakarta City Government supports the implementation of frugal innovations, including the introduction of cost-saving technologies, digitalization training, and training on diversifying local food processing.

Prior studies on frugal innovation have been extensive (Cuevas-Vargas & Parga-Montoya, 2021; Nassani et al., 2022; Permatasari & Kesaulya, 2024; Suharti et al., 2014). However, none have specifically focused on the adoption of frugal innovation by agrifood SMEs in Surakarta. Moreover, most existing studies have examined this topic only partially, focusing on a limited set of variables. This study bridges that gap by using the agribusiness sector in Surakarta as an empirical case study. By integrating digital platforms, compatibility, low-cost manufacturing, technology turbulence, and sustainable leadership into an integrated model, this study provides a comprehensive analysis of the mechanisms driving the adoption of frugal innovations in resource-constrained environments.

1. LITERATURE REVIEW AND HYPOTHESES

Digital platforms have emerged as an important enabler of frugal innovation by facilitating data exchange, collaboration, and knowledge sharing among competitors, consumers, suppliers, and business partners (Adana et al., 2023; Kolawale et al., 2017). Previous studies consistently indicate that digital platforms may improve market efficiency, broaden access to innovation-related information, and stimulate economic growth, particularly in developing countries (Zainal, 2024). Collectively, these findings suggest that digital platforms function not only as communication channels but also as strategic resources that enable firms operating under resource constraints to identify innovation opportunities and access external knowledge more efficiently.

The adoption of innovation refers to the acceptance and utilization of new ideas, technologies, or tools by potential users (Marikyan et al., 2026). According to the diffusion of innovation (DOI) theory, innovation adoption is influenced by several innovation attributes that determine whether an innovation is accepted or rejected by adopters (Rogers, 1983). Among these attributes, compatibility has received considerable attention because innovations that align with users' existing values, experiences, and operational needs are more likely to be adopted (Suharti et al., 2014). Previous empirical studies also demonstrate that technology adoption is associated with stronger organizational competitiveness by improving business performance and supporting more effective strategic decision-making (Wang et al., 2024). Therefore, DOI provides an

appropriate theoretical foundation for explaining the adoption of frugal innovation among agrifood SMEs.

Frugal innovation has attracted scholarly attention as organizations seek to achieve economic, social, and environmental objectives while operating under resource constraints (Albert, 2022; Stöber et al., 2022). Existing studies consistently characterize frugal innovation as an approach emphasizing simplicity, affordability, efficient resource utilization, and reduced environmental impact (Cuevas-Vargas & Parga-Montoya, 2021). Rather than focusing solely on cost reduction, frugal innovation enables firms to create value through practical and sustainable solutions that meet market needs despite limited financial and technological resources. This perspective suggests that frugal innovation is particularly relevant for agrifood SMEs, which frequently operate in environments characterized by resource scarcity and market uncertainty.

Previous studies further indicate that environmental conditions also shape firms' innovation decisions. Technology turbulence, characterized by rapid technological change, creates opportunities for firms to access affordable technologies and develop more efficient innovations (Zhang et al., 2024).

At the organizational level, sustainable leadership encourages innovation by promoting collaboration, employee learning, and managerial support, all of which are essential for implementing frugal innovation under resource-constrained conditions (Dabic et al., 2022; Tian & Wang, 2023). Furthermore, effective leadership facilitates knowledge management by encouraging employees to acquire, share, and utilize knowledge from both internal and external sources (Donate & Pablo, 2015; Tian & Wang, 2023). These findings collectively suggest that sustainable leadership contributes not only directly to innovation but also indirectly through strengthening organizational knowledge capabilities.

Knowledge has long been recognized as a fundamental support of innovation. However, previous studies suggest that knowledge effectiveness depends not only on availability but also on its

source and quality. Frugal innovation, in particular, requires firms to integrate internal capabilities with external knowledge from customers, suppliers, universities, governments, business communities, and other stakeholders to generate practical, resource-efficient solutions (Upadhyay & Puneekar, 2023). Although the importance of external knowledge has been widely acknowledged, empirical evidence regarding its role in facilitating frugal innovation adoption, particularly among agrifood SMEs in developing countries, remains limited (Rehman et al., 2024). This gap indicates the need to examine how digital platforms, compatibility, technology turbulence, sustainable leadership, and external knowledge collectively influence the adoption of frugal innovation within the agrifood SME context.

This study focuses on analyzing the motivational factors influencing the adoption of frugal innovations among agrifood SMEs in Surakarta. Considering the positive influence of diverse knowledge sources on innovation, this study put forward the following hypotheses (Figure 1):

- H1: Digital platforms have a significant and positive effect on the adoption of frugal innovation.*
- H2: Compatibility has a significant and positive effect on the adoption of frugal innovation.*
- H3: Low-cost manufacturing has a significant and positive effect on the adoption of frugal innovation.*
- H4: Technology turbulence has a significant and positive effect on the adoption of frugal innovation.*
- H5: Sustainable leadership has a significant and positive effect on the adoption of frugal innovation.*
- H6: Sustainable leadership has a significant and positive effect on external sources of knowledge.*
- H7: External sources of knowledge have a significant and positive effect on the adoption of frugal innovation.*

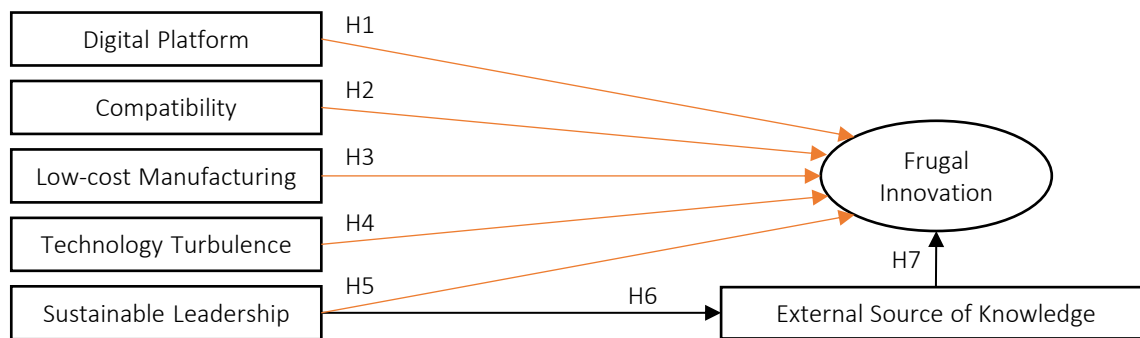


Figure 1. Conceptual model

2. METHODS

This study employed a quantitative method, one of the quantitative research approaches designed to formulate problems by exploring the social situations under investigation and systematically describing the facts or characteristics of a population. Quantitative research involves the use of numerical data, analyzed using statistical methods (Sugiyono, 2013). A quantitative approach was used to measure the influence of digital platforms, compatibility, low-cost manufacturing, technological disruption, sustainable leadership, and external knowledge sources on the adoption of frugal innovations, using a structured questionnaire to collect primary data. This method is suitable for describing the motivational patterns of agrifood SMEs in adopting frugal innovations.

The study was conducted in Surakarta City, Central Java Province, Indonesia. This region was selected purposively for its role as the economic center of the Solo Raya region and its strong potential for agrifood SME development. The study involved 150 agrifood SMEs that had adopted frugal innovation. The sample size was determined by the variable ratio: 1:20 (Hair et al., 2019). The number of variables in this study was seven, resulting in a sample size of 140 respondents. We added 10 additional samples to account for incomplete or unsuitable data, resulting in a sample size of 150 agrifood SME owners. The sampling was implemented using a snowball method because there was no database of agrifood SMEs in Surakarta that implemented frugal innovation. The sample criteria were agrifood SMEs in Surakarta with at least 2 years of business experience that had implemented frugal innovation, identified by first asking po-

tential respondents before the interview. Agrifood SMEs in Surakarta that did not implement frugal innovation were not eligible to participate. Information on the initial five agro-food MSME respondents was obtained from the Surakarta City Cooperatives and MSME Agency; subsequent respondents were selected using the snowball method, adhering to the established criteria. Data were collected through direct interviews with agrifood SME owners in Surakarta using a structured questionnaire between April and June 2025.

The demographic characteristics of the respondents are presented in Appendix A. There were 51 respondents (34%) with an income of < IDR 5,000,000, 79 respondents (52.7%) with an income of IDR 5,000,000–IDR 40,000,000, and 20 respondents (13.3%) with an income of > IDR 40,000,000. The majority of respondents (100; 66.7%) had been running their businesses for < 10 years. A total of 75 respondents (50%) were male, and 75 respondents (50%) were female. The majority of respondents in this study were aged between 21 and 60 years.

All variables were measured using a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) using latent indicators. The digital platform variable was measured using five indicator items adapted from Nassani et al. (2022) and Tuijl and Knorrinda (2023). The compatibility variable was measured through four indicator items modified from Gandasari (2021), Nguyen et al. (2022), and Setyowati et al. (2024). The technology turbulence variable was measured using four indicator items, developed from Calantone et al. (2003) and Dost et al. (2019). The low-cost production variable was measured with four indicator items adapted

from Cuevas-Vargas et al. (2022). The sustainable leadership variable was measured using six indicator items from Fauzan et al. (2021) and Yanti et al. (2018). The external knowledge source variable was measured using six indicator items from Dost et al. (2019). Finally, the frugal innovation adoption variable was measured using five indicator items from Cuevas-Vargas et al. (2022) and Dost et al. (2019). The questionnaire is available in Appendix A.

This study involved the voluntary participation of agrifood SMEs in Surakarta. Before the interviews were conducted, respondents were briefed on the study's objectives, benefits, and data confidentiality guarantees. Informed consent was obtained from respondents prior to data collection. All data were used solely for academic purposes and analyzed anonymously.

The analysis employed SEM, using the PLS approach with SmartPLS 4. The analysis included the outer (measurement) model, the inner (structural) model, and hypothesis testing, following the rule of thumb described in Table 1.

3. RESULTS

The measurement model was evaluated through validity and reliability tests. The validity test included both convergent and discriminant validity assessments. Convergent validity was examined using two parameters: factor loadings and

the average variance extracted (AVE), while discriminant validity was assessed using the Fornell-Larcker criterion, HTMT, and cross-loadings. Reliability was estimated using Cronbach's alpha and composite reliability values. The results of the measurement for factor loading, AVE, Cronbach's alpha, and composite reliability for all indicators are presented in Table 2.

Based on Table 2, the factor loading values in this study met the required threshold of > 0.7 . This indicates that each indicator satisfied the convergent validity requirement. Meanwhile, indicators COM1, DP3 and 4, IKS1, 2 and 4, FI1 and 3, LCP2, SL2-4, and TT2 were dropped from further testing because they were invalid, namely having a loading factor of less than 0.7. Furthermore, validity testing was also conducted using AVE, with a minimum acceptable value of 0.5. The AVE values for all variables exceeded 0.5, confirming that the variables and their corresponding indicators are valid and meet the criteria for convergent validity. Although some indicators were dropped, the variables remain valid and suitable for further analysis.

The reliability test was conducted using two indicators, namely Cronbach's alpha and composite reliability. All variables met the reliability criteria, with Cronbach's alpha and composite reliability exceeding 0.7. These results indicate good internal consistency among the items. With the requirements fulfilled, it can be settled that the research instrument demonstrates strong reliability and

Table 1. Rule of thumb for outer model, structural model, and hypothesis testing

Source: Ghazali (2014), Hair et al. (2022), Ghazali and Lathan (2014), Hair et al. (2019), Lachowicz et al. (2018), Ogbeibu et al. (2021).

Model	Criteria	Rule of Thumb
Convergent validity	Factor loading	> 0.7
	AVE	> 0.5
	Fornell–Larcker	$\sqrt{AVE} > 0.5$
Discriminant validity	Heterotrait–monotrait ratio (HTMT)	< 0.9
	Cross loading	$>$ Loading factor on other variables
Reliability	Cronbach's Alpha	> 0.7
	Composite reliability	> 0.7
Structural model	Q^2 predictive relevance	$Q^2 > 0$ indicates predictive relevance; $Q^2 < 0$ indicates low predictive relevance; 0.02, 0.15, and 0.35 signify weak, moderate, and strong predictive relevance
	VIF	< 3
	R-squared	0.75, 0.50, and 0.25 represent strong, moderate, and weak models
Hypothesis testing	Significance (two-tailed)	$p\text{-value} < 0.05$ (5%) and $t\text{-statistics} > 1.96$
Mediation testing	Upsilon V	< 0.075 , $0.075\text{--}0.175$, and > 0.175 represent small, medium, and large mediation effects

Table 2. Factor loading, AVE, Cronbach's alpha, and composite reliability

Variable	Indicator	Factor Loading	AVE	Cronbach Alpha	Composite Reliability
Compatibility	COM2	0.801	0.672	0.756	0.860
	COM3	0.785			
	COM4	0.871			
Digital platform	DP1	0.890	0.711	0.797	0.880
	DP2	0.832			
	DP5	0.806			
External knowledge	EKS3	0.895	0.770	0.702	0.870
	EKS5	0.859			
FI adoption	FIA2	0.793	0.668	0.752	0.858
	FIA4	0.841			
	FIA5	0.817			
Low-cost manufacturing	LCP1	0.874	0.671	0.772	0.859
	LCP3	0.710			
	LCP4	0.864			
Sustainable leadership	SL1	0.876	0.717	0.809	0.884
	SL5	0.802			
	SL6	0.862			
Technology turbulence	TT1	0.878	0.668	0.749	0.857
	TT3	0.824			
	TT4	0.744			

consistency in measuring all constructs. Overall, the findings confirm that all variables are reliable and that each questionnaire item exhibits satisfactory consistency.

In addition to the convergent validity test, a discriminant validity test was also conducted. Discriminant validity ensures that each construct is truly distinct and does not excessively overlap with other constructs. Discriminant validity indicates the degree to which constructs in a model differ from one another. The discriminant validity test was assessed using the Fornell–Larcker, HTMT, and cross-loading parameters, as presented in Appendix B.

The discriminant validity results confirm that all indicator items meet the required criteria, with each indicator's factor loading higher for its corresponding variable than for any other variable. In addition, the $\sqrt{AVE}$ is > 0.5 , and the HTMT is < 0.9 . This indicates that each indicator effectively represents its intended construct.

The structural model was evaluated by examining the values of the variance inflation factor (VIF), R -squared, and Q -squared. The VIF test aims to identify multicollinearity among variables. Multicollinearity happens when there is a perfect

linear correlation between two or more independent variables. The outcomes of the VIF test are presented in Table 3.

Table 3. VIF and F-squared values

Variable	VIF value		F-Squared	
	EKS	FIA	EKS	FIA
COM		1.301		0.040
DP		1.447		0.066
EKS		1.507		0.028
LCP		1.097		0.063
SLS	1.000	1.464	0.094	0.025
TT		1.222		0.041

Note: COM = Compatibility; DP = Digital Platform; EKS: External Knowledge; FIA = Frugal Innovation Adoption; LCP: Low-cost Manufacturing; SLS = Sustainable Leadership; TT = Technology Turbulence.

Table 3 shows that all inner VIF values are less than 3, indicating no multicollinearity among the predictor variables. This indicates that the model's estimated path coefficients are unbiased and reliable for subsequent hypothesis testing. Based on the f -squared values, the influence of the predictor variables in the study is classified as weak, ranging from 0.025 to 0.094.

The structural model was further evaluated using the R -squared value for the dependent constructs. When evaluating the model using PLS, the anal-

Table 4. R^2 and Q^2 values

Variable	R2	Q2	Description
External source of knowledge	0.080	0.058	Weak; has predictive relevance.
FI adoption	0.301	0.176	Weak; has predictive relevance.

ysis begins by examining the R -squared values for each dependent latent variable. Changes in R -squared values can be used to assess the influence of specific independent latent variables on the dependent latent variable. The coefficient of determination ranges from 0 to 1, with thresholds of 0.67, 0.33, and 0.19 representing strong, moderate, and weak models, respectively. Additionally, the relationships between latent variables can be evaluated using the Q -squared value, which measures the extent to which the model's observed values and parameter estimates fit the data. The results of R^2 and Q^2 measurements are presented in Table 4.

The R -squared value indicates the extent to which exogenous variables explain the variance of endogenous variables. The analysis results suggest an R -squared value of 0.08 for the external source of knowledge, indicating that this variable accounts for 8% of the variance explained by sustainable leadership. Meanwhile, the R -squared value for frugal innovation adoption is 0.301, indicating that this variable is described by its exogenous variables, including compatibility, low-cost production, digital platform, sustainable leadership, technology turbulence, and external source of knowledge, to the extent of 30.1%. A relatively low R -squared value does not necessarily indicate poor research. Behavioral studies, such as those on the adoption of frugal innovation, consider numerous influencing factors, including personal, technological, social, and environmental factors, not all of which were included in this study.

Although the R -squared values are relatively weak, all dependent variables in this model exhibit good predictive ability, as shown by Q -squared values greater than zero. Q -squared measures how well the observed values are predicted by the model and its parameter estimates.

Hypothesis testing was conducted to assess the effects of exogenous variables on endogenous variables using bootstrapping. The results are detailed in Table 5 and illustrated in Figure 2.

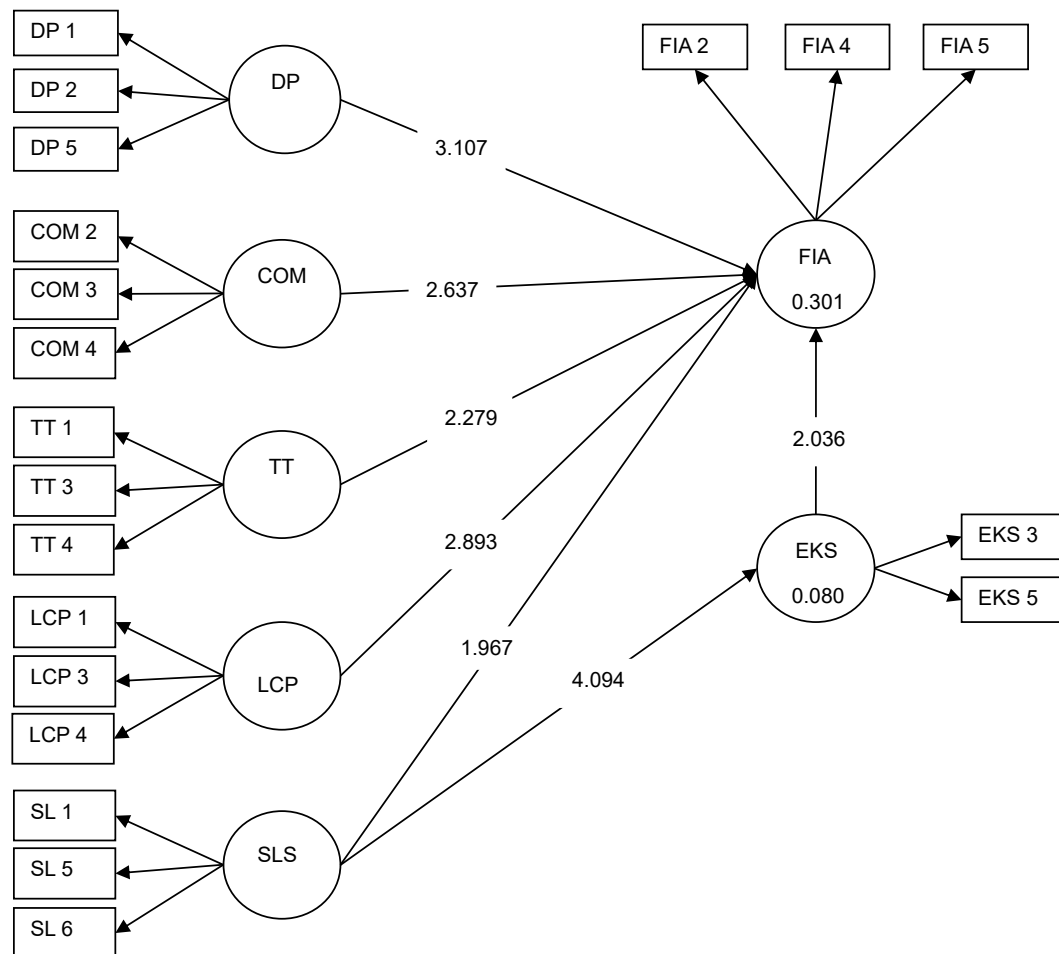
The analysis shows that digital platforms have a significant positive effect on FI adoption among agri-food SMEs in Surakarta City. This is evidenced by a p -value of 0.002, so H1 is accepted. Compatibility has a significant and positive effect on FI adoption (p -value of 0.008), supporting H2. Low-cost manufacturing has a significant and positive effect on FI adoption (p -value of 0.004), supporting H3. Furthermore, technology turbulence also has a significant and positive effect on FI adoption, as evidenced by a p -value of 0.023, supporting H4. Similarly, sustainable leadership has a significant positive effect on FI adoption ($p = 0.049$), supporting H5. Sustainable leadership also has a significant and positive effect on external knowledge, with a p -value of 0.000, supporting H6. Finally, external knowledge has a significant, positive effect on FI adoption among agrifood SMEs in Surakarta City, so that H7 is accepted with a p -value of 0.042.

The bootstrapping results show that external sources of knowledge do not act as mediators. This

Table 5. Bootstrapping

Hypothesis	Original sample (O)	T Statistics (O/STDEV)	P-value	Significance
DP → FIA	0.258	2.637	0.002	Significant
COM → FIA	0.191	3.107	0.008	Significant
LCP → FIA	0.220	2.036	0.004	Significant
TT → FIA	0.188	2.893	0.023	Significant
SL → FIA	0.160	4.094	0.049	Significant
SL → EKS	0.293	1.967	0.000	Significant
EKS → FIA	0.172	2.279	0.042	Significant

Note: COM = Compatibility; DP = Digital Platform; EKS = External Knowledge; FIA = Frugal Innovation Adoption; LCP: Low-cost Manufacturing; SLS = Sustainable Leadership; TT = Technology Turbulence.



Note: COM = Compatibility; DP = Digital Platform; EKS: External Knowledge; FIA = Frugal Innovation Adoption; LCP: Low-cost Manufacturing; SLS = Sustainable Leadership; TT = Technology Turbulence.

Figure 2. Path model diagram

is evidenced by the p -value for the indirect effect among sustainable leadership, external knowledge, and frugal innovation adoption, which is 0.075 (not significant). Sustainable leadership significantly affects the adoption of frugal innovation (p -value = 0.049). Sustainable leadership directly influences the adoption of frugal innovation, not through external knowledge, thus constituting a “direct-only, non-mediated” type of influence.

4. DISCUSSION

Hypothesis testing confirms that the digital platform has a significant positive influence on the adoption of frugal innovation. Digital platforms effectively promote the adoption of frugal innovation among agrifood SMEs in Surakarta. These platforms serve as efficient, fast, and accessible

media that enable agrifood SMEs in Surakarta to discover ideas for frugal innovation. The presence of digital platforms also helps agrifood SMEs in Surakarta identify innovators to serve as references when designing frugal innovation strategies. Furthermore, digital platforms help agrifood SMEs in Surakarta find suppliers of materials and equipment necessary to implement frugal innovation. The digital platform provides both internal and external support for implementing frugal innovation by offering a range of services, product-processing capabilities, and data-exchange mechanisms. Additionally, digital platforms facilitate communication and information sharing among diverse stakeholders, locally and globally, including competitors, consumers, suppliers, investors, and business partners (Zainal, 2024). Social media platforms, as key digital platforms, play a crucial role for agrifood SMEs in Surakarta. Social me-

dia acts as an essential channel for driving frugal innovation, not only by explaining product functions but also by serving as a direct sales channel. Moreover, it highlights the diversity of actors involved in frugal innovation, including innovators, consumers, and government institutions (Tuijl & Knorringa, 2023). Agrifood SMEs in Surakarta are familiar with utilizing social media as an efficient marketing tool. In addition, these platforms have been used to seek information, acquire knowledge, and identify potential partners who support frugal innovation efforts.

The bootstrapping test results indicate that compatibility has a significant and positive impact on the adoption of frugal innovation. This finding suggests that the more compatible frugal innovation is with the values and business principles of agrifood SMEs in Surakarta, the higher the likelihood of its adoption. Agrifood SMEs in Surakarta will adopt frugal innovation if it aligns with their goals and expectations and contributes to meaningful improvements. This result is consistent with the findings of Permatasari and Kesaulya (2024) and Suharti et al. (2014), who argue that compatibility refers to the extent to which a technological innovation aligns with the adopter's values, experiences, and needs. It also reflects how well a technology's novelty aligns with the business style and operational requirements of agrifood SMEs. In the context of agrifood SMEs in Surakarta, entrepreneurs often adhere to core principles when developing product innovations. They prioritize quality food innovations while emphasizing cost efficiency and the accessibility of raw materials.

Low-cost production has a significant and positive effect on the adoption of frugal innovation. Agrifood SMEs in Surakarta are encouraged to adopt frugal innovation to reduce expenses and production costs. Implementing frugal innovation helps reduce operational costs. Furthermore, frugal innovation supports agrifood SMEs in developing high-quality innovations at low cost. This finding aligns with the paradigm of frugal innovation, which emphasizes cost efficiency and waste reduction while fostering the creation of new, high-quality ideas and innovations (Cuevas-Vargas & Parga-Montoya, 2021). Frugal innovation is an approach to innovation that delivers greater, higher-quality value and experiences for

consumers at lower cost. Through frugal innovation, products are developed by eliminating unnecessary components, resulting in simpler, more durable, high-quality, resource-efficient innovations (Kusumawardhany et al., 2022). For example, the SME Tweety Fried Chicken introduced a product innovation, namely green chili sambal, as a substitute for sachet sauces, as it is healthier and fresher. Green chilies were chosen because they offer a more pleasant aroma while being more affordable than red chilies.

The analysis indicates that technological turbulence significantly influences the adoption of frugal innovation. Technological turbulence affects the adoption of frugal innovation among agrifood SMEs in Surakarta City. In general, environmental turbulence comprises two primary components: market turbulence and technological turbulence. Technological turbulence refers to the speedy pace of technological change, which can create opportunities for companies, particularly those operating in emerging markets, to access more affordable technologies, thereby enhancing the performance of frugal innovation. In other words, rapid technological change is not an obstacle but rather an opportunity for business actors to continue innovating efficiently (Zhang et al., 2024). This turbulence has also been associated with new product development (Calantone et al., 2003). The present analysis confirms that technology turbulence has a significant impact on the adoption of frugal innovation among agrifood SMEs in Surakarta. This finding aligns with Zhang et al. (2024), who showed that when antecedent conditions lead to high frugal innovation, technological turbulence is not a hindrance to innovation. Instead, it serves as a driving force, enabling entrepreneurs or agrifood SMEs in Surakarta to establish close collaboration with suppliers and customers and manage their relationships through strong governance. Agrifood SMEs in Surakarta are aware that technology will continue to evolve. They strive to adapt to technological changes while considering the capacity of their available resources. For instance, coffee SMEs using motorized carts have recently become popular in Surakarta. Although the coffee is sold from a motorcycle cart, consumers can still enjoy café-style coffee at a very affordable price. While a cup of coffee in a café may

cost around twenty-five thousand rupiah, the same quality of coffee from a mobile vendor can be purchased for only ten thousand rupiah.

The results of the bootstrapping test indicate that sustainable leadership has a significant positive effect on the adoption of frugal innovation. Sustainable leadership influences the adoption of frugal innovation among agrifood SMEs in Surakarta City. Frugal innovation has emerged as a viable strategy to address resource constraints and achieve sustainable growth. One of the key factors driving frugal innovation is sustainable leadership. Sustainable leadership refers to a leader's ability to integrate economic, environmental, and social aspects into the decision-making process (Rehman et al., 2024). The findings and analysis by Tian and Wang (2023) also support the bootstrapping test results, showing that sustainable leadership positively impacts frugal innovation. Sustainable leadership is crucial to enabling a company to develop specialized products or services in resource-constrained environments. The positive effect of sustainable leadership is evident in its role in helping employees build innovation capabilities, integrate information, share knowledge, and generate new ideas that lead to cost-efficient and innovative solutions. Agrifood SMEs in Surakarta City continue to ensure that the quality of their innovations remains consistent despite resource limitations, while still meeting the needs of markets and consumers with limited resources.

The hypothesis tests indicate that sustainable leadership has a significant positive influence on external sources of knowledge. The stronger the sustainable leadership, the greater the motivation to be open to the external environment. Sustainable leadership represents an integration of leadership and management practices that emphasize key principles, for example, staff motivation and competence, team orientation, trust, strategic planning, clear vision, ethical behavior, financial independence, social and environmental responsibility, organizational culture, and knowledge management through information sharing, innovation, and quality improvement (Dalati et al., 2017). Owners of agrifood SMEs in Surakarta recognize that openness to the external environment provides numerous opportunities. These agrifood SMEs can access workshops, training

sessions, and innovation seminars organized by the government and universities. As a business hub, Surakarta is home to various business communities and SME clusters, including agrifood SME clusters. These clusters serve as learning platforms to design and implement frugal innovations. Agrifood SMEs in Surakarta can also gain ideas for frugal innovation by evaluating customer feedback and observing competitors' strategies.

The analysis indicates that external knowledge significantly influences the adoption of frugal innovation. External sources of knowledge are imperative in influencing the adoption of frugal innovation among agrifood SMEs in Surakarta City. Frugal innovation is supported by multiple sources of knowledge, both internal and external to the organization. Given the significant impact of knowledge sources on innovation, access to reliable and diverse knowledge sources is essential to foster frugal innovation. This finding aligns with previous research, which highlights that a company's access to information can be a key support of innovation (Rehman et al., 2024). The use of external knowledge sources in frugal innovation provides significant benefits for two main reasons. First, frugally developed products often result from reverse engineering or improvising existing products on the market. Developing such products with frugal characteristics requires knowledge that may not be obtainable within the company. Second, obtaining knowledge from external sources can be advantageous, as it provides a pool of information that complements and may enhance internal knowledge sources. This external knowledge is often acquired through networking relationships (Dost et al., 2019). Agrifood SMEs in Surakarta have various channels for gathering ideas, insights, and references to design frugal innovations. Access to diverse knowledge, references from innovators, and business sharing activities enable these agrifood SMEs in Surakarta to adopt frugal innovations that align with their business values and resource capacities.

The results indicate that external knowledge does not mediate the influence of sustainable leadership on agrifood SMEs' decisions to adopt frugal innovation in Surakarta. Agrifood SMEs in Surakarta, with a leadership spirit oriented toward sustainability, tend to adopt frugal innovation.

CONCLUSION

The purpose of this study is to examine the motivational factors driving the adoption of frugal innovation among agrifood SMEs in Surakarta. The results show that the adoption of frugal innovation is influenced by digital platforms, compatibility, low-cost production, technology turbulence, sustainable leadership, and external sources of knowledge. Agrifood SMEs adopt frugal innovation, driven by the availability of digital platforms that serve as sources of ideas, solution insights, and market-need information for designing frugal innovations. These SMEs also consider the compatibility of innovations with their business principles and cultural values. From an economic perspective, they emphasize cost efficiency in production and business operations achieved through frugal innovation. Moreover, external sources of knowledge do not mediate the influence of sustainable leadership toward the adoption of frugal innovation.

The findings have managerial implications for agrifood SMEs in Surakarta, encouraging proactive adaptation to technological turbulence and greater innovation agility. Entrepreneurs should actively join business communities or clusters and respond promptly to educational programs. Digital platforms also serve as efficient media for accessing various sources of innovation and building business networks. On a personal level, entrepreneurs should strengthen their personal qualities by learning quickly, collaborating effectively, and planning their business futures strategically.

This study enriches the understanding and provides a real depiction of frugal innovation adoption at the SME level from personal, technological, and organizational perspectives. However, as the research area was limited to Surakarta City, further studies are needed to expand the geographical scope to enhance the generalizability of the results. Future research could investigate the impact of adopting frugal innovation on business performance and on public acceptance of frugal food products.

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ACKNOWLEDGMENT

The authors are grateful to Universitas Sebelas Maret, Surakarta, Central Java, Indonesia, for funding this study with Contract No: 371/UN27.22/PT.01.03/2025.

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APPENDIX A

Table A1. Demographic characteristics

Factor	Respondent's profile	Frequency	%
Income	< 5,000,000	51	34
	5,000,00 – 40,000,000	79	52.7
	> 40,000,000	20	13.3
Length of business operation (years)	≤ 10	100	66.7
	11 – 20	28	18.7
	21 – 30	13	8.7
	31 – 40	4	2.6
	41 – 50	2	1.3
	> 50	3	2
Gender	Male	75	50
	Female	75	50
Age (years)	≤ 20	5	3.3
	21 – 30	33	22
	31 – 40	39	26
	41 – 50	37	24.7
	51 – 60	28	18.7
	> 60	8	5.3

Table A2. Questionnaire

Source: Nassani et al. (2022), Tuijl and Knorrninga (2023), Gandasari (2021), Nguyen et al. (2022), Setyowati et al. (2024), Calantone et al. (2003), Dost et al. (2019), Cuevas-Vargas et al. (2022), Fauzan et al. (2021), Yanti et al. (2018).

No.	Particulars	Question
Demographic Information		
1	Gender	
2	Age	
3	Formal education (years)	
4	Monthly income	
5	Products produced	
5 point Likert Scale questions (1 = strongly disagree – 5 = strongly agree)		
Compatibility		
1	Frugal innovation aligns with my desired work methods/practices.	
2	Frugal innovation fits my business culture.	
3	Frugal innovation brings the changes I desire.	
4	Frugal innovation aligns with my business principles.	
Digital platform		
1	Digital platforms make it easier for me to find ideas for frugal innovations.	
2	Digital platforms make it easier for me to find innovators with ideas for frugal innovations.	
3	Digital platforms make it easier for me to find partners for innovation.	
4	Digital platforms help me find new markets for frugal innovation products.	
5	Digital platforms help me find materials for frugal innovations.	
External knowledge		
1	I get ideas for frugal innovations from consumers.	
2	Competitors sometimes give me ideas for frugal innovations.	
3	Government training and workshops can be a source of frugal innovations.	
4	University educational programs can encourage me to pursue frugal innovations.	
5	The business community I am a member of inspires frugal innovations.	
FI adoption		
1	I have implemented frugal innovations for my business.	
2	I am satisfied with the frugal innovations I have created.	
3	I plan to design more frugal innovations to improve business process efficiency.	
4	The cost-effective innovations I implemented are functioning as expected.	
5	I am happy to have implemented frugal innovations in my business.	

Table A2 (cont.). Questionnaire

No.	Particulars	Question
Low-cost manufacturing		
1	Frugal innovation is a solution for producing quality yet affordable products.	
2	Frugal innovation can reduce product prices.	
3	Frugal innovation can reduce operational costs.	
4	Frugal innovation supports cost efficiency.	
Sustainable leadership		
1	I am able to understand and absorb what is conveyed.	
2	I am able to collaborate with others.	
3	I am open with employees regarding business decisions.	
4	I am able to take advantage of current trends.	
5	I am able to plan my future business activities.	
6	I have a clear vision for business development.	
Technology turbulence		
1	Technology in my business sector is evolving rapidly.	
2	Cost-effective innovation is highly possible based on current technological advancements.	
3	Production innovation in my business sector is constantly changing.	
4	Business service innovation is developing even more rapidly.	

APPENDIX B

Table B1. Fornell–Larcker

	COM	DP	EKS	FIA	LCP	SL	TT
COM	0.820						
DP	0.007	0.843					
EKS	−0.052	0.500	0.877				
FIA	0.326	0.292	0.100	0.817			
LCP	0.126	0.048	0.219	0.278	0.819		
SLS	0.424	0.302	0.293	0.356	0.152	0.847	
TT	0.154	0.322	0.305	0.335	0.184	0.288	0.817

Note: COM = Compatibility; DP = Digital Platform; EKS: External Knowledge; FIA = Frugal Innovation Adoption; LCP: Low-cost Manufacturing; SLS = Sustainable Leadership; TT = Technology Turbulence

Table B2. Heterotrait–monotrait ratio (HTMT)

	COM	DP	EKS	FIA	LCP	SL	TT
COM							
DP	0.116						
EKS	0.152	0.665					
FIA	0.430	0.369	0.161				
LCP	0.188	0.118	0.316	0.327			
SLS	0.559	0.366	0.390	0.419	0.175		
TT	0.233	0.425	0.424	0.436	0.245	0.341	

Note: COM = Compatibility; DP = Digital Platform; EKS: External Knowledge; FIA = Frugal Innovation Adoption; LCP: Low-cost Manufacturing; SLS = Sustainable Leadership; TT = Technology Turbulence

Table B3. Cross-loading values

	COM	DP	EKS	FIA	LCP	SL	TT
COM2	0.801	−0.032	0.083	0.231	0.117	0.456	0.091
COM3	0.785	0.056	−0.129	0.262	0.038	0.359	0.263
COM4	0.871	−0.010	−0.064	0.303	0.150	0.259	0.037
DP1	−0.090	0.890	0.430	0.275	−0.043	0.219	0.172
DP2	0.108	0.832	0.451	0.248	0.123	0.330	0.410

Table B3 (cont.). Cross-loading values

	COM	DP	EKS	FIA	LCP	SL	TT
DP5	0.011	0.806	0.381	0.210	0.053	0.215	0.240
EKS3	−0.079	0.450	0.895	0.122	0.314	0.264	0.188
EKS5	−0.007	0.427	0.859	0.048	0.053	0.250	0.359
FIA2	0.197	0.263	0.115	0.793	0.373	0.240	0.204
FIA4	0.293	0.274	0.125	0.841	0.163	0.348	0.383
FIA5	0.313	0.170	−0.009	0.817	0.145	0.277	0.219
LCP1	0.145	−0.008	0.182	0.275	0.874	0.142	0.174
LCP3	−0.035	0.013	0.265	0.102	0.710	0.083	0.152
LCP4	0.122	0.106	0.155	0.244	0.864	0.132	0.136
SL1	0.358	0.292	0.256	0.416	0.173	0.876	0.309
SL5	0.343	0.218	0.258	0.159	0.122	0.802	0.167
SL6	0.382	0.241	0.236	0.267	0.077	0.862	0.223
TT1	0.170	0.238	0.315	0.302	0.174	0.341	0.878
TT3	0.146	0.298	0.246	0.266	0.112	0.253	0.824
TT4	0.053	0.258	0.175	0.249	0.165	0.091	0.744

Note: COM = Compatibility; DP = Digital Platform; EKS: External Knowledge; FIA = Frugal Innovation Adoption; LCP: Low-cost Manufacturing; SLS = Sustainable Leadership; TT = Technology Turbulence