

The Influence of Hexahelix Model on The Sustainability of MSMEs: The Moderating Effect of Frugal Strategy

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Abstract

Background Problem: Existing studies have largely examined Hexahelix collaboration or frugal innovation separately, providing limited empirical evidence on how frugal strategy enhances the effectiveness of multi-actor collaboration in supporting MSME sustainability, particularly in medium-sized cities. **Novelty:** This study contributes by integrating the Hexahelix model and frugal strategy into a single empirical framework, positioning frugal strategy as a moderating variable. It also provides evidence from Madiun City, Indonesia, a regional context that remains underrepresented in sustainability research. **Method:** A quantitative survey was conducted among 180 MSMEs selected through purposive sampling. Data were collected using structured questionnaires and analyzed using Partial Least Squares–Structural Equation Modeling (PLS-SEM). **Results/Findings:** The results reveal that the Hexahelix model significantly improves MSME sustainability. Frugal strategy not only has a positive direct effect on sustainability but also strengthens the influence of Hexahelix collaboration by enabling MSMEs to transform external support into resource-efficient, environmentally friendly, and competitive business practices. **Conclusion:** The findings extend the Hexahelix framework by demonstrating that collaborative success depends on both stakeholder synergy and MSMEs' internal frugal capabilities. Integrating collaborative governance with frugal strategies can enhance MSME competitiveness while promoting long-term economic, social, and environmental sustainability.

Keywords: Frugal Strategy; Hexahelix; MSME Sustainability; PLS-SEM

JEL Classification: L26; O32; R11

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INTRODUCTION

Madiun is recognized as a region with significant potential, supported by a conducive environment that fosters the growth of Micro, Small, and Medium Enterprises (MSMEs). As of 2020, the city recorded 36.555 MSMEs, distributed across three districts: Taman, Kartoharjo, and Manguharjo (Dinas Koperasi Usaha Kecil Dan Menengah Provinsi Jawa Timur, 2020). (BPS-Statistic Indonesia Madiun Municipality, 2021) ocumented a significant increase in MSME growth from 7,91% in 2018 to 9,86% in 2019, with the MSME

contribution to Madiun City's GDP ranging from 57,3% to 60%. The rapid growth of Madiun's MSME sector has made it a pillar of regional economic growth. In the past five years since the pandemic, the MSME ecosystem in Madiun City has expanded. Madiun's economic growth in 2023 reached 5,8%, surpassing the previous year and even surpassing East Java's economic growth of 4,95%. (Jatim Pos Online, 2024). The Madiun city government provides increased attention to MSMEs, including facilitating business licensing, improving financial reporting, business oversight, and even providing assistance in analyzing business risks. The city government also facilitates capital and product marketing (Amah et al., 2023).

Sustainable management of MSMEs aligns with efforts to maintain the continuity of their life cycle and sustain their businesses. Sustainable business management in several studies refers to business sustainability. Business sustainability is considered a key subdomain of solutions to social and environmental problems (Anand et al., 2021; Argade et al., 2021). It is based on exploration, discovery, creation, innovation and exploitation of business opportunities that contribute to sustainability (Sarma et al., 2024; Shafique et al., 2021). The concept of business sustainability is identical to measuring a company's success through Triple-Bottom-Line objectives, highlighting the interdependence of the social, environmental and economic dimensions (People-Planet-Profit) of a business (Abraham, 2024; Edeigba & Arasanmi, 2022). Companies are increasingly responsive to business sustainability as an effort to increase value for stakeholders. (Aviyanti et al., 2022).

Research on MSME sustainability and sustainable entrepreneurship so far has emphasized conceptual differences from traditional entrepreneurship (Barth et al., 2021; Oliveira-Dias et al., 2022), Triple-Bottom-Line goal promise (Arya et al., 2023; Vig, 2023), obstacles and challenges for sustainable business (Hummels & Argyrou, 2021; Su et al., 2022).

The sustainability of MSMEs requires the support and synergy of multiple stakeholders to be optimal. (Islam et al., 2025) esigned a strategic collaborative helix paradigm (MSMEs-Government-Conventional and Sharia NGOs) for sustainable MSME growth. (Armas et al., 2024) examined MSME development efforts and economic growth in the Philippines, highlighting the importance of targeted government intervention and triple helix collaborative efforts (academia, government, industry) to achieve the sustainable development goals (SDGs). In Indonesia, research on the role of the helix in the development and performance of MSMEs, including by (Mardiatmi et al., 2024) examined the role of the quadruple-helix and suggested that local communities be more actively involved with MSMEs, the government support through policies, and academics actively provide insights into MSME management practices. (Melany et al., 2024) The hexahelix model involves multiple stakeholders influencing product innovation and integrated marketing. This study will examine the roles of each actor and their interactions as key determinants of the hexahelix model, distinguishing it from (Melany et al., 2024). Hexahelix is a synergy between 6 elements including government, industry, academics, NGOs, mass media, and affected communities that will accelerate the MSME sustainability program (Firmansyah et al., 2022; Tuthaes et al., 2024).

Efforts to maintain business sustainability are certainly correlated with increased costs by MSMEs, so a frugal strategy is needed. (Shahid et al., 2023) menyebutkan inovasi hemat sebagai identified frugal innovation as a source of sustainable entrepreneurship that addresses social and environmental challenges, creates new markets in developing countries, and drives inclusive growth. Supporting factors and methods for maintaining business sustainability were developed (Cuevas-Vargas et al., 2022; Hossain & Sarkar, 2023) namely frugal innovation and its revolution into frugal entrepreneurship.

Frugal strategy, which involves cost-effective innovation practices, utilizing local resources, and simple process redesign, offers a practical way for MSMEs to remain competitive with limited resources. Recent literature confirms that frugal innovation in MSMEs grows more effectively when supported by organizational capacity, external knowledge sources, and institutional networks—elements directly provided by Hexahelix actors. Thus, frugal strategy acts as a moderator, strengthening the relationship between multi-actor collaboration and MSME sustainability outcomes (Ur Rehman et al., 2024).

Although studies on Hexahelix and frugal innovation are growing, there are several shortcomings that become research areas: (1) many Hexahelix studies focus on certain sectors (e.g. tourism) or are descriptive in nature, while quantitative evidence on its influence on MSME migration in the context of medium-sized cities is still limited; (2) studies on frugal innovation often examine the determinants and outcomes of innovation, but few examine the moderating role of frugal strategies in strengthening the influence of Hexahelix collaborative networks on MSME intentions. The literature review and systematic review by (Dabić et al., 2022) also recommend further research that integrates aspects of networks, frugal innovation, and sustainability in SMEs/MSMEs.

This study offers several novelties: (a) testing the influence of the Hexahelix model on the sustainability of MSMEs with frugal strategy as a moderating variable, a combination that has rarely been tested empirically; (b) focusing on the context of a medium-sized city (Madiun) provides evidence from a regional level that is often underrepresented.

Literature on innovation ecosystems increasingly emphasizes that capacity building and innovation diffusion are inadequate if they rely solely on one or two actors. Multi-actor collaborations involving government, academia, industry, communities, media, and environmental/legal actors (Hexahelix) accelerate resource access, social legitimacy, and the adoption of new practices relevant to local sustainability. Applied research by (Basri et al., 2025) shows that Hexahelix is effective in the context of tourism and creative economy development because each actor bridges the institutional gaps of the others (e.g., policy, technical knowledge, markets, and community legitimacy).

Innovation network theory and empirical evidence on MSMEs (Muchtar et al., 2025) suggest that the existence of heterogeneous networks and strong inter-actor relationships enables knowledge transfer, facilitates access to capital and marketing, and facilitates policy support all factors relevant to improving the economic, social, and environmental aspects of business sustainability. Therefore, Hexahelix collaboration is predicted to positively contribute to MSME sustainability indicators (operational efficiency, green reputation, social inclusion).

Hypothesis 1 (H1): The Model of Hexahelix collaboration has a positive effect on MSME sustainability management.

Frugal strategies (frugal innovation) refer to efforts to create value with minimal resources: cost efficiency, product/process simplification, utilization of local resources, and redesign for essential uses. Multidisciplinary studies show that frugal innovation thrives under resource constraints and can improve market access while lowering production costs, making it relevant for MSMEs in developing countries. Frugal innovation is also often associated with elements of environmentally friendly/circular practices (e.g., recycling production waste) that enhance business sustainability (Dabić et al., 2022).

Hypothesis 2 (H2): The implementation of a frugal strategy has a positive effect on the sustainability of MSME management.

Several studies indicate that network support (e.g., academics, government) accelerates the adoption of frugal innovation, while frugal practices make the benefits of such support more operational at the micro-enterprise level. Conceptually, Hexahelix provides external resources including policies, knowledge, and market access, but frugal strategy determines how these resources are internalized and executed at the MSME operational level. Therefore, frugal strategy can strengthen (moderate) the relationship between multi-actor collaboration and sustainability: under conditions of high frugality, Hexahelix support is more easily translated into tangible efficiencies, green innovation, and increased profits. Empirical reviews on frugal innovation and network support corroborate this interaction logic. (Ur Rehman et al., 2024).

Hypothesis 3 (H3): Frugal strategies moderate the influence of Hexahelix on the sustainability of MSMEs.

RESEARCH METHOD

This study uses a quantitative approach with a survey method to analyze the influence of the Hexahelix collaboration model on the sustainability of MSMEs, with frugal strategy as a moderating variable. The empirical model was tested using Partial Least Squares–Structural Equation Modeling (PLS-SEM), as it is suitable for analyzing complex latent relationships with a relatively limited sample size and data that is not fully normally distributed.

The population of this study covers all MSMEs in Madiun City. Based on the latest data from the Cooperatives and MSMEs Office, the number of MSMEs is recorded at more than 36,555. The sampling technique used purposive sampling, with the following criteria: MSMEs have been actively operating for at least 3 years, have interacted with other parties (government, academics, communities, media, or the environment), and have participated in training programs, digitalization programs, or cross-actor collaborations. The number of respondents collected was 180 MSMEs, thus meeting the minimum requirements for PLS-SEM analysis. Primary data was obtained through a closed-ended questionnaire with a Likert scale of 1–5 (strongly disagree–strongly agree). Distribution was conducted using a combination of online (Google Form) and offline (field visits). To strengthen validity, a pilot test was conducted on 30 respondents.

The frugal strategy variable consists of the following indicators: cost efficiency, simple innovation, utilization of local resources, financial management and reporting. Furthermore, the hexahelix model variables include the following dimensions: Government (licensing

policies, training, capital assistance, tax policies and credit interest subsidies, access to information), Academics (mentoring, training, research and application of the results, communication and collaboration), business / industry (market access / distribution networks, mentoring, partnership opportunities), MSME Community and Law (promotion, channeling / opening market access, MSME motivation, synergy in building joint businesses, business legality and IPR protection), Media (promotion, disseminating information, increasing visibility to increase demand for MSME products), Affected communities and environmental activists (training, exhibitions, collaboration, Feedback on improving product / service quality, Advocacy for the use of environmentally friendly materials, Encouragement for the adoption of sustainability principles. The dependent variable is MSME Sustainability which includes economic, social, and environmental aspects (increased income / profit, job creation, social reputation, and environmentally friendly practices).

Research data analysis includes descriptive statistics, measurement model analysis, determination coefficient test and Goodness of Fit test, and hypothesis testing. According to Hair et al. (2013) ; Cahyonowati et al. (2023) the measurement model analysis carried out includes convergent validity, discriminant validity, construct reliability. Researchers use Smart Partial Least Square (Smart-PLS) when analyzing moderation regression models.

RESULTS AND DISCUSSION

Analysis of respondent characteristics data to illustrate the demographic distribution of the MSMEs in this study. Respondent characteristics include type of business, respondent age, gender, and respondent's business turnover. Based on business sector, respondents from culinary business were 48, grocery store 23, automotive 14, mode 20, Art and handicraft 43, other 32. Respondents taken in the study were those who have small and medium businesses with age < 25 years were 11, age 25-34 years were 21, age 35-44 were 71, age 45-54 years were 59, age 55 years were 8. Then based on gender, male respondents were 76 and female respondents were 104. Based on business turnover, respondent with less than Rp 500 million were 95, Rp 500 million – Rp 4,800 billion were 59, and more than Rp 4,800 billion were 26.

Table 1. Descriptive Statistic

Variable	N	Min	Max	Mean	Standard Deviation
Hexahelix	180	21	59	40,95	9,558
Frugal Strg	180	18	50	39,12	7,126
Sustainability	180	21	50	41,15	6,455

Source: The Processed Primary Data (2025)

The standard deviation value describes the variation of the collected data. The collected and processed variable Hexahelix data produced information with an mean value of 40,95 and a standard deviation of 9,558. Then, the data on Frugal Strategy had a smaller standard deviation value, namely 7,126 compared to the mean value of 39,12. The data on sustainability had a standard deviation value of 6,455 smaller than the mean value of 41,15. The standard deviation value was smaller than the mean value, meaning that the data on

Hexahelix, Frugal Strategy, and Sustainability were concentrated around the mean value. This indicates that the collected data is homogeneous data where the data values are in a small and uniform range.

Table 2. Factor Loading and AVE

No	Items	Loading Factor	AVE
1	Hexahelix (Hexa)		0,728
	Hexa1	0,741	
	Hexa2	0,851	
	Hexa3	0,773	
	Hexa4	0,823	
	Hexa5	0,785	
	Hexa6	0,752	
	Hexa7	0,776	
	Hexa8	0,827	
	Hexa9	0,822	
	Hexa10	0,861	
	Hexa11	0,848	
	Hexa12	0,819	
2	Frugal Strategy (FS)		0,862
	FS1	0,821	
	FS2	0,847	
	FS3	0,763	
	FS4	0,874	
	FS5	0,769	
	FS6	0,782	
	FS7	0,748	
	FS8	0,887	
	FS9	0,848	
	FS10	0,759	
3	MSMEs Sustainability (Sustain)		0,733
	Sust1	0,757	
	Sust2	0,734	
	Sust3	0,823	
	Sust4	0,793	
	Sust5	0,786	
	Sust6	0,745	
	Sust7	0,795	
	Sust8	0,818	

Source: The Processed Primary Data (2025)

Convergent validity is used to evaluate the level of agreement between each indicator and the latent construct or measured variable. Convergent validity testing is conducted by considering the outer loading value and the Average Variance Extracted (AVE) value. A summary of the convergent validity test results is presented in the following table. Table 2 illustrates the loading factors and AVE statistics. Each indicator of the hexahelix construct achieves loading values above 0,7 and AVE scores exceeding 0,5 thereby fulfilling the conditions for convergent validity. Consequently, the measurement of this construct is valid and appropriate for further analysis. Comparable outcomes are obtained for the frugal strategy and MSME sustainability constructs, both of which report loading factors greater than 0,7 and AVE values higher than 0,5.

Table 3. Construct Reliability

Variable	Composite Reliable	Cronbach Alpha
Hexa	0,864	0,822
FS	0,838	0,816
Sustain	0,912	0,840

Source: The Processed Primary Data (2025)

As shown in table 3, the Composite Reliability values of all variables are above 0,7, while Cronbach's Alpha values are higher than 0,6. This demonstrates that the instruments applied in this study are consistent and dependable. Accordingly, all latent constructs meet the reliability requirements and are suitable for subsequent analysis. After verifying the outer model, the study proceeds with testing the inner model, which involves examining the coefficient of determination and the Goodness of Fit (GOF). Table 4 provides the Adjusted R² and AVE results.

Table 4. Adjusted R² dan AVE

Variable	Adjusted R ²	AVE
Hexa		0,728
FS		0,862
Sustain	0,517	0,733

Source: The Processed Primary Data (2025)

Table 4 illustrates that the adjusted R² value of 0,517 means the independent variables account for 51,7% of the variance in the dependent construct, whereas 48,3% is explained by external factors not included in the model. To further assess model fit, the customized R² value and the mean AVE are computed based on the earlier formula. The resulting GoF value is calculated as follows.

$$GoF = \sqrt{AVE \times Adjusted R^2}$$

$$GoF = \sqrt{0,774 \times 0,517}$$

$$GoF = 0,5632$$

The calculation results indicate that the GoF value is 0,5632 which reflects a high level of model fit. A higher GoF demonstrates that the model is adequately representative of the sample, thereby allowing the hypothesis testing process to proceed.

Hypothesis testing was conducted using a 5% significance threshold. Accordingly, the alternative hypothesis is considered valid if the p-value is less than 0,05. The results are summarized in the following table.

Table 5. Summary of Hypothesis Test Results

Hypothesis	Path-Coefficient	P-Values	Decision
H1 Hexa → Sustain	0,347	0,001	Supported
H2 FS → Sustain	0,251	0,013	Supported
H3 Hexa*FS → Sustain	0,374	0,019	Supported

Source: The Processed Primary Data (2025)

The path-coefficient value of the hexahelix model on MSMEs Sustainability is 0,347 with a P-value of 0,001. P-values are less than 0.05 so that **hypothesis 1 is supported**. A positive path-coefficient means that the hexahelix model has a positive effect on MSME sustainability. Likewise, the path-coefficient of Frugal strategy on MSME sustainability is positive and P-values are less than 0,05 which means that Frugal strategy has a positive effect on MSME sustainability. **Hypothesis 2 is supported**. The path coefficient of the interaction variable of the Hexahelix*Frugal Strategy model is positive and the P-value is less than 0.05, meaning that Frugal Strategy moderates the effect of the Hexahelix model on the sustainability of MSMEs. **Hypothesis 3 is supported**.

The research results show that the Hexahelix Model has a positive impact on the sustainability of MSMEs. This confirms that collaboration between actors, namely the government, academics, industry players, communities, media, and environmental activists, will provide significant support for MSMEs in maintaining their business sustainability. The government plays a role through policies, incentives, and facilities that reduce capital barriers and encourage environmentally friendly practices. Environmentally friendly practices increase cost efficiency and a green reputation, which will ultimately impact the sustainability of MSMEs (Pauzy et al., 2025; Tuthaes et al., 2024).

Academics strengthen knowledge and managerial skills so that MSMEs can absorb and implement new innovations. Academics provide technical training, SOP development, and mentoring for financial management or product innovation (Noya et al., 2023). The mechanism implemented is to increase the absorptive capacity of MSMEs, namely the ability to capture, absorb, and apply new knowledge so that frugal technology and environmentally friendly practices can be implemented correctly.

Industry players provide market access and supply chain networks that lower costs while expanding business scale. Connecting with industry players helps MSMEs improve their supply chains, source quality local raw materials, or enter distribution channels. Ease and availability of market access, along with increased production scale, lowers per-unit costs and encourages investment in efficient processes. This, in turn, impacts the economic dimension of sustainability (profitability and business stability). The existence of a banking

industry that offers easy financial access will impact the sustainable competitive advantage of MSMEs (Susandini et al., 2025)

Community support increases social legitimacy and local demand. Community support increases local demand, acceptance of MSME products, and facilitates local employment, thus impacting social desirability (job creation, empowerment) (Octavianto et al., 2024).

Media plays a role in building image and expanding markets through information and branding. Media accelerates the dissemination of information about green practices and the social value of products. Media information shapes consumer perceptions of green reputation, thereby increasing willingness to pay or customer loyalty, and driving commercial interest among MSMEs (Melany et al., 2024).

Furthermore, environmental activists encourage MSMEs to adopt efficient green practices while enhancing their business reputation. Technical interventions and social pressure from affected communities and environmental activists will encourage MSMEs to adopt green practices, thereby reducing long-term costs (Zhou et al., 2024)

Dengan demikian, Model Hexahelix membentuk ekosistem yang menyediakan sumber daya eksternal penting untuk mendukung keberlangsungan UMKM baik dari aspek ekonomi, sosial, maupun lingkungan (Muchtar et al., 2025; Octavianto et al., 2024; Toda et al., 2024).

This study found that a frugal strategy has a positive impact on the sustainability of MSMEs. Economical and innovative strategies based on utilizing local resources have been proven to help MSMEs reduce production costs, deliver products relevant to market needs, and implement environmentally friendly practices such as recycling and energy efficiency. With this approach, MSMEs can increase competitiveness while strengthening business resilience amidst resource constraints. This finding aligns with the literature on frugal innovation, which emphasizes the importance of design simplicity, improvisation, and adaptation to local contexts as keys to MSME success in developing countries. (Shahid et al., 2023) mentions frugal innovations as a source of sustainable entrepreneurship addressing social and environmental challenges, creating new markets in developing countries and driving inclusive growth.

The frugal strategy also moderates the effect of the Hexahelix Model on MSME sustainability. This moderation indicates that the multi-actor network support offered by Hexahelix will be more effective if MSMEs already have the internal capabilities to manage resources economically and efficiently (Tursanurohmad et al., 2023). Without a frugal strategy, support from the government, academia, or industry is often hampered during implementation due to limited capital and operational capacity. However, with a frugal strategy, MSMEs can translate external resources into simple innovations, contextual products, and low-cost operational practices. In other words, the frugal strategy increases the absorption capacity of MSMEs for the benefits of Hexahelix, reduces the cost of adopting innovation, and strengthens social legitimacy so that the impact of multi-actor collaboration on business sustainability becomes more tangible.

The theoretical implication that this study broadens the understanding of the Hexahelix model by showing that the effectiveness of multi-actor collaboration does not stand alone, but is influenced by the internal capabilities of MSMEs in implementing frugal strategies.

The practical implication is that the government needs to design policies and incentives that not only encourage collaboration between actors (Hexahelix) but also internalize the spirit of frugal innovation, for example through microfinance programs aimed at resource-saving practices, simple product design training, and environmentally friendly certification. Universities can expand their role as business incubators that instill the principles of frugal strategy in students and assisted MSMEs, so that research collaboration and mentoring are more effective and contextual. The need to establish a flexible and efficient supply chain (with industry support), for example by opening opportunities for co-production or joint design with MSMEs, so that frugal innovations can enter the market more quickly.

The community provides support to increase the social legitimacy of MSMEs that adopt frugal and environmentally friendly practices, for example through local product purchasing movements and awareness campaigns. Media exposure of frugal strategy practices in the Hexahelix collaboration can improve the positive image of local products. Intense collaboration between the community, environmental activists, and MSMEs in creating solutions based on recycling, the circular economy, and energy efficiency, so that environmental sustainability aspects are internalized in business strategies.

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AUTHORSHIP CONTRIBUTION STATEMENT

The first author conceptualized the research, developed the theoretical framework, designed the methodology, and oversaw the overall research process and finalized the manuscript. The second author was responsible for data analysis, interpretation of results, and drafting and critically revising the article's content. The third author contributed to data collection, initial data processing, literature review, and drafting the first draft under the direction and supervision of the first author. All authors have read and approved the final version of the manuscript for publication.

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