SCIENTIFIC CULTURE
www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 12, No. 2.1, (2026), pp. 474-484
Open Access. Online & Print

DOI: 10.5281/zenodo.122.12646

SYNERGIZING ALGORITHMIC AND INNOVATION LEADERSHIP VIA INTERACTION: CONTRIBUTIONS TO THE DEVELOPMENT OF RURAL ENTREPRENEURIAL ECOSYSTEMS IN THE DIGITAL AGE

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Received: 01/12/2025
Accepted: 02/01/2026

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ABSTRACT

The rural entrepreneurship ecosystem faces various obstacles in access to funding, infrastructure, digital literacy, and limited networks, yet holds significant economic potential through MSMEs, cooperatives, and Village-Owned Enterprises (BUMDes). This article analyzes the contribution of Algorithmic Leadership and Innovation Leadership via interaction in strengthening the rural entrepreneurship ecosystem, based on a study in Malang Regency, East Java. A survey of 270 entrepreneurs (253 eligible for analysis) and FGDs with 36 entrepreneurs were conducted. The obtained data were analyzed using PLS-SEM. The results have revealed that via interaction, algorithmic leadership has a positive and significant effect on the entrepreneurship ecosystem ($\beta = 0.296$; $p < 0.01$), and Innovation Leadership has a stronger effect ($\beta = 0.585$; $p < 0.01$). Substantively, algorithmic leadership strengthens data-driven decision-making, actor coordination, and process efficiency via interaction; while innovation leadership creates adaptive space, orchestrates networks, and accelerates market orientation. These findings enrich the theoretical framework of the entrepreneurship ecosystem and provide practical guidance for village business leaders to build sustainable competitiveness.

KEYWORDS: Interaction, Entrepreneurial Ecosystem; Algorithmic Leadership; Innovative Leadership; Msmes; Data-Driven Decision Making.

1. INTRODUCTION

Entrepreneurial ecosystems have increasingly become a major focus for researchers, practitioners, and policymakers over the past decade (Bărbulescu, Nicolau & Munteanu, 2021; Zivdar & Sanaeepour, 2022; Stam & van de Ven, 2021). Since 2010, research on entrepreneurial ecosystems has grown rapidly and become one of the most popular areas in management (Ratten, 2020a). This strong interest in this issue stems from the role of ecosystems in describing the locational and collaborative aspects of entrepreneurship. However, most research still tends to rely on a single theoretical framework (Ratten, 2020b), despite the availability of numerous theories that could serve as a foundation. This situation underscores the need for exploration to determine whether new theories on entrepreneurial ecosystems can be applied across global contexts (Ratten, 2020b).

Despite receiving significant attention, the concept of entrepreneurial ecosystems remains underdeveloped theoretically. This is evident in the absence of a universal definition, the absence of a standard analytical framework, and the lack of a theoretical basis that can explain the evolutionary processes within ecosystems (Cho, Ryan, & Buciuni, 2021; Roundy & Lyons, 2023; Jones & Ratten, 2021; Kansheba & Wald, 2020; Stam & van de Ven, 2021). Keywords such as "lack of theory" or "underdevelopment" have continued to emerge in academic discourse since 2015, indicating the need for more serious theoretical efforts.

In rural contexts, entrepreneurship is growing rapidly and offers significant economic potential, whether through MSMEs, agriculture, or tourism (Sohns & Revilla, 2018). However, entrepreneurs face various obstacles: limited infrastructure, limited access to resources and markets, weak human capital, and limited business networks. These challenges emphasize the crucial role of rural entrepreneurship as a driver of local economies, as entrepreneurs' capacity to identify and capitalize on opportunities is crucial for development. On the other hand, the emergence of new technologies such as Artificial Intelligence (AI), Big Data, and the Internet of Things (IoT) opens up significant opportunities to strengthen the efficiency and innovation of rural businesses.

However, most previous research has focused on national-level entrepreneurial ecosystems (Autio et al., 2018) or specific industries (Sohns & Wojcik, 2020). However, rural entrepreneurial ecosystems have distinct characteristics, including poverty, limited access to technology, funding, and cultural values (Aguilar, 2021). Therefore, the success of a rural ecosystem depends not solely on local values but also on the roles of actors connected within a social system. This situation demands innovative and algorithmic leadership to ensure more informed decision-making and a modern village ecosystem.

Research gaps are also evident in leadership studies, where innovative leadership has been shown to be crucial in driving technology adoption and rural economic growth (Rezaei & Izadi, 2019; Kumar, Mathur, & Misra, 2023), but has not addressed the technical aspects of its implementation. Meanwhile, Algorithmic Leadership by Harms & Han (2019); Kellogg, Melissa & Angele (2020); McGuire & De Cremer (2023) highlights the use of algorithms in organizational decision-making, but its application in the village context is still limited. The success of an entrepreneurial ecosystem depends on the dynamic interaction between business actors, government, and the community (Audretsch & Belitski, 2021). This principle is also relevant when applied to ecosystem development at the village level.

This study seeks to highlight a new theoretical framework, identify gaps, and design a Sustainable Entrepreneurship Ecosystem program relevant to rural areas. This framework adapts principles previously discussed in entrepreneurial ecosystem studies (e.g., Theodoraki, (2024) and also Pato, L., & Teixeira, A. A. (2019). This study will also examine the relevance of ecosystem elements proposed by [22] Barrera-Verdugo (2025), including culture, support, human capital, policies, markets, and finance—which have been shown to vary across regional contexts. Therefore, this study formulates three main questions: (1) are the elements of the entrepreneurial ecosystem relevant for rural MSMEs; (2) to what extent does collaboration between Algorithmic Leadership and Innovation leadership foster a rural entrepreneurial ecosystem? and (3) how can this collaboration model contribute to economic growth and welfare equity at the local level.

2. RESEARCH METHODOLOGY

2.1. *Instrument Development*

The items used to measure the variables in this study were adapted from previous research based on and validated by data-driven management theory, algorithmic leadership theory, performance management theory, innovation leadership theory, and entrepreneurship ecosystem theory. These items underwent rigorous validity and reliability testing, which can increase confidence in the measurement instrument used in this study. The Likert scale with three answer choices appropriate to the context of the indicators. Algorithmic Leadership, with five indicators and 15 items, was adapted from Chang, Zhang, & Xiao (2025) for X1.1 and X1.3; Harms & Han (2019), McGuire & De Cremer (2023) for X1.3 and X1.4; Parent-Rocheleau et al. (2024) for X1.5.

Innovation Leadership in this study is a multidimensional construct adapted from several established theories. Innovation Leadership consists of 7 indicators and 21 items. The creative behavior indicator (X2.1) uses the construct developed by Crossan & Apaydin (2010) and Jansen et al. (2016). The idealized influence indicator (X2.2) is adapted from the MLQ developed by Bass & Avolio (1996), effective communication (X2.3) is adapted from Yukl (2012), empowerment and mentoring (X2.4) is adapted from Arnold et al. (2000), and technical skills (X2.5) uses the construct developed by Katz (2009).

Meanwhile, the entrepreneurial ability indicator is adapted from Renko et al. (2015), the open behavior indicator is adapted from Covin & Miller (2014), and the open behavior indicator (X2.7) uses the construct developed by Edmondson (2018). The Entrepreneurship Ecosystem, with 6 indicators and 18 items, was developed by [35] Isenberg (2010); [36] Stam (2017); and [37] Spigel (2017), covering culture (Y1), support (Y2), human capital (Y3), policy (Y4), market (Y5), and finance (Y6).

2.2. Sample Selection

This study used a survey method, analyzing samples to generalize to the population. The unit of analysis was the leadership of Village Economic Institutions, which include MSMEs, Cooperatives, and Village-Owned Enterprises (BUMDes) in Malang Regency, spread across 33 sub-districts, as parties involved in the Village Entrepreneurship Ecosystem. The total number of MSMEs, including Cooperatives and BUMDes in Malang Regency is 431,376. However, in this study, 5,000 MSMEs, Village-Owned Enterprises (BUMDes), and Village-Owned Enterprises (KUD) that already have basic permits based on the Online Single Submission (OSS) and business licenses will be selected as subjects [38] (Imadudin, 2024, 31). The sample size was determined using the theory proposed [39] (Hair, Risher, & Ringle, 2018, 33), which states that sample size is determined based on the number of indicators multiplied by 5 to 10. In this study, the multiplication factor used was 5, with 54 research items, resulting in a sample size of 270 units of analysis.

2.3. Data Collection

To test this research framework, data was collected from MSMEs in Malang Regency, East Java, Indonesia, using a questionnaire. An offline survey method was implemented through the presence of the researcher to distribute the questionnaires to MSMEs. The questionnaire instrument used in this study used a Likert scale with three answer options. The response format was adjusted to the type of question to increase content validity and minimize response errors. The choice of 3 points is due to the varying levels of literacy/comfort in completing the questionnaire. A pilot study was used to check item comprehension, and polychoric correlations and appropriate estimators were used when analyzing ordinal data to ensure differences in scale formats did not compromise inferential validity [40] (Rhemtulla, Brosseau-Liard, & Savalei, 2012; [41] Flora & Curran, 2004).

Of the 270 questionnaires distributed to respondents, 17 were unsuitable for analysis, leaving 253 eligibles for analysis. Of these 253, 15 were from Village Cooperatives, 19 from Village-Owned Enterprises, and 219 from MSMEs. In addition to distributing the questionnaire, the researchers also conducted a focus group discussion (FGD) with 36 business actors to explore the implementation of algorithmic leadership and innovation leadership in the MSME business environment amidst the development of digital technology and how innovation is adopted in micro, small, and medium enterprises.

3. RESULTS

3.1. Respondent Data Description

Respondent characteristics and business profiles show that of the 253 valid respondents, 219 were MSMEs, 19 were Village-Owned Enterprises (BUMDes), and 15 were cooperatives. Gender: 66% female, 34% male. The dominant age range was 40–49 years. Educational attainment: 68% bachelor's degree, 25% high school/equivalent, 7% diploma. Business scale: 82% micro, 12% small, 6% medium (referring to capital criteria). Form of ownership: 83% sole proprietorships, 14% partnerships, 3% joint ventures, covering 55% in the industrial sector, 36% in the service sector, and the remainder in the agricultural sector. Markets served: 50% mixed (local & export), 45.9% local, 4.1% export only. This composition indicates an ecosystem dominated by locally oriented and mixed-use micro-enterprises, with relatively good formal literacy (high proportion of graduates) and significant female participation. These factors provide a relevant backdrop for examining the influence of Algorithmic Leadership (AL) and Innovation Leadership (IL) on Ecosystem Entrepreneurial.

3.2. Measurement Model

In the measurement model, convergent and discriminant validity were assessed. Convergent validity requires factor loadings above 0.70, average variance extracted (AVE) above 0.50, and composite reliability (CR) above 0.70 (Hair et al., 2017). Appendix B (**Table 1**) reports the convergent validity results: all item loadings exceed 0.70, all AVEs exceed 0.50, and all CRs exceed 0.70.

Tabel 1. Convergent Validity

Constructs	Indicators		Factor Loading	CR	AVE
Algorithmic Leadership	AL1	Situational and contextual analysis	0,851	0,943	0,767
	AL2	Data based decision making	0,894		
	AL3	Leadership strategy implementation and evaluation	0,889		
	AL4	Data and information collection	0,910		
	AL5	Continuous improvement	0,831		
Innovation Leadership	IL1	Creative behavior	0,894	0,960	0,777
	IL2	Idealized influence	0,758		
	IL3	Effective communication	0,819		
	IL4	Empowerment and mentoring	0,937		
	IL5	Technical skills	0,895		
	IL6	Entrepreneurial ability	0,962		
	IL7	Openness behavior	0,890		
Ecosystem Entrepreneurship	EE1	Culture	0,810	0,854	0,501
	EE2	Support	0,507		
	EE3	Human capital	0,676		
	EE4	Policy	0,605		
	EE5	Market	0,834		
	EE6	Finance	0,759		

Discriminant validity was then evaluated using the Heterotrait–Monotrait ratio of correlations (HTMT), with the recommended threshold of ≤ 0.85 (Henseler et al., 2015). As shown in (**Table 2**), all HTMT values fall below 0.85, indicating that respondents distinguished among the three constructs.

Tabel 2. Discriminat Validity: HTMT Creterion

		X1	X2	Y
1	Algorithmic Leadership			
2	Innovation Leadership	0,341		
3	Entrepreneurship Ecosystem	0,488	0,593	

3.3. Structural Model

To evaluate the structural model and test the hypothesized relationships, we estimated path coefficients, standard errors, and t- and p-values using bootstrapping with 253 cases, following Hair et al. (2019). Consistent with Hahn and Ang (2017), we interpreted significance using a combination of p-values, confidence intervals, and effect sizes. Model results and reporting criteria are summarized in (**Table 3**).

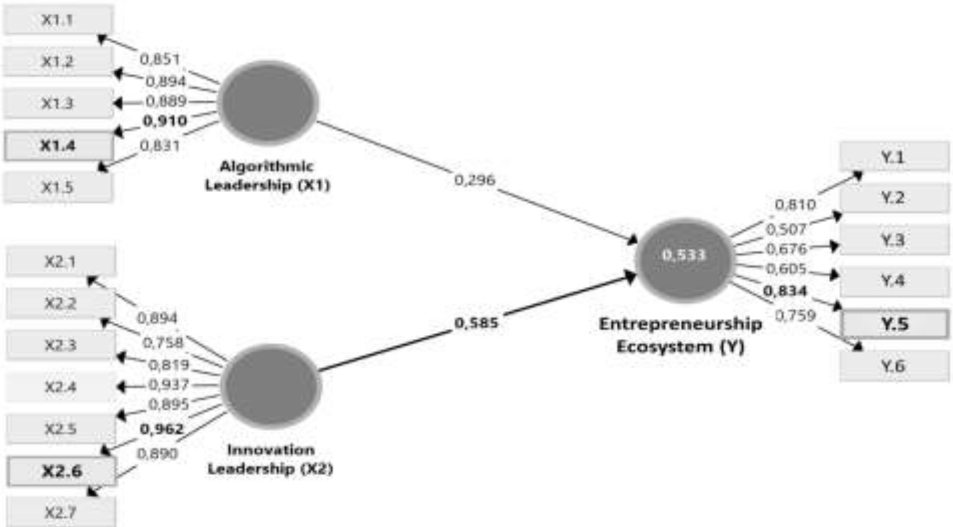
Tabel 3. Structural Model

Hypothesis	Relationship	Std Beta	Std Error	t-Value	P-Value	BCI LL	BCI UL	f²	Decision
H1	Algorithmic Leadership (X1) → Entrepreneurship Ecosystem (Y)	0.296	0.058	5.071	0.000	0.188	0.427	0.171	Supported
H2	Innovation Leadership (X2) → Entrepreneurship Ecosystem (Y)	0.585	0.053	11.111	0.000	0.454	0.673	0.668	Supported

Findings indicate that Algorithmic Leadership positively and significantly affects the Entrepreneurship Ecosystem ($\beta = 0.296$, $p < 0.01$). The second hypothesis tests the effect of Innovation Leadership on the Entrepreneurship Ecosystem; results show a positive and significant effect ($\beta = 0.585$, $p < 0.01$). Thus, both H1 and H2 are supported. Based on the path diagram (Figure 2), Innovation Leadership (X2) is the most influential predictor of the Entrepreneurship Ecosystem (Y), with the highest path coefficient (β = 0.585). Within Innovation Leadership, the most salient indicator is IL2 (Entrepreneurial Capability), which exhibits the highest factor loading (0.962). The table shows that the Algorithmic Leadership (X1) variable has a positive influence on the Entrepreneurial Ecosystem (Y). This means that the higher the Algorithmic Leadership (X1), the higher the Entrepreneurial Ecosystem (Y). The path coefficient is 0.296 with a t-value of 5.071. Because the t-value is greater than the critical value (5.071 > 1.96), the statistical hypothesis H0 is rejected, meaning that the Algorithmic Leadership (X1) variable has a significant influence on the Entrepreneurial Ecosystem (Y).

Meanwhile, the Innovation Leadership (X2) variable has a positive influence on the Entrepreneurial Ecosystem (Y). This means that the higher the Innovation Leadership (X2), the higher the Entrepreneurial Ecosystem (Y). The path coefficient is 0.585 with a t-value of 11.111. Because the t-value is greater than the critical value (11.111 > 1.96), the statistical hypothesis states that H0 is rejected, meaning that the Innovation Leadership variable (X2) has a significant influence on the Entrepreneurship Ecosystem variable (Y). The path coefficients in the structural model and the weight values of the manifest variable factors in the measurement model can be described through the following path diagram of the measurement model and structural model.

Based on the Path Diagram above, it can be seen that the most dominant variable in influencing the Entrepreneurship Ecosystem (Y) is Innovation Leadership (X2) with the highest path coefficient of 0.585, where among the indicators whose dominant role in measuring the construct of Innovation Leadership (X2) is X2.6 (Entrepreneurial Ability) with the highest factor loading of 0.962. Thus, to increase the value of the Entrepreneurship Ecosystem variable (Y), the statistical recommendation as material for evaluating strategic policies, especially regarding key indicators that need to be prioritized for improvement is the indicator X2.6 (Entrepreneurial Ability) with the highest factor loading of 0.962 (**Picture 1**).



Picture 1: Diagram Path Analysis.

4. DISCUSSION

1. Ecosystem Elements Most Influenced by Innovation Leadership (IL) And Algorithmic Leadership

Based on the results of quantitative analysis (PLS-SEM) indicated by indicators from the constructs modeled in this study, as well as further analysis through focus group discussions (FGDs), the Ecosystem Elements most dominantly influenced by Innovation Leadership (IL) are innovation capability and market experimentation (β = 0.585). This aligns with the view of Crossan & Apaydin (2010), who stated that innovation leadership drives the process of idea generation, experimentation, and commercialization. A similar view is also explained by Jansen et al. (2009), who stated that innovative leaders facilitate exploration, creativity, and product innovation. The results of the PLS-SEM analysis also indicate that IL influences the dimensions of product innovation and experimentation. IL also impacts the development of ecosystem networks and collaboration.

The results of this study align with those of Aarikka-Stenroos & Ritala (2017), who argued that innovation in the entrepreneurial ecosystem relies heavily on collaborative networks and value co-creation. Dyer, Singh, & Hesterly (2018) argued that innovative leaders are capable of creating inter-organizational collaboration that results in shared excellence. The elements of the entrepreneurial ecosystem, namely Entrepreneurial Culture and Market Orientation, are also influenced by innovative leadership, which can transform the ecosystem's culture to be more creative, adventurous, and market-oriented. These results are supported by Schein's (2010) study, which explains that innovative leaders shape a culture of experimentation and learning. Similarly, Özşahin et al. (2013) found that leadership determines market orientation and customer focus. This view aligns with the findings of this study, which states that cultural change and market orientation are determined by the implementation of innovative leadership.

Meanwhile, the results of this study also indicate that the Ecosystem Elements most influenced by Algorithmic Leadership (AL) are business processes, coordination, and ecosystem efficiency. Algorithmic (data-driven) leadership improves efficiency, coordination, and decision accuracy across actors. The results of this study support the findings of Almheiri et al. (2025) who explained that big data improves capabilities and performance derived from data-driven decision-making, which also improves coordination and operational performance. Brynjolfsson & McElheran (2016) explained that evidence-based management improves efficiency in small businesses, which is certainly in line with this study. This study shows that algorithmic leadership, which encompasses processes, coordination, and ecosystem efficiency, can improve efficiency, coordination, and decision accuracy across actors.

Brynjolfsson & McElheran (2016) found that evidence-based management improves efficiency in small businesses. These findings align with the findings of this study regarding sales/stock recording, dashboards, and resource allocation. AL also influences aspects of market intelligence and decision clarity, where data-driven leadership improves market understanding and decision-making. Pal Kaur, G., & Bedi, H. S. (2024) in their study also found that market intelligence influences the entrepreneurial ecosystem where the process of data collection, analysis, and visualization strengthens the sensitivity of MSMEs to demand dynamics. The ecosystem support system (information infrastructure) also requires data-based leadership that requires a connected information infrastructure. Autio et al. (2018) stated that digitalization & ecosystems in the form of information infrastructure are the foundation of a technology-based ecosystem.

2. The Influence of Algorithmic Leadership on the Entrepreneurship Ecosystem

The results of this study indicate that Algorithmic Leadership has a positive and significant influence on the Entrepreneurship Ecosystem ($\beta = 0.296$; $p < 0.01$). Substantively, this means that improving algorithm-based leadership practices through systematic data collection, evidence-based decisions, and continuous evaluation and improvement contributes to strengthening the entrepreneurial ecosystem, particularly in the dimensions of actor connectivity, market quality, and innovation capacity. This finding aligns with Evidence-Based Management theory (Rousseau, 2006), which asserts that managerial decision quality will be higher when based on the best evidence from organizational data, scientific research, and practical expertise. Therefore, when SME leaders in Malang Regency adopt a data-driven approach, they not only improve the quality of internal decisions but also contribute to the formation of an entrepreneurial ecosystem that is more adaptive and responsive to market changes.

These results are consistent with the findings of Brynjolfsson & McElheran (2016) who showed that adopting data-driven decision-making improves organizational productivity. Wang et al. (2025) also added that digital leadership improves organizational innovative performance, ultimately strengthening the ecosystem's capacity to adapt. Thus, the results of this study extend the empirical evidence that Algorithmic Leadership is relevant not only in large organizations but also in the context of village-based entrepreneurial ecosystems. However, there are critical nuances that need to be considered. Roundy (2022) cautions that the implementation of algorithmic leadership can reduce the frequency of informal interactions between actors, which are the foundation of trust and social capital in entrepreneurial ecosystems.

Jarrahi et al. (2021) also found that algorithms can influence power structures within organizations and generate resistance if not managed inclusively. Similarly, Höddinghaus et al. (2021) showed that the acceptance of algorithmic leadership is highly dependent on context, particularly social trust. In the context of Malang Regency, where the majority of businesses are micro-scale and supported by local community networks, the potential erosion of social trust needs to be addressed. Therefore, the implementation of Algorithmic Leadership must be balanced with human involvement (human-in-the-loop) to maintain social cohesion, the primary asset of the village entrepreneurial ecosystem.

3. The Influence of Innovation Leadership on the Entrepreneurship Ecosystem

This study also found that Innovation Leadership had a positive and significant effect on the Entrepreneurship Ecosystem ($\beta = 0.585$; $p < 0.01$), with a more dominant influence than Algorithmic Leadership. This finding supports the innovation theory proposed by Crossan & Apaydin (2010) [26], which states that leadership is a primary determinant of both the process and outcomes of organizational innovation. Visionary leaders, capable of mobilizing resources, and creating adaptive space (Uhl-Bien & Arena, 2018), enable the entrepreneurial ecosystem to be more responsive to changes in the business environment. Empirical support is also seen in the study by Gumusluoğlu & Ilsev (2009), which demonstrated that transformational leadership enhances organizational creativity and innovation.

Furthermore, Rosing, Frese & Bausch (2011) emphasized that flexible leaders who balance exploration and exploitation (ambidextrous leadership) are highly effective in creating a dynamic ecosystem. In the context of this research, high levels of innovation leadership mean that leaders, who are essentially business actors in villages in Malang Regency, can encourage the emergence of new ideas, connect networks, and accelerate market adaptation, thereby strengthening the vitality of the village's entrepreneurial ecosystem. However, the results of this study also highlight important limitations. A study by Mokhber et al. (2018) [59] showed that the impact of innovative leadership on innovation can be diminished if there is no adequate organizational support, such as incentives for new ideas or the courage to take risks.

In other words, although the influence coefficient in this study is large ($\beta = 0.585$), its effectiveness remains highly dependent on the conditions of the supporting ecosystem. This aligns with the argument of Stam & Spigel (2016), who emphasized that without orchestrated relationships between actors, innovation leadership has the potential to become fragmented and fail to be monetized in the market. In the context of Malang Regency, limited formal networks and minimal institutional support from the government and financial institutions can be limiting factors. Therefore, public policy intervention is essential to strengthen the ecosystem infrastructure so that innovation leadership can truly have an optimal impact.

Overall, this study supports previous theory and research that asserts that both Algorithmic Leadership and Innovation Leadership positively contribute to the entrepreneurial ecosystem. However, the results also provide novel contributions by highlighting the context of village-based entrepreneurship, where social dynamics and community capital play a crucial role. Algorithmic Leadership has been shown to enhance information efficiency and decision quality, but must be implemented sensitively to local social networks. Meanwhile, Innovation Leadership demonstrates a dominant influence in creating adaptive space and strengthening market orientation, but its impact is highly dependent on organizational support and institutional policies. These findings demonstrate that leadership in the entrepreneurial ecosystem is not a single variable but must be interpreted in interaction with the social, cultural, and structural context.

5. IMPLICATION

1. Theoretical Implications

The research findings broaden the theoretical basis by integrating algorithmic leadership and innovative leadership, thus addressing literature criticisms regarding the weak theoretical foundations of entrepreneurial ecosystems. Empirical evidence shows that data-driven mechanisms (algorithmic) and innovation (adaptive leadership) function complementary in orchestrating actors, markets, and networks. The study results confirm the relevance of algorithmic leadership in the rural context, which has previously been studied primarily in corporate organizations, and emphasize innovation leadership as a key determinant of ecosystem dynamics. This research fills this gap by positioning villages as the locus of analysis, demonstrating that the effectiveness of ecosystem elements (culture, support, human capital, policies, markets, and finance) is influenced by unique socio-geographical conditions. The dominance of entrepreneurial capability indicators suggests that leaders' entrepreneurial behavior is a critical pathway in transforming creativity into market value.

2. Managerial Implications

Leaders of MSMEs, Village Cooperatives, and Village-Owned Enterprises (BUMDes) need to adopt systematic data collection practices, evidence-based analysis, and continuous evaluation cycles to improve the quality of ecosystem coordination. Therefore, it is necessary to create a culture of experimentation, effective communication, and empower team members so that local ideas can be developed and commercialized according to market needs. Village leaders should build collaborations with local governments, educational institutions, and the private sector to expand market access, funding, and technology. The adoption of AI-based technologies, Big Data, and IoT must be implemented with a human-in-the-loop approach to maintain community trust while improving operational efficiency. The implementation of algorithmic and innovative leadership has the potential to drive local economic growth, create jobs, and strengthen equitable welfare among village communities.

6. CONCLUSION, LIMITATIONS, AND FUTURE RESEARCH

Algorithmic leadership has been shown to have a positive and significant impact on strengthening the entrepreneurial ecosystem. Its primary mechanisms operate through data-driven decision-making and evidence-based management, which improve decision quality, streamline information flow, and strengthen coordination across actors within the ecosystem. Systematic data collection, continuous evaluation, and the use of empirical evidence enable micro, small, and medium enterprises (MSMEs) and Village-Owned Enterprises (BUMDes) to respond more adaptively to market dynamics. However, if applied too automatically, algorithmic leadership can reduce the intensity of social interactions and erode community cohesion, which are fundamental elements of the rural entrepreneurial ecosystem.

Innovation leadership exerts a more dominant influence than algorithmic leadership in enhancing the vitality of the entrepreneurial ecosystem. Innovative leaders create an adaptive space where ideas, networks, and experiments can develop into tangible economic value. This role is demonstrated through their ability to craft and communicate a vision, orchestrate networks, and manage the balance between opening (exploring new ideas) and closing (commercial execution). The findings indicate that market dimensions and entrepreneurial capabilities are the most crucial factors driving ecosystem dynamics, consistent with the centrality of market indicators as the "heart" of the entrepreneurial ecosystem.

Algorithmic and innovation leadership contribute significantly, albeit in different and complementary ways. Algorithmic leadership emphasizes rationality, efficiency, and data-driven decision-making, while innovation leadership emphasizes creativity, vision, and dynamic adaptation. The combination of the two produces a rural entrepreneurial ecosystem that is not only operationally efficient but also innovative and resilient to change. Thus, this study concludes that the collaboration of algorithmic leadership and innovation is a crucial foundation for strengthening the rural entrepreneurship ecosystem in the digital era, with each form of leadership offering different but mutually reinforcing contributions to the growth and sustainability of the ecosystem.

Like other studies, this study has several limitations that can be addressed by further research. First, this study has examined the influence of Algorithmic Leadership and Innovation Leadership on the Entrepreneurship ecosystem. This research may need to be expanded to include moderation and mediation: examining the role of social capital, institutional support, and market access as moderators; testing mediation through adaptive space, dynamic capabilities, or market sensing. Second, because this study was conducted on business actors in Malang Regency, further research needs to conduct cross-context comparisons: rural-urban comparisons, across districts/provinces, and across sectors (agriculture, tourism, MSME manufacturing) to test the generalizability of the model. Third, further studies on objective outcomes are needed to understand the relationship between the constructs and actual performance (turnover growth, exports, technology adoption, business continuity), not just perceptions. Finally, using a causal and longitudinal design to test the causality of the impact of Algorithmic Leadership vs. Innovation Leadership on ecosystem dynamics with field experiments and repeated measurements.

Acknowledgments: The authors thanks to Ma Chung University and Faculty Economic and Business for the facilities and administrative support provided during the research. The authors also express their gratitude to all parties who contributed, directly or indirectly, to the completion of this research.

Funding: This research was made possible thanks to the financial support of the Ministry of Higher Education, Science, and Technology (Kemdiktisaintek) through the Regular Fundamental Research Grant program, Contract No.: 10.

Declaration of Conflicting Interests: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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