Navigating the Digital Divide: Barriers to Digital Innovation Adoption among Rural MSMEs in Sabah, Malaysia

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DOI: https://doi.org/10.47772/IJRISS.2026.100500082

Received: 25 April 2026; Accepted: 30 April 2026; Published: 23 May 2026

ABSTRACT

Despite the growing emphasis on digital transformation in national development agendas, rural micro, small, and medium-sized enterprises (MSMEs) in Malaysia continue to lag in adopting digital innovations. This study investigates the multifaceted barriers to digital innovation adoption among rural MSMEs in Sabah, using a quantitative exploratory approach. Drawing on responses from 103 firms across various rural districts, the study evaluates six key categories of barriers: socio-cultural, technical, economic, regulatory-institutional, policy-related, and innovation environment. Descriptive analysis reveals uniformly high barrier perceptions, with innovation environment (M = 4.79) and economic constraints (M = 4.79) rated as the most significant. Comparative analysis across firm age groups highlights that startup firms experience the highest innovation-related constraints, while growth-stage firms encounter intensified economic and policy-related barriers. Contrary to earlier infrastructure-centric literature, findings suggest that behavioral inertia, institutional misalignment, and capability deficits are now the dominant inhibitors of digital adoption. Grounded in the Diffusion of Innovations and Unified Theory of Acceptance and Use of Technology (UTAUT) frameworks, the study underscores the need for policy interventions that are context-sensitive, age-specific, and ecosystem-oriented. It concludes that bridging the rural digital divide requires not only technological provisioning but also robust strategies to cultivate innovation mindsets, restructure financing mechanisms, and align multi-level policies.

Keywords: Digital Innovation Adoption, Rural MSMEs, Digital Divide, Innovation Barriers

INTRODUCTION

In the era of the Fourth Industrial Revolution (IR4.0), digital transformation has become a cornerstone of socio-economic development globally (Nipo et al., 2024). However, rural regions, especially in developing countries like Malaysia, continue to face persistent disparities in digital access and innovation adoption. The digital divide, a multidimensional gap involving disparities in internet access, digital skills, and technology use, remains a significant issue, particularly in East Malaysia, including Sabah. Despite Malaysia's digital readiness ranking among the highest in Southeast Asia, studies show a stark contrast between digital uptake in Peninsular and East Malaysia, with rural Sabah still grappling with fundamental infrastructural limitations (Ladin et al., 2020).

According to a 2023 study involving 724 respondents across Sabah, digital poverty persists post-COVID-19, particularly affecting rural households with low income and educational attainment (Salleh et al., 2023). Despite federal initiatives like the National Digital Network (JENDELA) and the Universal Service Provision (USP) programs, connectivity and digital literacy remain insufficient, hindering meaningful use of digital tools and services.

In Sabah specifically, barriers to digital innovation include lack of infrastructure, limited technical skills, cultural factors, and socioeconomic constraints (Fang et al., 2022). For instance, native communities in rural Sabah still

experience limited access to basic telecommunication services. While there is openness toward digital innovation, this receptivity is not matched by access or ability, which reflects van Dijk's (2025) four-layer digital divide theory (motivational, material, skills, and usage gaps). Furthermore, educators in rural Sabah face severe hurdles in implementing digital education due to unreliable internet, insufficient tools, and lack of training. These issues have compounded educational inequalities, especially during the COVID-19 pandemic (Donald & Hashim, 2025). A related study involving 233 rural students found that access to devices significantly influenced class attendance and learning effectiveness, pushing students into part-time work to afford necessary tools (Surianshah, 2021).

The significance of this study lies in its effort to systematically identify and understand the barriers that hinder digital innovation adoption among Sabah's rural communities. This includes infrastructure gaps, affordability issues, cultural hesitance, and the absence of targeted policy implementation. Previous research has examined aspects of these challenges but often in isolation. Furthermore, a comprehensive, localized analysis tailored to the unique socio-cultural landscape of Sabah is lacking. Addressing this gap will not only provide actionable insights for policymakers and NGOs but also contribute to the academic understanding of digital transformation in rural and indigenous contexts. This study offers an interdisciplinary contribution by merging frameworks from technology adoption, community informatics, and rural development. Moreover, it responds to calls for more research that emphasizes lived experiences and community-drqwerrrrrriven digital strategies in underrepresented regions of Sabah (Nipo et al., 2024). As Malaysia pushes toward inclusive digitalization, understanding and dismantling the unique barriers in Sabah's rural areas is not only timely but crucial. This study aims to fill the scholarly and practical gaps by shedding light on these digital inequities and proposing grounded, context-sensitive solutions.

LITERATURE REVIEW

Theoretical Foundation

Understanding the barriers to digital innovation adoption in rural communities such as Sabah necessitates an integrative theoretical framework that captures both individual behavioral dynamics and broader institutional constraints. To achieve this, the present study draws upon three established and complementary theories: the Diffusion of Innovations (DOI) Theory (Rogers, 2003), the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003), and Institutional Theory (Scott, 2001). Collectively, these theories provide a multidimensional perspective to assess the socio-cultural, technical, economic, regulatory, policy, and innovation environment barriers affecting micro, small, and medium enterprises (MSMEs) in rural Sabah.

The DOI Theory explains the mechanisms through which innovations spread within a social system and identifies five key attributes such as relative advantage, compatibility, complexity, trialability, and observability that influence adoption decisions. In rural Sabah, where communities often adhere to longstanding socio-cultural norms and may have limited exposure to successful digital innovations, DOI is instrumental in diagnosing socio-cultural resistance and innovation environment constraints. For example, innovations perceived as incompatible with existing practices or too complex relative to users' technological fluency are less likely to be adopted.

The UTAUT model, on the other hand, focuses on individual-level acceptance and usage behavior. Its core constructs include performance expectancy, effort expectancy, social influence, and facilitating conditions, highlighting the technical and economic barriers to digital adoption, particularly the influence of perceived usefulness, ease of use, peer influence, and available infrastructure. In the context of Sabah's rural MSMEs, the absence of reliable connectivity, lack of digital literacy, and low social endorsement significantly undermine behavioral intention to adopt digital tools.

Complementing both DOI and UTAUT, Institutional Theory offers a macro-level lens by addressing the regulatory and policy environment that shapes organizational behavior. According to Scott (2001), institutional environments are governed by regulative, normative, and cognitive elements that either enable or constrain action. In rural settings, inconsistent digital policy implementation, bureaucratic funding mechanisms, and ambiguous data governance structures collectively contribute to institutional inertia and policy fatigue.

Together, these theories are not only complementary in scope but synergistic in explanatory power. DOI emphasizes the attributes of the innovation itself and its perceived fit within the local culture, UTAUT focuses on the individual decision-maker's readiness and intention, and Institutional Theory captures the systemic constraints imposed by organizational and policy structures. By triangulating these perspectives, the study achieves a robust theoretical foundation

Socio-Cultural Barriers

Socio-cultural barriers refer to the norms, beliefs, traditions, and collective behavioral patterns that influence the acceptance or resistance toward technological change within a community. These barriers are especially pronounced in rural areas, where traditional ways of life and generational practices significantly shape how technology is perceived and used. In the context of digital innovation, socio-cultural barriers often manifest as distrust in digital systems, reluctance to abandon established practices, limited digital literacy, and intergenerational gaps in technology use.

Empirical studies in Malaysia underscore the role of cultural attachment and generational mindset as major impediments. For example, a study on MSMEs in Johor revealed that cultural resistance and limited digital literacy were significant obstacles to digital marketing adoption, despite the availability of government initiatives (Malik & Othman, 2025). Similarly, among rural farmers in Kedah, the adoption of precision farming technologies was hampered by low digital confidence and reliance on traditional agricultural methods, despite access to mobile devices (Baharin et al., 2025).

In Sabah, the indigenous and rural populations demonstrate a positive attitude toward ICT adoption but remain restrained by lack of digital knowledge and attachment to traditional work practices. Fang et al. (2022) observed that while there was willingness among native Sabahans to adopt ICT, barriers such as fear of hidden costs, perceived irrelevance, and generational resistance significantly influenced adoption patterns (Fang et al., 2022).

Globally, cultural influences similarly dictate digital adoption behavior. In Indonesia, small traders in rural markets often blend mobile technologies with traditional practices, resulting in “digital bricolage” rather than full digital transformation. This hybrid approach reflects a socio-cultural mediation process, where kinship, trust, and community norms outweigh standard diffusion mechanisms (Samuel, 2025).

In sum, socio-cultural barriers are not merely peripheral issues but deeply embedded systems that regulate technological change. Recognizing and addressing these through culturally tailored engagement strategies is essential for inclusive digital innovation in rural Sabah.

Technical Barriers

Technical barriers refer to the infrastructural, environmental, and system usability challenges that hinder the implementation and effective use of digital technologies. In rural contexts, these barriers typically include poor internet connectivity, unreliable digital infrastructure, limited access to compatible hardware, and usability challenges associated with technological tools (Manning, 2024).

In Malaysia, particularly in Sabah, such issues are persistent and multifaceted. Donald and Hashim (2025) highlighted that English as a Second Language (ESL) teachers in rural Sabah schools face continuous disruptions due to low bandwidth internet, lack of digital tools, and insufficient ICT training. These technical deficits directly limit educational digitalization and perpetuate the rural-urban digital divide (Donald & Hashim, 2025). Similarly, in agriculture-dominant regions like Kota Marudu, the continuity of innovation adoption is heavily reliant on the availability of reliable infrastructure. Jamsari et al. (2012) found that poor maintenance of digital platforms and inadequate technical support in remote districts of Sabah discouraged rural farmers from continuing with digital tools.

Globally, Manning (2024) reported that rural agri-tech adopters in the UK were often deterred by infrastructure unreliability and technology’s lack of resilience in harsh rural environments. These concerns mirror the Malaysian context, where weather conditions and landscape remoteness exacerbate hardware breakdowns and reduce the longevity of tech systems (Manning, 2024). Moreover, evidence by Ghobakhloo and Tang (2015)

indicates that SMEs in developing countries often lack internal technical expertise, rely on informal management practices, and possess insufficient ICT knowledge among users, which collectively hinder effective implementation and sustained use of digital systems These limitations are compounded by dependence on external support that is frequently inaccessible or inadequate, particularly in geographically remote areas, as well as by the complexity and poor usability of many digital platforms relative to users' skill levels. Consequently, rather than achieving full digital transformation, rural enterprises tend to engage in partial and fragmented ICT use, limiting their ability to realise sustained productivity and performance gains.

In conclusion, technical barriers in Sabah and comparable regions globally are structural and systemic, requiring targeted investment in resilient infrastructure, maintenance support, and context-appropriate digital tools to enable sustainable digital transformation.

Economic Barriers

Economic barriers refer to financial and cost-related limitations that impede individuals, businesses, or communities from adopting digital technologies. These barriers typically include high technology costs, lack of funding mechanisms, low perceived return on investment, and inadequate access to credit, particularly for rural or underserved populations.

In rural Malaysia, particularly Sabah, such barriers are prevalent. A study by Nipo et al. (2024) emphasized that digital transformation in rural entrepreneurship is often constrained by financial limitations, including poor access to capital, high upfront technology costs, and the absence of digital subsidies tailored to rural economies. These constraints significantly affect local entrepreneurs' ability to adopt digital platforms, despite growing interest in digital tools to enhance market access and efficiency. Similarly, in Sarawak, digital marketing adoption by rural tourism providers was hindered by the high cost of equipment and the need for external assistance in content creation and system maintenance. Communities in Long Lamai and Ba'kelalan were found to be receptive to digital innovation but lacked the economic means to sustain implementation without government or NGO support (Cheuk et al., 2018).

On a broader scale, Darail et al. (2023) found that Malaysian consumers in rural areas showed low adoption rates of mobile digital wallets primarily due to perceived high costs, insufficient incentives, and limited trust in financial institutions. These factors highlight how affordability intersects behavioral hesitation, reinforcing economic inaccessibility (Darail et al., 2023). Globally, similar patterns emerge. Manning (2024) reported that rural farmers in the UK viewed digital technologies as high-risk investments due to unclear long-term financial benefits and uncertain cost recovery in volatile rural markets (Manning, 2024).

Thus, economic barriers present not just affordability issues but deeply rooted structural inequities that discourage investment in digital tools. Tailored financial aid, rural-specific grants, and digital microcredit schemes could be critical enablers for advancing rural digital inclusion.

Regulatory-Institutional Barriers

Regulatory-institutional barriers are structural constraints rooted in policy, governance, and institutional misalignment that inhibit or delay the adoption of digital innovations. These may include unclear data governance, inflexible grant criteria, changing regulatory frameworks, or institutional unpreparedness.

In Malaysia, legal frameworks such as the Electronic Commerce Act 2006 and Personal Data Protection Act 2010 were designed to promote secure digital transactions, yet they often fail to reflect the realities of rural regions like Sabah. Mohamad et al. (2025) highlight that while regulatory measures exist, rural e-readiness remains low due to unclear policies, cybercrime concerns, and inconsistent infrastructure support, thereby inhibiting rural digital growth Mohamad et al., 2025). Further, in Sabah and Sarawak, the fragmentation of digital innovation policies, combined with bureaucratic red tape in accessing development grants, creates an institutional deadlock that rural innovators struggle to navigate. According to Darail et al. (2023), lack of alignment between policy design and rural needs in digital wallet adoption created institutional mistrust, discouraging digital uptake in remote areas.

Rural digital transformation is not primarily constrained by the absence of national policies, but by insufficiently adaptive regulatory and policy capacity at the local level, which must align with rural infrastructural realities, institutional conditions, and community dynamics. In the case of Indonesia, Fiestiandani et al. (2026) demonstrated that implementation outcomes vary significantly across villages due to differences in institutional frameworks, operational capacity, and social integration mechanisms. The findings show that villages with formalised, context-specific regulatory frameworks achieve greater stability, continuity, and sustainability in digital service delivery, particularly during leadership transitions, whereas those relying on informal or generic directives experience fragmented and inconsistent implementation. This indicates that national strategies alone are insufficient; effective rural digital infrastructure development requires locally embedded regulatory systems that can be adapted to population size, staffing constraints, and infrastructure disparities.

In summary, regulatory-institutional barriers are not only about policy absence but often about policy misfit. For rural Sabah, effective digital transformation will require not just new regulations, but reforming existing ones to reflect rural constraints and enable context-appropriate innovation.

Policy and Support Measures Barriers

Policy and support measures play a crucial role in facilitating or hindering digital innovation adoption in rural areas. However, these measures often fail to address the unique contextual realities of rural communities, especially in developing regions such as Sabah, Malaysia.

One of the key challenges is the mismatch between national policy frameworks and local needs. In Malaysia, digital support programs frequently emphasize agricultural modernization, but they often overlook the broader digital ecosystem required for sustainable rural innovation. For instance, a study in Kedah found that government-driven precision farming policies were hindered by the lack of localized digital literacy programs and limited extension services, despite high mobile phone ownership among farmers (Baharin et al., 2025). In Sabah, similar structural limitations persist. Digital wallet adoption in rural Malaysia suffers from fragmented government support, with rural programs narrowly targeting fintech outcomes without infrastructure development or long-term support plans (Darail et al., 2023). Moreover, capacity-building tools like Malaysia's AGRIKIT have proven effective at improving literacy, but experts argue that these tools need to be institutionalized and supported long-term through rural innovation policies. AGRIKIT's success depends not only on local uptake but on consistent funding and training support (Naseri & Idris, 2025).

In sum, policies lacking continuity, scope, and rural-specific adaptation act as critical barriers. Overcoming them requires not just new initiatives, but better policy design and administrative reform grounded in rural realities.

Innovation Environment Barriers

A conducive innovation environment is essential for fostering digital innovation, yet rural communities especially in regions like Sabah, Malaysia often lack the foundational ecosystem necessary for its success. This includes limited innovation culture, low digital ambition, and a preference for traditional or low-cost solutions, all of which hinder adoption and scalability of digital innovation.

Empirical studies have consistently emphasized the role of organizational culture and mindset as primary inhibitors to innovation. For example, in Malaysia's manufacturing SMEs, internal factors such as limited innovation-oriented leadership, financial conservatism, and resistance to experimentation significantly dampened innovation performance (Halim et al., 2023). These barriers reflect a broader lack of innovation culture and long-term vision within rural enterprises.

In the context of rural entrepreneurship, studies in Sabah have identified low digital readiness and innovation literacy as critical setbacks. A regional review emphasized how entrepreneurial mindsets in rural Sabah remain cautious and risk-averse, driven by economic insecurity and a survivalist approach to business operations (Nipo et al., 2024). Despite access to basic ICT tools, the perception that digital solutions are complex or non-essential reinforces a stagnant innovation environment.

Globally, similar patterns have emerged. Manning (2024) highlighted systemic and social barriers such as rural isolation, role conflict, and limited peer support that discourage experimentation and reduce innovation capacity in agriculture and small-scale industries. These constraints are often embedded in community-level dynamics and require systemic interventions to overcome.

Thus, to unlock rural digital transformation, it is not enough to provide access to digital tools; there must also be strategic efforts to nurture an innovation-friendly culture, address fear of change, and empower rural innovators through exposure, incentives, and peer ecosystems.

METHODOLOGY

Research Design

This study adopts a quantitative research design with an exploratory approach to investigate the barriers to digital innovation adoption among micro, small, and medium-sized enterprises (MSMEs) in rural Sabah. Quantitative research is suitable for measuring and analyzing variables using numerical data, while the exploratory approach is particularly appropriate when the phenomenon under investigation lacks extensive prior study in a specific geographic or socio-economic context (Creswell, 2022).

Participants and Sampling

The target population for this study comprises MSMEs located in rural areas of Sabah, Malaysia. These enterprises include smallholders, rural entrepreneurs, and service providers operating in digitally underserved regions. The sampling method employed is purposive sampling, which allows for the deliberate selection of participants based on their relevance to the research objectives (Palinkas et al., 2015).

A total of 103 usable responses were obtained from over 200 distributed questionnaires. The sample was drawn from multiple validated databases including local economic development agencies, SME directories, and rural innovation programs. This sample size is considered sufficient for exploratory research, particularly in preliminary studies aiming to identify potential patterns and relationships in rural digital adoption contexts (Saunders et al., 2019).

Data Collection Methods

This study employed a structured, self-administered questionnaire to quantitatively assess the barriers to digital innovation adoption among rural micro, small, and medium enterprises (MSMEs) in Sabah. The instrument was constructed based on rigorously validated items from prior research to ensure both theoretical and empirical soundness. Specifically, the items addressing socio-cultural, technical, and regulatory-institutional barriers were adapted from Ferrari et al. (2022), whose study explored multidimensional impediments to digital transformation in rural enterprise contexts. The economic barrier constructs were drawn from Indrawati et al. (2020), focusing on the financial challenges experienced by MSMEs in adopting digital solutions. Items concerning policy and support mechanisms as well as the innovation environment were adapted from Uvarova and Vitola (2019), who investigated policy fragmentation and innovation inertia in rural regions.

To achieve broader respondent representation across varying levels of digital access, a dual-mode data distribution strategy was employed. First, the questionnaire was disseminated via email to digitally connected MSME owners. A follow-up reminder was sent two weeks after the initial distribution to increase response rates. Second, on-site data collection was conducted in selected rural districts to reach participants who may lack stable internet connectivity or digital literacy. Respondents in this mode were given the option to complete either a printed questionnaire or an electronic version via mobile device, with field researchers available to provide assistance where necessary.

This two-pronged distribution approach is consistent with recommended practices in survey research involving populations with heterogeneous digital accessibility. It helped improve response completeness and the reliability of the data collected (Oladokun et al., 2025). The strategy also ensured that the study captured a more inclusive sample, particularly those often excluded from digital-only research designs in rural innovation contexts.

Data Analysis Techniques

The data were analyzed using descriptive statistical techniques to explore frequencies, means, and standard deviations of the key variables. The analysis was conducted using IBM SPSS Statistics software, which is widely recognized for its reliability in handling survey data in social science research. The exploratory nature of the study justified the use of descriptive analysis to identify prevailing patterns and distribution of barriers across the rural MSME population.

RESULTS AND DISCUSSION

Profile of Firms

Table 1: Business Profile of the Firms

Category	Item	Frequency	Percent (%)
Type of Industry	Agriculture	20	19.4
	Construction	6	5.8
	Food and Beverage	38	36.9
	Manufacturing	10	9.7
	Services	22	21.4
	Trading and Retail	7	6.8
Number of Employees	5 and less	51	49.5
	6-75	40	38.8
	75-200	12	11.7
Firm Age	Start up (5 years and below)	47	45.6
	Growth (6 to 10 years)	37	35.9
	Mature (above 10 years)	19	18.4

The profile of firms participating in the study highlights a diverse business landscape. The most represented industry is Food and Beverage (36.9%), followed by Services (21.4%) and Agriculture (19.4%), indicating a strong presence of consumer-oriented and primary sector enterprises. Smaller proportions are involved in Manufacturing (9.7%), Trading and Retail (6.8%), and Construction (5.8%), reflecting a varied but concentrated industrial composition.

In terms of firm size, nearly half of the businesses (49.5%) employ five or fewer employees, and 38.8% have between 6 to 75 employees, suggesting that the majority are micro and small enterprises. Only 10.7% have 75–200 employees, and just 1.0% exceed 200 employees, confirming the sample's focus on small and medium-sized enterprises (SMEs).

Regarding firm age, 45.6% are classified as startup firms, 35.9% as growth, and 18.4% as mature, indicating a relatively youthful business environment. This distribution suggests that many firms are still in early or growth stages, which may influence their capacity for innovation, investment, and adaptation to digital transformation.

Profile of Respondents

Table 2: Profile of Respondents

Category	Response	Frequency	Percent
Position in the Company	Chief Executive Officer (CEO)	1	1.0
	Executives	2	1.9
	Manager	25	24.3
	Owner or Director	63	61.2
	Supervisor	12	11.7
Respondent Age	20 – 30 years	22	21.4

	31 – 40 years	47	45.6
	41 – 50 years	20	19.4
	51 – 60 years	14	13.6
Highest Education	Postgraduate	3	2.9
	Primary school	6	5.8
	Secondary school	34	33.0
	Undergraduate	60	58.3
Gender	Female	42	40.8
	Male	61	59.2

The demographic profile of the respondents reveals a sample predominantly composed of individuals in leadership roles, with 61.2% identified as Owners or Directors and 24.3% as Managers, indicating that the majority of insights were gathered from decision-makers within their organizations. The age distribution shows that 45.6% of respondents are between 31–40 years, followed by 21.4% aged 20–30 years, suggesting a relatively young and active workforce. In terms of education, 58.3% hold an Undergraduate degree, and 33.0% have completed Secondary school, reflecting a generally well-educated sample. Gender representation is slightly skewed, with 59.2% male and 40.8% female respondents. Overall, the profile suggests that the data was collected from a knowledgeable and influential group, capable of providing informed perspectives on organizational and technological challenges.

Perceived Barriers to Digital Innovation Adoption

Table 3: Perceived Barriers

Construct	Item	Mean	Overall Mean
Socio-cultural barriers	SB1. Sparse and aged rural population	4.83	4.78
	SB2. Lack of trust in business partners who use the data	4.68	
	SB3. Fear of dependency and loss of control from using technology	4.76	
	SB4. Fear of hidden costs	4.81	
	SB5. Attachment to traditional ways of working and identity	4.79	
	SB6. Lack of specific knowledge of technology	4.83	
	SB7. Lack of practical skills to deal with technology	4.76	
Technical barriers	TB1. Lack of connectivity	4.80	4.77
	TB2. Lack of dependability in challenging environmental conditions	4.80	
	TB3. Lack of usability	4.73	
Economic barriers	EB1. Lack of funding	4.83	4.79
	EB2. High cost of technology	4.80	
	EB3. Low evidence of cost-effectiveness	4.79	
	EB4. Difficulties in obtaining loans from financial institutions	4.77	
	EB5. High interest rates	4.77	
Regulatory-institutional barriers	RB1. Unclear data ownership	4.76	4.71
	RB2. Inappropriate grant scheme criteria for rural contexts	4.67	
	RB3. Frequent changes in regulations	4.71	
Policies and support measures	PB1. Focus of rural support programs on agriculture	4.82	4.76
	PB2. Fragmentation of digital innovation policies	4.73	
	PB3. Administrative burden in digital innovation support	4.73	
Innovation environment	IB1. Lack of innovation culture	4.83	4.79
	IB2. Low interest in digital innovative solutions	4.76	
	IB3. Focus on low prices instead of quality improvements	4.80	

Note: N = 103

The findings from this study present a compelling portrait of the deeply embedded and interrelated challenges constraining digital innovation adoption among rural micro, small, and medium enterprises (MSMEs) in Sabah. Across 22 items and six constructs, the uniformly high mean scores ranging from 4.67 to 4.83, indicate not a fragmented but a systemic landscape of digital resistance. These results suggest that rural MSMEs are not merely technology-averse but are situated within socio-technical systems that perpetuate structural inertia.

Among the constructs assessed, innovation environment barriers (M = 4.79) and economic barriers (M = 4.79) emerged with the highest overall mean, followed closely by socio-cultural (M = 4.78) and technical barriers (M = 4.77). Regulatory-institutional and policy-related barriers also registered high (M = 4.71 and M = 4.76, respectively), reinforcing the view that digital exclusion in Sabah is a multi-causal phenomenon. These findings refine and extend prior regional studies, which have attributed Sabah's innovation stagnation not solely to infrastructural deficits but to a more complex interplay of behavioral, financial, and institutional frictions.

A closer inspection of the highest-ranked items provides important insights. The five items with the maximum mean score of 4.83 include: *sparse and aged rural population* (SB1), *lack of specific knowledge of technology* (SB6), *lack of funding* (EB1), and *lack of innovation culture* (IB1). This convergence reveals a multidimensional deficit such as demographic, epistemic, fiscal, and cultural that fundamentally undermines the conditions necessary for rural digital transformation. These findings suggest that that rural innovation challenges stem not from isolated variables but from the absence of a self-reinforcing innovation ecosystem.

Socio-cultural factors play a defining role in digital reluctance. Items such as sparse and aged rural population and lack of specific technology knowledge scored highest, pointing to a workforce composition and cultural mindset that are ill-suited for innovation diffusion. Other concerns such as *fear of hidden costs* (M = 4.81), *attachment to traditional working modes* (M = 4.79), and *mistrust in digital data use* (M = 4.68), reveal embedded skepticism toward technology, mirroring Rogers' (2003) diffusion theory where perceived complexity and lack of relative advantage suppress adoption among late adopters in conservative settings. These results affirm that innovation hesitation in Sabah is not merely about risk aversion but is rooted in identity, history, and generational divides.

While infrastructure remains essential, the findings suggest a more evolved discourse on technical barriers. *Lack of connectivity* and *dependability in challenging environments* (both M = 4.80) are accompanied by *usability concerns* (M = 4.73), suggesting that even where access exists, rural users face friction in meaningful utilization. Digital readiness involves not just "being connected" but ensuring that digital tools are usable, context-specific, and trustworthy. These technical issues are not standalone but intersect with low digital confidence and skills, further compounding the socio-cultural resistance.

The economic barriers construct (M = 4.79) reveals embedded financial precarity among rural MSMEs. Top-scoring items such as *lack of funding* (EB1 = 4.83) and *high cost of technology* (EB2 = 4.80), alongside persistent *difficulties in accessing loans* (EB4 = 4.77) and contending with *high interest rates* (EB5 = 4.77), highlight the systemic financial exclusion that these enterprises face. These findings align with Indrawati et al. (2020), who argue that conventional lending models fail to accommodate the liquidity patterns and risk profiles of digitally transitioning MSMEs in emerging markets. Without adaptive financial instruments such as phased funding, revenue-based financing, or blended finance models, rural digital innovation will remain undercapitalized.

Regulatory-institutional barriers, while slightly lower in overall mean (M = 4.71), are far from negligible. *Unclear data ownership* (M = 4.76) and *frequent policy changes* (M = 4.71) reflect not only legal ambiguity but governance volatility. These findings corroborate Ferrari et al. (2022), who argue that institutional instability and poor regulatory contextualization stifle rural innovation. The relatively lower but still high score for *inappropriate grant criteria* (M = 4.67) highlights a design-execution gap: eligibility rules often fail to consider the informal, multi-sectoral, and hybridized nature of rural MSMEs. Policy barriers further compound this with *fragmentation of digital innovation strategies* (M = 4.73) and *bureaucratic burden* (M = 4.73), confirming Uvarova and Vitola's (2019) concern that policy complexity undermines accessibility and legitimacy of support mechanisms.

The highest-scoring construct, *innovation environment* (M = 4.79) speaks to the latent and arguably most consequential barrier: a lack of innovation culture. *Lack of innovation culture (IB1 = 4.83)* and *focus on low price rather than quality improvement (IB3 = 4.80)* suggest that the mental models guiding business practices are deeply risk-averse and cost-centric. This suggests that digital innovation in rural areas must be preceded by a shift in values and expectations, which is a process that is as psychological and discursive as it is infrastructural.

Taken together, the narrow variance in means (from 4.67 to 4.83) signals not just co-existence of barriers but a structural interdependence. Each barrier reinforces the other, creating a feedback loop where poor infrastructure feeds mistrust, which undermines experimentation, which limits innovation success, which in turn justifies continued risk aversion. This recursive logic maps onto Scott's (2001) Institutional Theory, which emphasizes how regulative, normative, and cognitive pillars coalesce to maintain organizational inertia.

Therefore, digital exclusion in rural Sabah is not a single-policy failure or a technological lag—it is a systemic condition. Interventions must be multi-pronged, addressing infrastructure and access, but equally, reshaping incentives, reforming policy design, and most importantly, transforming digital culture from within.

Table 4: Mean Scores of Perceived Barriers to Digital Innovation by Firm Age Category

Barrier Type	Startup (N = 47)	Growth (N = 37)	Mature (N = 19)
Socio-Cultural Barrier	4.7720	4.7876	4.7669
Technical Barrier	4.7801	4.7838	4.7368
Economic Barrier	4.7957	4.8000	4.7474
Regulatory Barrier	4.6879	4.7297	4.7368
Policy Barrier	4.7447	4.7748	4.7544
Innovation Environment Barrier	4.8511	4.7658	4.7018

The comparative analysis of mean scores across startup, growth, and mature firms reveals distinct perceptual profiles tied to organizational maturity. While overall barrier intensity remains consistently high across all stages (mean > 4.7), the variations in perception suggest differentiated readiness, needs, and strategic posture toward digital innovation adoption. The classification of firms into startup, growth, and mature stages follows prior research emphasizing the relationship between firm age, innovation behavior, and structural flexibility (Sørensen & Stuart, 2000; Coad et al., 2016).

The most striking observation lies in the startup firms, which reported the highest mean score for innovation environment barriers (M = 4.85). This reinforces findings by Nipo et al. (2024), indicating that early-stage MSMEs in Sabah face acute challenges related to risk aversion, lack of mentorship, and limited exposure to innovation culture. For startups, the psychological cost of failure is amplified by their limited buffers, making them highly sensitive to uncertainty in digital experimentation. This aligns with Rogers' (2003) DOI theory, where perceived complexity and lack of observability disproportionately affect early adopters in resource-constrained contexts.

In contrast, growth-stage firms scored marginally higher on sociocultural, technical, economic, and policy barriers, indicating a transitional struggle. These firms are likely engaging with digital tools more actively but are simultaneously encountering systemic frictions such as infrastructure gaps, underdeveloped digital ecosystems, and misaligned government support. The pattern mirrors Venkatesh et al.'s (2003) UTAUT model, which highlights how performance expectations and facilitating conditions become increasingly salient as organizations scale.

Mature firms, by comparison, reported slightly lower barrier perceptions across all dimensions, particularly regarding innovation (M = 4.70). This trend may reflect institutional learning and established coping mechanisms, including stronger networks, better access to capital, and internal capacity to manage digital complexity. Such firms may benefit from accumulated tacit knowledge, as proposed by the SECI (socialization, externalization, combination, and internalization) model of knowledge creation (Nonaka & Takeuchi, 1995), thereby enabling them to contextualize digital tools within existing processes more effectively.

However, the minimal variation in mean scores across firm ages (differences typically <0.1) suggests that barriers are universally felt, albeit with slightly differentiated emphasis. This confirms assertions by Ferrari et al. (2022) that structural barriers – whether cultural, regulatory, or technical – are deeply embedded in the rural Malaysian innovation landscape and not easily attenuated by organizational maturity alone.

DISCUSSION

The findings of this study underscore a pervasive and multidimensional resistance to digital innovation among rural micro, small, and medium enterprises (MSMEs) in Sabah. The consistently high mean scores across all six barrier constructs, namely socio-cultural (M = 4.78), technical (M = 4.77), economic (M = 4.79), regulatory (M = 4.71), policy (M = 4.76), and innovation environment (M = 4.79), demonstrate that digital exclusion in rural contexts is not a function of isolated deficiencies, but rather the cumulative outcome of systemic inertia, demographic stagnation, and institutional misalignment. The findings advance current debates by shifting the locus of analysis from infrastructure deficits to the confluence of structural, behavioral, and institutional constraints.

Socio-Cultural and Innovation Environment Barriers: A Cultural-Behavioral Lock-In

The study's highest-rated items (sparse and aged rural populations, lack of innovation culture, and limited specific technological knowledge) reveal an entrenched cultural resistance and psychological hesitancy that transcend basic access concerns. These findings affirm the observations of Nipo et al. (2024), who identify fear of failure, generational divides, and a weak culture of experimentation as principal deterrents to digital transformation among rural entrepreneurs. From a theoretical lens, these patterns resonate with Rogers' (2003) DOI theory, particularly the constructs of perceived complexity and observability. The lack of visible success stories in peer enterprises exacerbates risk aversion, thereby inhibiting the spread of innovation through social learning mechanisms.

This cultural lock-in is compounded by a weak innovation environment, where digital solutions are perceived as either irrelevant or economically nonviable. The elevated mean for "focus on low prices over quality" reflects a survivalist market orientation typical of undercapitalized rural firms, where short-term liquidity concerns outweigh long-term innovation investment. Additionally, Gemelgo et al. (2025) argued that without deliberate cultivation of risk-tolerant values, infrastructure investments alone will fail to shift innovation behavior.

Technical and Economic Constraints: Beyond Infrastructure to Absorptive Capacity

While technical barriers (specifically connectivity and dependability) remain significant (M = 4.80), they did not eclipse the behavioral and cultural dimensions. This suggests an evolving digital discourse in rural Sabah, where access alone is no longer the sole bottleneck. However, usability limitations still present a barrier, reflecting a mismatch between available digital tools and the skillsets of rural users. As emphasized by Hollimon et al. (2025), digital equity involves not only physical access but also the ability to meaningfully engage with technologies – a concept echoed in the high score for lack of practical skills.

Economically, the findings confirm that financial exclusion is a core constraint. Items such as lack of funding (M = 4.83), high technology costs (M = 4.80), and difficulty obtaining loans (M = 4.77) indicate that rural MSMEs are operating within risk-averse and structurally exclusionary financial ecosystems. These patterns substantiate the claims of Indrawati et al. (2020), who stress that digital adoption remains prohibitively expensive for firms not integrated into formal financial markets. This financial marginalization dampens both investment in digital capabilities and long-term strategic planning.

Regulatory and Policy Misalignment: Institutional Frictions in Rural Innovation

Institutional barriers – particularly unclear data ownership (M = 4.76) and fragmented regulatory schemes (M = 4.71) – further inhibit adoption by introducing uncertainty into decision-making processes. These barriers align with Scott's (2001) Institutional Theory, which posits that cognitive and normative structures within institutions can constrain organizational behavior and reinforce inertia. Ferrari et al. (2022) similarly argue that institutional

fragmentation and misaligned grant mechanisms discourage rural firms from engaging with formal innovation systems. In Sabah, these findings suggest that existing regulatory structures do not adequately reflect the operational realities of rural MSMEs, thereby eroding trust and engagement.

Policy-related challenges reinforce this trend. Although support for agriculture remains prominent (M = 4.82), digital innovation support mechanisms are perceived as fragmented (M = 4.73) and administratively burdensome (M = 4.73). This reveals a policy paradox: while there is nominal commitment to rural innovation, the actual policy architecture lacks coherence and contextual fit. As Uvarova and Vitola (2019) caution, rural innovation policy that fails to integrate cross-sectoral coordination risks undermining its own objectives.

Firm Age and Barrier Intensity

The comparative analysis across firm age categories – startups, growth-stage, and mature – reveals that while overall barrier intensity remains high, startups perceive the greatest obstacles in innovation environment (M = 4.85), underscoring their vulnerability to risk and limited exposure to supportive ecosystems. This supports findings by Sen et al. (2023) who suggest that strategic and structural flexibility is least developed at the startup stage, particularly in volatile environments.

Growth-stage firms report slightly higher scores for technical, socio-cultural, and economic barriers, indicating transitional friction as these firms expand their digital engagement but encounter systemic bottlenecks. Mature firms, by contrast, exhibit marginally lower barrier perceptions, possibly reflecting institutional learning, enhanced networks, and more resilient absorptive capacities. However, the differences are modest (typically <0.1), affirming Ferrari et al.'s (2022) observation that structural barriers in rural Malaysia are deeply embedded and not easily mitigated through organizational maturation alone.

CONCLUSION AND RECOMMENDATIONS

This study offers a comprehensive examination of the perceived barriers to digital innovation adoption among rural micro, small, and medium enterprises (MSMEs) in Sabah, Malaysia. Drawing on empirical evidence from 103 respondents and structured around six key constructs—socio-cultural, technical, economic, regulatory, policy, and innovation environment barriers—the findings reveal a landscape marked by systemic and multi-layered constraints. The consistently high mean scores across all dimensions (ranging from 4.67 to 4.83) underscore not isolated weaknesses, but a deeply embedded resistance to digital transformation, spanning across behavioral, infrastructural, financial, and institutional domains.

At the core of this resistance lie four dominant impediments: a sparse and aging population, lack of specific technological knowledge, limited funding, and the absence of an innovation-supportive culture. These barriers are interconnected and reinforce each other, showing how demographic fragility, digital illiteracy, economic exclusion, and cultural inertia can combine to create a strong obstacle to innovation. The uniformity in barrier intensity across different firm age categories further suggests that structural challenges transcend the lifecycle of enterprises, thus calling into question assumptions that maturity alone can offset digital disadvantage.

Theoretically, the study confirms the utility of integrating Rogers' (2003) DOI theory, the UTAUT model (Venkatesh et al., 2003), and Institutional Theory (Scott, 2001) in explaining innovation inertia in rural settings. Collectively, these frameworks elucidate how perceived complexity, lack of institutional facilitation, and misaligned governance structures can suppress behavioral intention, even in the presence of technological access. This reconceptualization moves beyond the digital divide as a hardware problem to instead recognize it as a sociotechnical and institutional phenomenon.

To support inclusive digital innovation and future-ready rural transformation, the following multi-pronged strategies are recommended:

1. Embed digital competency and innovation culture in capacity-building initiatives: Training interventions should prioritize not only technical upskilling but also the cultivation of a digital mindset among rural MSMEs. Tailored programs that demystify digital tools, offer localized use-cases, and normalize

innovation as a gradual, low-risk process can enhance self-efficacy and reduce fear of failure (Rogers, 2003; Gemelgo et al., 2025).

2. Develop financial instruments aligned to MSME liquidity cycles: Given the prominence of funding barriers, traditional lending schemes must be complemented by alternative financing models such as digital microloans, government-backed co-investment platforms, and pay-as-you-grow subscription models. These approaches can mitigate cash flow volatility and reduce perceived risk (Indrawati et al., 2020).

3. Rationalize and decentralize policy support mechanisms: Policy fragmentation and administrative burdens must be addressed through integrated digital innovation roadmaps that cut across agriculture, commerce, and digital development. Policies should be decentralized to local authorities with adequate autonomy and resourcing, ensuring responsiveness to rural realities (Uvarova & Vitola, 2019).

4. Reframe innovation policy to include informal and indigenous models: Innovation definitions and metrics must be broadened to include informal, frugal, and indigenous innovations that are culturally resonant and contextually feasible. This inclusion will help legitimize alternative innovation pathways and broaden participation among non-traditional actors (Ferrari et al., 2022).

5. Foster peer-led demonstration and mentorship platforms: To break the cycle of invisibility and inaction, regional success stories should be systematically documented and diffused through peer networks. Structured mentorship programs that connect mature digital adopters with startups can facilitate trust-building, collective learning, and local relevance (Nipo et al., 2024).

While this study provides a robust empirical basis, further investigations are necessary to unpack the causal dynamics between perceived barriers and actual adoption behaviors. Future studies could employ longitudinal or experimental designs to assess how interventions in one domain (e.g., financial inclusion) produce ripple effects in others (e.g., innovation culture). Moreover, disaggregated analyses by sector (e.g., agriculture vs. retail) and by gender or indigenous identity could yield more targeted insights. Cross-regional comparisons within Malaysia and across Southeast Asia would also enhance the generalizability of these findings.

ACKNOWLEDGEMENT

The authors would like to thank Universiti Malaysia Sabah for supporting and funding this work under the Cluster Fund Research Grant (Grant Code: DKP0068).

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