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ASSESSING DIGITAL READINESS OF BORDER SMES: A COMPARATIVE STUDY BETWEEN BENGKALIS AND MUAR

PENILAIAN KESIAPAN DIGITAL USAHA MIKRO, KECIL, DAN MENENGAH (UMKM) DI PERBATASAN: STUDI PERBANDINGAN ANTARA BENGKALIS DAN MUAR

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ABSTRACT

This study aims to assess and compare the digital readiness of Small and Medium Enterprises (SMEs) located in the border regions of Bengkalis, Indonesia, and Muar, Malaysia, as they confront the accelerating demands of Industry 4.0. The objectives are to identify the level of technological adoption, evaluate the enabling and inhibiting factors for digital transformation, and determine the role of local ecosystems in supporting SME digitalization in these two geographically connected but administratively distinct areas. Despite growing interest in digital economy initiatives across Southeast Asia, border-area SMEs remain under-researched, especially in terms of their preparedness for digital competition and cross-border market integration. A quantitative comparative approach was employed using structured questionnaires distributed to 100 SMEs, equally divided between Bengkalis and Muar. The data was analyzed using descriptive statistics, t-tests, and correlation analyses to highlight readiness gaps and similarities across key dimensions such as infrastructure, skills, organizational strategy, and external support systems. This research is significant for policymakers, development agencies, and academic communities interested in narrowing the digital divide and strengthening cross-border SME ecosystems. The findings are expected to contribute to the formulation of targeted interventions, particularly through Penta-helix collaboration involving government, academia, private sector, media, and communities, to boost SME competitiveness and sustainability in border regions. The study underscores the need for localized digital strategies that recognize socio-economic and cultural differences across national boundaries.

***Keywords**: Digital Readiness, SMEs, Border Economy, Cross-Country Comparison*

ABSTRAK

Penelitian ini bertujuan untuk menilai dan membandingkan kesiapan digital Usaha Kecil dan Menengah (UKM) yang berlokasi di wilayah perbatasan Bengkalis, Indonesia, dan Muar, Malaysia, dalam menghadapi tuntutan yang semakin meningkat dari Industri 4.0. Tujuan penelitian ini adalah untuk mengidentifikasi tingkat adopsi teknologi, mengevaluasi faktor-faktor yang mendukung dan menghambat transformasi digital, serta menentukan peran ekosistem lokal dalam mendukung digitalisasi UKM di dua wilayah yang secara geografis terhubung namun secara administratif terpisah ini. Meskipun minat terhadap inisiatif ekonomi digital semakin meningkat di Asia Tenggara, UKM di wilayah perbatasan masih kurang diteliti, terutama dalam hal kesiapan mereka menghadapi persaingan digital dan integrasi pasar lintas batas. Pendekatan komparatif kuantitatif digunakan dengan menggunakan kuesioner terstruktur yang dibagikan kepada 100 UKM, dibagi rata antara Bengkalis dan Muar. Data dianalisis menggunakan statistik deskriptif dan uji t dan analisis korelasi untuk mengidentifikasi kesenjangan kesiapan dan kesamaan di berbagai dimensi kunci seperti infrastruktur, keterampilan, strategi organisasi, dan sistem dukungan eksternal. Penelitian ini penting bagi pembuat kebijakan, lembaga pengembangan, dan komunitas akademis yang tertarik untuk mengurangi kesenjangan digital dan memperkuat ekosistem UMKM lintas batas. Temuan ini diharapkan dapat berkontribusi pada formulasi intervensi yang ditargetkan, terutama melalui kolaborasi Penta-helix yang melibatkan pemerintah, akademisi, sektor swasta, media, dan komunitas, untuk meningkatkan daya saing dan keberlanjutan UMKM di wilayah perbatasan. Studi ini menekankan perlunya strategi digital yang disesuaikan secara lokal yang memperhitungkan perbedaan sosio-ekonomi dan budaya di lintas batas negara.

Kata kunci: Kesiapan Digital, UMKM, Ekonomi Perbatasan, Perbandingan Antar Negara

INTRODUCTION

The acceleration of digital technologies under the banner of Industry 4.0 has significantly reshaped business landscapes, pushing small and medium enterprises (SMEs) to adopt digital tools for survival and competitiveness. However, in remote and geographically isolated regions—particularly border areas—SMEs often face multifaceted challenges that hinder digital adoption, including limited infrastructure, skill shortages, and policy misalignment (Nguyen et al., 2021; Yusof et al., 2021). In Southeast Asia, regions like Bengkalis in Indonesia and Muar in Malaysia present unique cross-border contexts that are underexplored in digital transformation discourse. The urgency of this study stems from the widening digital divide between urban and peripheral SMEs, risking long-term marginalization of border economies (World Bank, 2022; Suryanto & Wibisono, 2022).

Prior studies have examined SME digital readiness in urban or national scopes (Chen et al., 2023; Susanti et al., 2022), but few have offered comparative insights between neighboring border regions with differing governance structures and digital ecosystem maturity. For instance, while Malaysia's SME digital policy is integrated under SME Corp and MDEC initiatives, Indonesian SMEs in Bengkalis often operate within less coordinated local frameworks (Mahyuni et al., 2021). Furthermore, studies have not adequately incorporated the perspectives of stakeholder synergy, which is critical in marginalized areas. The Penta-helix model—emphasizing collaboration between government, academia, business, media, and community—remains underutilized in addressing digital asymmetry in border economies (Carayannis & Campbell, 2010; Dewi et al., 2023).

This study is anchored in the Technology-Organization-Environment (TOE) framework (Tornatzky & Fleischer, 1990), which provides a robust lens to assess organizational readiness by examining internal and external factors influencing technology adoption. Coupled with the Penta-helix innovation model (Etzkowitz & Leydesdorff, 2000), this research integrates both micro- and macro-level dynamics in assessing digital readiness holistically. The novelty lies in combining comparative regional analysis and stakeholder collaboration to inform inclusive policy development for cross-border SMEs.

Digital readiness entails not only infrastructure and technological tools but also the strategic mindset, human capital, and regulatory enablers that allow SMEs to navigate digital ecosystems (Ghosh et al., 2022; Ramadani et al., 2021). In the Bengkalis-Muar corridor, differences in policy coherence, access to digital platforms, and SME digitization incentives illustrate a gap between the idealized vision of a unified ASEAN digital economy and on-ground realities (ASEAN, 2021). Addressing this discrepancy requires localized, comparative insights to shape effective interventions and transnational digital strategies.

The objective of this study is to assess and compare the digital readiness of SMEs in Bengkalis and Muar, identify critical enabling and inhibiting factors across the TOE dimensions, and explore the extent to which stakeholder collaboration supports digital transformation. The findings are expected to inform national and regional policy directions, contribute to digital inclusion strategies, and enhance border

economic resilience through tailored ecosystem-based approaches.

METHODOLOGY

This study employs a quantitative comparative research approach to assess and compare the digital readiness of SMEs in the border regions of Bengkalis (Indonesia) and Muar (Malaysia). The unit of analysis is registered small and medium enterprises operating in both regions across sectors such as retail, services, and manufacturing. A structured questionnaire was developed based on adapted instruments from previous digital readiness frameworks. The instrument includes closed-ended questions rated on a 5-point Likert scale to measure four key parameters: (1) Digital Infrastructure, (2) Digital Skills and Literacy, (3) Organizational Readiness, and (4) External Support and Policy Access. The questionnaire was validated through expert review and a pilot test with 10 SMEs

The sample size consisted of 100 SMEs, with 50 from Bengkalis and 50 from Muar, selected using purposive sampling to ensure inclusion of digitally active and non-active enterprises. Inclusion criteria include SMEs that have been operational for at least 3 years and are legally registered.

Data collection was conducted through online and face-to-face surveys administered between April and May 2025. Respondents were business owners or digital managers who possess decision-making roles in their respective organizations. The research procedure included informed consent, confidentiality assurance, and consistent administration of the questionnaire. Responses were checked for completeness before analysis. The data analysis was carried out using SPSS (Statistical Package for the Social Sciences). Descriptive statistics were used to summarize the digital readiness levels, and independent sample t-tests were conducted to compare mean scores between the two regions. Additionally, Pearson correlation analysis was applied to examine relationships between key parameters. This methodological framework allows for replication in other border or peripheral regions seeking to assess SME digital readiness in a comparative and structured manner.

RESULT AND DISCUSSION

Result

The study aimed to examine the digital readiness of SMEs located along the Bengkalis–Muar border, analyze their capacity to respond to Industry 4.0 demands, and assess the effectiveness of the Penta-Helix collaboration model in supporting their digital transformation. The analysis was based on responses from 100 SMEs (50 from Bengkalis, 50 from Muar) Overall Digital Readiness Figure 1 illustrates the overall digital readiness scores categorized into four dimensions: digital infrastructure, human resources/digital skills, organizational strategy, and external stakeholder support. SMEs in Muar scored consistently higher across all dimensions compared to Bengkalis.

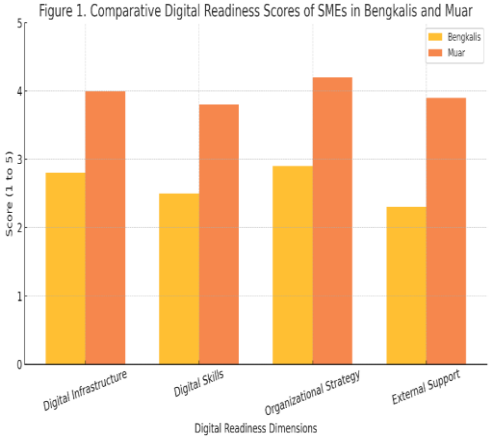

Figure 1. Comparative Digital Readiness Scores of SMEs in Bengkalis and Muar

2. Penta-Helix Collaboration Intensity

Table 1 summarizes the intensity of collaboration between SMEs and the five stakeholder elements in the Penta-Helix model. Muar SMEs reported stronger engagement with government agencies, academia, and technology partners, while Bengkalis SMEs showed limited engagement, particularly with universities and media.

Table 1. Mean Collaboration Scores with Penta-Helix Actors

Stakeholder	Bengkalis (Mean)	Muar (Mean)
Government	**3.2**	**4.1**
Academia	**2.4**	**3.9**
Industry	**3.5**	**3.8**
Media	**2.1**	**3.7**
Community	**3.0**	**3.6**
Stakeholder	**Bengkalis (Mean)**	**Muar (Mean)**
Government	3.2	4.1
Academia	2.4	3.9
Industry	3.5	3.8
Media	2.1	3.7
Community	3.0	3.6

3. Correlation Between Penta-Helix Support and Readiness

Pearson correlation analysis revealed a significant positive relationship ($r = 0.61$, $p < 0.01$) between the level of stakeholder collaboration and SME digital readiness. This supports the hypothesis that stronger Penta-Helix engagement contributes to higher readiness for Industry 4.0.

4. Barriers and Opportunities

Figure 2 presents the most reported barriers and perceived opportunities. SMEs in Bsengkalis cited "lack of digital literacy," "limited internet connectivity," and "weak institutional support" as major barriers. In contrast, SMEs in Muar saw "cross-border trade via e-commerce" and "smart marketing technologies" as growth opportunities.

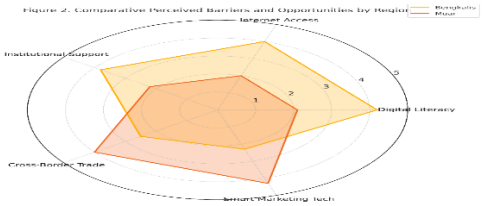

Figure 2. Barriers and Perceived Opportunities

Summary of Findings

The hypothesis was confirmed: SMEs with stronger stakeholder collaboration (via the Penta-Helix model) demonstrated higher digital readiness. Muar SMEs are more advanced in digital marketing readiness and collaboration than those in Bengkalis. The gap highlights disparities in infrastructure, training access, and inter-institutional engagement between the two regions. The Penta-Helix model shows clear potential as a catalyst for overcoming digital marketing dilemmas in border-area SMEs.

Discussion

The findings of this study highlight critical differences in digital readiness between SMEs in Bengkalis (Indonesia) and Muar (Malaysia), underlining the varying degrees of preparedness to respond to the challenges and opportunities presented by Industry 4.0. These results offer deeper insights into how localized ecosystems, stakeholder engagement, and digital infrastructure significantly influence SME digital transformation. The higher digital

readiness scores in Muar SMEs suggest a more mature ecosystem supported by robust policy frameworks, stronger digital infrastructure, and effective stakeholder collaboration. This supports findings by Yusof et al. (2021), who concluded that Malaysian rural SMEs benefit from structured initiatives led by SME Corp and MDEC, which provide training, subsidies, and access to digital platforms. In contrast, SMEs in Bengkalis face limitations in infrastructure, digital literacy, and weak inter-institutional coordination, mirroring challenges observed by Mahyuni et al. (2021) in other Indonesian peripheries.

The significant correlation between Penta-Helix stakeholder collaboration and digital readiness confirms the relevance of this model in fostering digital ecosystems. Carayannis and Campbell's (2010) quintuple helix innovation theory argues that the integration of academia, government, industry, media, and civil society drives systemic innovation, particularly in underdeveloped areas. In this study, Muar's SMEs reported stronger collaboration across all five actors, resulting in a higher level of digital adaptation. This reinforces Nguyen et al. (2021), who demonstrated that such collaborative environments significantly improve SMEs' technological adoption.

From a theoretical standpoint, the findings align with the Technology–Organization–Environment (TOE) framework (Tornatzky & Fleischer, 1990). Muar SMEs showed better outcomes in all three dimensions: technological access, organizational strategy, and environmental support. This implies that a well-integrated external environment—via the Penta-Helix—is a key enabler of SME digital readiness. Conversely, in Bengkalis, the absence of institutional synergy and limited digital literacy among SME owners contributed to lower readiness levels, supporting previous critiques of regional disparity in digital transformation efforts (Suryanto & Wibisono, 2022). The perceived barriers such as lack of digital skills and internet access among Bengkalis SMEs echo the findings of Ramadani et al. (2021), who emphasized that rural SMEs in developing countries struggle with foundational digital competencies. Meanwhile, Muar SMEs identified cross-border e-commerce and smart marketing technologies as emerging opportunities, suggesting a forward-looking mindset that is already aligned with Industry 4.0 expectations. These findings imply that cross-border policy harmonization and targeted local interventions are essential. The study suggests that adopting the Penta-Helix model in a structured and localized manner could bridge the digital divide in border areas. For policymakers, this means building inclusive innovation ecosystems where education institutions provide relevant training, governments streamline digital support policies, and the media acts as a bridge for information flow. Theoretically, this study proposes an enhancement of the TOE framework by embedding the Penta-Helix dimension as a contextual enabler, offering a novel model for digital readiness in peripheral economies. This contributes to both academic discourse and policy formulation, particularly for ASEAN border regions with shared socio-economic characteristics.

CONCLUSION

This study set out to assess and compare the digital readiness of SMEs located on the Bengkalis–Muar border and explore the extent to which the Penta-Helix collaboration model can

support their transition into the digital economy within the context of Industry 4.0. The research has successfully validated its original proposition: that border-area SMEs exhibit significantly varied levels of digital readiness due to disparities in infrastructure, policy environment, stakeholder collaboration, and institutional support. The comparative findings demonstrate that Muar SMEs are more digitally prepared than their counterparts in Bengkalis, a result attributed to structured digital support programs, stronger stakeholder networks, and more consistent government intervention. In contrast, SMEs in Bengkalis continue to face persistent barriers such as digital illiteracy, inadequate infrastructure, and minimal engagement with academia and media—highlighting a significant gap between the ideal of inclusive digital development and the current reality. By integrating the TOE framework with the Penta-Helix model, this study not only confirms that external environmental support is critical to SME readiness but also proposes an expanded view in which stakeholder synergy plays a vital enabling role in digital transformation. This hybrid model can serve as a conceptual foundation for future research and policy design, particularly in underserved border and rural areas across ASEAN. In broader terms, this research contributes to the growing discourse on digital equity, cross-border economic resilience, and collaborative innovation in peripheral regions. It offers practical implications for policymakers, educational institutions, business associations, and local communities to co-create inclusive digital ecosystems. Looking forward, future research can enrich these findings by expanding the scope to other border regions, incorporating longitudinal studies to measure digital progress over time, and developing intervention-based models to evaluate the direct impact of Penta-Helix-driven initiatives. There is also room to explore deeper qualitative narratives from SME actors themselves, capturing their lived experiences and strategies in overcoming digital dilemmas in constrained environments. Ultimately, addressing digital marketing dilemmas in border SMEs requires more than technological provision—it demands systemic collaboration, context-sensitive policies, and a shared vision of inclusive growth across boundaries.

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