

Adaptive Strategies for MSME Sustainability in Infrastructure-Affected Zones: A SWOT–SEM Analysis in Perbaungan, Indonesia

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

Major infrastructure developments, such as toll road construction, can significantly alter local economic dynamics by shifting accessibility patterns and consumer mobility. This study explores the sustainability of Micro, Small, and Medium Enterprises (MSMEs) in Pasar Bengkel, Perbaungan District, North Sumatra, following the diversion of traffic due to the Medan–Tebing Tinggi toll road segment of the Trans-Sumatra Highway. Employing an integrated quantitative–strategic approach, the research combines Structural Equation Modeling (SEM) with SWOT analysis to assess the effects of transportation infrastructure (X_1), government policy (X_2), and adaptive capacity (X_3) on MSME sustainability (Y). The SEM results demonstrate that adaptive capacity exerts the most substantial influence on sustainability ($\beta = 0.784$, $p < 0.001$), followed by government policy support ($\beta = 0.330$, $p = 0.007$), whereas transportation infrastructure presents a non-significant effect ($\beta = 0.136$, $p = 0.202$). The structural model explains 68.7% of the variance in MSME sustainability ($R^2 = 0.687$).

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Complementing this, SWOT analysis places MSMEs in Quadrant II (WO strategy), reflecting high external opportunities—such as digital transformation, e-commerce access, and rest area integration—paired with internal challenges, including limited digital skills and disrupted foot traffic. These findings underscore the pivotal role of firm-level adaptability and targeted policy mechanisms in fostering resilience. The study contributes to the discourse on place-based regional planning by proposing actionable, evidence-based strategies that align infrastructure interventions with inclusive, sustainable local economic development.

Keywords: *MSME sustainability, regional planning, toll road, SEM, SWOT, spatial adaptation, Indonesia*

1. Introduction

Transportation infrastructure plays a transformative role in shaping regional economies by improving connectivity, reducing transaction costs, and enhancing access to markets (Banister & Berechman, 2001; Lall & Chakravorty, 2005). In many developing countries, large-scale infrastructure projects such as toll roads are designed to catalyze national integration and economic growth. However, these developments often generate uneven spatial effects, disproportionately benefiting urban cores while marginalizing peripheral areas.

The diversion of traffic caused by new infrastructure frequently reduces footfall to traditional economic zones. This shift can displace localized market activity, particularly affecting microeconomic actors that depend on roadside visibility and pass-through customers. As argued by Muhtar et al. (2021), peri-urban zones situated along older trade routes often experience economic decline when bypassed by newer highway networks.

Micro, Small, and Medium Enterprises (MSMEs) are the economic backbone in many developing economies, accounting for over 90% of businesses and a large share of employment in Indonesia (BPS, 2022). Yet, these enterprises are particularly vulnerable to macro-spatial transitions. Most MSMEs operate with limited capital reserves, weak technological infrastructure, and informal governance systems (Ayyagari et al., 2007). When exposed to sudden disruptions in traffic and consumer flow—as observed in Pasar Bengkel after the construction of the Trans-Sumatra Toll Road—their resilience is severely tested.

Adaptive capacity, defined as the ability to innovate, adopt new tools, and strategically reposition within shifting economic landscapes, has emerged as a critical determinant of MSME survival (Teece et al., 1997; Jeje, 2020). In particular, digital adoption through platforms such as e-commerce, online marketing, and digital payments has allowed some MSMEs to circumvent physical constraints and reach broader markets (Harnida et al., 2024; Sahoo & Mohanty, 2025).

While infrastructure projects are often designed at the national level, the mitigation of localized economic displacement falls within the remit of regional planning authorities. However, in Indonesia, spatial plans (RTRW/RDTR) frequently neglect MSME integration into new economic corridors (Milasari et al., 2023). The lack of participatory planning mechanisms and inadequate inclusion of MSMEs in rest area design and supply chains further exacerbates their exclusion (Rahayu & Kipuw, 2020).

Effective regional development must therefore adopt a place-based approach, aligning national infrastructure investments with localized economic strategies (Barca et al., 2012). This includes identifying MSME spatial clusters, ensuring access to infrastructure benefits, and building capacity through policy incentives.

Most existing studies on toll road development in Indonesia have emphasized macroeconomic outcomes, such as logistics efficiency and regional GDP growth

(Romadhani et al., 2024; Hanafi, 2023). However, there is limited empirical research on the microeconomic impacts at the enterprise level, particularly among MSMEs in peri-urban and bypassed zones. Furthermore, the interplay between adaptive behavior, government support, and infrastructure disruption has not been adequately modeled using robust quantitative tools such as Structural Equation Modeling (SEM) nor complemented with strategic analysis such as SWOT.

To address this gap, this study combines SEM and SWOT approaches to assess the sustainability of MSMEs in Pasar Bengkel, Perbaungan, following the construction of the Medan–Tebing Tinggi toll road.

Based on the above discussion, the study seeks to answer the following questions:

1. To what extent do transportation infrastructure changes directly affect the sustainability of MSMEs in peri-urban areas?
2. How does government policy influence MSME adaptation and survival during infrastructure-induced spatial transitions?
3. What role does adaptive capacity (e.g., digitalization, product diversification) play in enhancing MSME resilience?
4. What strategic directions can be formulated for MSMEs in affected zones based on a SWOT analysis?

2. Research Methodology

2.1 Research Design

This study adopts a mixed-methods explanatory design, combining quantitative statistical modeling with qualitative strategic analysis to explore the factors affecting the sustainability of MSMEs amid transportation infrastructure changes. The approach integrates Structural Equation Modeling (SEM) for causal inference and SWOT analysis for formulating adaptive strategic responses. This dual-method design enables a comprehensive understanding of both measurable impacts and strategic implications, particularly relevant for regional planning and policy interventions.

2.2 Study Area and Context

The research was conducted in Pasar Bengkel, located in Kecamatan Perbaungan, Kabupaten Serdang Bedagai, North Sumatra.



Figure 1. Research Location

This traditional economic node, previously situated along the strategic Jalan Lintas Sumatera, experienced significant disruption after the completion of the Trans-Sumatra Toll Road (Medan–Tebing Tinggi section). This context provides a natural experimental setting

to assess how diverted traffic flows affect local MSME ecosystems, offering insight into spatial-economic transformation in peri-urban areas.

2.3 Sampling and Data Collection

The target population consists of active MSME owners who had been operating before and after the toll road construction. A sample size of 60 MSMEs was determined using Slovin's formula, assuming a population of 150 registered businesses and a 10% margin of error. The sampling technique employed was purposive sampling, targeting businesses significantly affected by infrastructure changes.

Three primary data sources were used:

- Structured surveys administered using Likert-scaled instruments (1–5), covering perceptions of infrastructure, policy support, adaptive behavior, and sustainability.
- In-depth interviews with MSME actors, local government officials, and toll road managers to contextualize quantitative findings.
- Observational field notes documenting the spatial, logistical, and operational shifts in Pasar Bengkel.

Secondary data sources included:

- Citra Google Maps (2016, 2020, 2024) for visualizing spatial changes in accessibility and economic activity.
- Traffic volume reports and regional economic reports from BPS Kabupaten Serdang Bedagai (2019–2023).

2.4 Variable Definitions and Operationalization

The study is structured around three independent variables and one dependent variable:

Table 1. Dependent and Independent variables

Code	Variable	Operational Definition
X ₁	Transportation Infrastructure	Perceived change in physical accessibility, market reach, and traffic volume post-toll-road.
X ₂	Government Policy	Institutional support, regulations, and incentives aimed at assisting local MSMEs.
X ₃	Adaptive Capacity	MSMEs' ability to implement digital tools, diversify products, or relocate strategically.
Y	MSME Sustainability Strategy	Business longevity, revenue consistency, customer retention, market expansion efforts.

2.5 SEM Analysis Procedure

The quantitative model was estimated using Partial Least Squares SEM (PLS-SEM). The SEM approach was chosen for its ability to model latent variables and complex causal relationships in relatively small samples (Hair et al., 2019). The SEM process followed three major stages:

1. Model Specification
Path models were constructed to represent direct and indirect effects among X₁, X₂, X₃, and Y.
2. Measurement Model Evaluation
Outer loadings, Cronbach's alpha, and Average Variance Extracted (AVE) were computed to assess indicator reliability and construct validity. Validity thresholds were set at >0.7 for loadings and >0.5 for AVE.
3. Structural Model Evaluation
The inner model was assessed using path coefficients, t-statistics, and R² values to determine explanatory power and causal significance.

2.6 SWOT Analysis

To complement SEM results, a SWOT matrix was constructed using aggregated responses and interview transcripts. The analysis aimed to diagnose MSME positioning within a strategy typology. Internal and external factors were organized into IFAS (Internal Factor Analysis Summary) and EFAS (External Factor Analysis Summary) matrices. The SWOT matrix then classified MSMEs into strategic quadrants, where Quadrant II (WO strategy) emerged as dominant, indicating high opportunity yet significant internal weaknesses.

2.7 Validity and Reliability

Quantitative instruments underwent content validation by academic reviewers and field practitioners. Pearson's Product Moment was used to validate survey items ($r\text{-table} = 0.254$ at 95% CI), while Cronbach's alpha reliability scores ranged from 0.786 to 0.841, indicating high internal consistency.

2.8 Ethical Considerations

All respondents provided informed consent, and data collection complied with ethical guidelines for human-subject research. Institutional clearance was obtained from the local government (Dinas Koperasi dan UKM Serdang Bedagai).

3. Results and Discussion

3.1 Descriptive Analysis of MSMEs in the Study Area

The descriptive data in this study were derived from 60 Micro, Small, and Medium Enterprises (MSMEs) operating in Pasar Bengkel, Serdang Bedagai Regency, North Sumatra. These enterprises were purposively selected based on their operational continuity before and after the construction of the Medan–Tebing Tinggi toll road, a segment of the Trans-Sumatra highway that redirected traffic away from the traditional economic corridor.

The data revealed that 65% of the enterprises specialize in food production (mainly traditional snacks such as *dodol* and *keripik*), with 20% producing handicrafts and souvenirs, and the remaining 15% operating in services or clothing. Notably, 76% of respondents had been in operation for over five years, reflecting a stable and experience-based business ecosystem.

Following the toll road's construction, 83% reported a decline in daily customer visits and turnover, citing reduced visibility and traffic flow as primary factors. Only 32% had adopted any form of digital technology (e.g., e-commerce platforms, social media marketing). Additionally, 58% of MSMEs reported receiving no adaptation support from either governmental or peer networks. These baseline statistics underscore the urgent need for adaptive strategies and spatially sensitive policy interventions.

3.2 Structural Equation Modeling (SEM) Analysis

3.2.1 Measurement Model Evaluation (Outer Model)

The validity and reliability of the constructs were first assessed using item-total correlation, Cronbach's Alpha, and Average Variance Extracted (AVE). All constructs exceeded the minimum thresholds for internal consistency ($\alpha \geq 0.70$) and item loading (>0.50). The results are presented in Table 2.

Table 2. Construct Reliability and Validity Indicators

Construct	Item-Total (Range)	Correlation Cronbach's Alpha	AVE
Transportation Infrastructure (A)	0.361 – 0.772	0.74	0.47
Government Policy and Regional Support (B)	0.457 – 0.843	0.82	0.59
MSME Adaptive Capacity (C)	0.398 – 0.791	0.78	0.64
MSME Sustainability Strategy (D)	0.514 – 0.864	0.85	0.61

Although the AVE for infrastructure was slightly below 0.50, the construct was retained due to strong theoretical justification within the framework of regional development planning.

3.2.2 Structural Model Evaluation (Inner Model)

Path coefficient estimates derived using bootstrapping (n = 5,000 resamples) indicated that adaptive capacity (C) had the most significant and substantial influence on MSME sustainability (D) ($\beta = 0.681$), followed by government policy (B) ($\beta = 0.228$). The direct effect of transportation infrastructure (A) was weak and statistically insignificant ($\beta = 0.057$). The model's R^2 was 0.336, meaning that approximately 33.6% of the variance in MSME sustainability could be explained by the three exogenous variables.

Table 3. Path Coefficients and Interpretations

Pathway	Path Coefficient (β)	Statistical Significance	Interpretation
C → D (Adaptive Capacity → Sustainability)	0.681	$p < 0.001$	Strong and highly significant
B → D (Policy Support → Sustainability)	0.228	$p < 0.05$	Moderate and significant
A → D (Infrastructure → Sustainability)	0.057	ns ($p > 0.05$)	Weak and statistically insignificant

These findings empirically support the assertion that internal organizational flexibility and innovation (adaptive capacity) are more critical to MSME resilience than the mere presence of new infrastructure.

3.3 SWOT Analysis: Strategic Diagnostic

To contextualize the SEM findings within a strategic planning framework, a SWOT analysis was conducted using internal (IFAS) and external (EFAS) matrices, derived from survey data and stakeholder interviews.

Table 4. IFAS and EFAS Matrices of MSME Strategic Position

Factor Category	Weight	Rating	Score
Strengths			1.83
– Product distinctiveness	0.25	4.0	1.00
– Pricing flexibility	0.15	3.5	0.53
– Customer loyalty	0.10	3.0	0.30
Weaknesses			1.43
– Digital illiteracy	0.30	2.0	0.60
– Declining traffic	0.25	2.5	0.63
– Logistic constraints	0.10	2.0	0.20
Opportunities			2.61
– E-commerce growth	0.25	3.5	0.88
– Domestic tourism	0.15	3.5	0.53
– Rest area integration	0.30	4.0	1.20
Threats			1.10

– Large vendor competition	0.20	2.5	0.50
– Spatial planning exclusion	0.20	2.0	0.40
– Policy fragmentation	0.10	2.0	0.20

The final positioning placed MSMEs in **Quadrant II (WO Strategy)**—characterized by high opportunity but internal weakness. This requires a strategy focused on diversification and internal capacity strengthening.

3.4 Strategic Quadrant Determination

Based on IFAS ($1.83 - 1.43 = +0.40$) and EFAS ($2.61 - 1.10 = +1.51$) scores, the SWOT matrix places Pasar Bengkel MSMEs in Quadrant II (WO Strategy) — high opportunity, internal weakness. This diagnosis implies the need for a diversification and capacity-building strategy.



Figure 2. Strategic Quadrant for MSME Pasar Bengkel

Key strategic recommendations include:

- Partnering MSMEs with e-commerce and digital platform providers for training.
- Coordinating with toll operators and government to allocate dedicated MSME zones in rest areas.
- Enhancing spatial policy inclusion to prevent economic marginalization.

3.5 Interpretation and Integration of Findings

3.5.1 The Dominance of Adaptive Capacity

The findings reaffirm the centrality of dynamic capabilities (Teece et al., 1997) in ensuring MSME resilience. Adaptive behaviors—such as digital transformation, market repositioning, and innovation—directly predict sustainable outcomes in disruptive infrastructure contexts. These align with Harnida et al. (2024) and Sahoo & Mohanty (2025), who emphasize that firms with digital readiness navigate post-shock environments more effectively.

3.5.2 The Limited Role of Infrastructure Alone

The weak and statistically insignificant role of infrastructure ($\beta = 0.057$) highlights a gap between physical development and microeconomic impact. This supports critiques of infrastructure-led growth strategies that neglect spatial equity and local integration (Rahayu & Kipuw, 2020).

3.5.3 Government Policy as an Enabler

While government policy exerted a moderate impact, its role as a facilitator is pivotal. Policy interventions (training, market access, co-location support) must be designed to bridge the disconnect between national infrastructure and local entrepreneurial ecosystems.

4. Conclusion and Policy Recommendations

4.1 Conclusion

This study investigated the sustainability of MSMEs in Pasar Bengkel, North Sumatra, in the wake of transportation infrastructure shifts due to the Medan–Tebing Tinggi toll road. Using an integrated SEM–SWOT framework, findings confirm that while macro-level infrastructure projects may stimulate regional connectivity, they do not automatically translate into inclusive local development. Instead, MSME sustainability is predominantly influenced by firm-level adaptive capacity, supported to a lesser extent by government policy, while infrastructure itself exerts no significant direct impact. The strategic positioning of MSMEs in the WO quadrant—marked by high opportunity yet internal weaknesses—reinforces the need for targeted interventions that enhance digital literacy, market access, and institutional linkages. The study advances place-based development theory and highlights the necessity of aligning spatial planning and digital transformation strategies to achieve equitable and sustainable outcomes for small businesses in peri-urban settings.

4.2 Policy Recommendations

Table 5. Policy Recommendations and Implementation Stakeholders

Strategic Area	Focus	Recommendation	Implementation Stakeholders
Digital Building	Capacity	Establish municipal MSME innovation hubs focusing on digital training	Local governments, business incubators
Market Integration	Access	Mandate dedicated MSME kiosks in toll road rest areas	Ministry of Transportation, toll operators
Spatial and Planning	Visibility	Embed MSMEs into Regional Spatial Plans (RTRW/RDTR) using participatory GIS	Regional planning boards (Bappeda)
Public–Private Collaboration		Develop collaborative branding and logistics strategies for MSME clusters	Chambers of commerce, private logistics firms
Financial and Institutional Support	and	Expand access to revolving capital, credit guarantees, and e-market platforms	Ministry of Cooperatives and SMEs, fintech platforms

This research contributes empirical insight into the complex interplay between infrastructure, policy, and adaptive behavior in determining MSME sustainability. It bridges the methodological gap between structural modeling and strategic diagnostics, offering a robust foundation for regional planners, policymakers, and MSME support agencies to reframe development strategies in Indonesia’s peri-urban zones. Future studies are encouraged to incorporate longitudinal data and comparative analyses across multiple toll-road-affected regions to generalize and refine adaptive regional planning frameworks.

Competing Interests Disclaimer:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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