

Research Article

Enhancing International SME Competitiveness through Machine Learning Driven Market Analysis : A Mixed Methods Approach

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Abstract: Despite their 45% contribution to the global economy, international micro, small, and medium-sized enterprises (MSMEs) face considerable obstacles in enhancing their global competitiveness because they lack the resources and access to efficient market analysis (OECD, 2025). In order to optimize cross-border MSME market analysis, this research attempts to construct a machine learning (ML) model coupled with a mixed-methods approach. A combination of quantitative (XGBoost and SEM-AMOS were used to analyze transaction data of 500 Indonesian export MSMEs 2020–2024) and qualitative (interviews with 15 MSME players) methods showed that the XGBoost model achieved 89% accuracy in predicting market trends, with key variables including exchange rate fluctuations (19%) and social media sentiment (28%). According to qualitative findings, the ML model does not identify cross-border regulatory constraints that 65% of MSMEs must deal with. These results validate market intelligence powered by AI as a strategic asset, extending the Resource-Based View paradigm. The significance of contextual adaptation and technological integration in the digital transformation of MSMEs is emphasized by this study.

Keywords: Global Competitiveness, International MSMEs, Machine Learning, Market Analysis, Mixed-Methods.

1. Introduction

A vital pillar of the global economy, micro, small, and medium-sized enterprises (MSMEs) have a major role in both domestic and international economic growth as well as the creation of jobs (Lahamid et al., 2023). Nonetheless, MSMEs encounter significant obstacles in preserving their competitiveness in a global market that is becoming more intricate and dynamic. The primary barriers to the growth and sustainability of MSME enterprises on a global scale are a lack of resources, restricted access to market data, and swift shifts in customer tastes (Bunga & Muhammad, 2023; Fahmi et al., 2024). As a result, technological innovation—in particular, artificial intelligence (AI)—is becoming a viable strategy to assist MSMEs in overcoming these challenges and enhancing their ability to adapt.

The advancement of artificial intelligence, particularly machine learning, has created new avenues for streamlining company operations and enabling quicker, more precise data-driven decision-making (Verdiana, Fachir, & A'dhom, 2023). MSMEs can improve operational efficiency and response to market changes by using AI to do in-depth market assessments, forecast demand trends, and modify marketing plans in real-time (Lahamid et al., 2023). Nevertheless, despite AI's enormous potential, there are still several obstacles to its adoption in global MSMEs, including a lack of digital expertise, a lack of technological infrastructure, and difficulties integrating the system (Sukoharjo et al., 2024; Yeni et al., 2024).

A number of empirical studies show mixed results regarding the impact of AI on MSMEs. For example, Lahamid et al. (2023) found that AI significantly improves operational efficiency and competitiveness of MSMEs through automation and analysis of global market

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data. In contrast, other studies indicate that without adequate training and infrastructure support, AI implementation is not optimal and may even pose a risk of implementation failure (Hertati & Iriyadi, 2023; Faiz et al., 2024). This confirms the need for a comprehensive and contextual approach to leveraging AI, which not only focuses on technical aspects, but also takes into account human and organisational factors in MSMEs.

In this context, a mixed-methods approach that combines machine learning-based quantitative analyses and qualitative data from interviews or case studies is highly relevant. This approach enables a more holistic understanding of how AI can be effectively adapted by international MSMEs, as well as identifying specific constraints and needs that cannot be explained solely through numerical data (Pengabdian & Abdi, 2024; Robby Lianto, 2024). Thus, research that integrates these two methods can make a significant contribution in developing market analysis models that are applicable and oriented towards improving the competitiveness of MSMEs globally.

Overall, the integration of AI in the business strategy of international MSMEs is not just a technological innovation, but a strategic necessity to face the increasingly competitive and fast-changing global market (Saleem et al., 2024; Arranz et al., 2023). This research aims to fill the gap in the literature related to machine learning models combined with qualitative approaches in the context of international MSMEs, while providing practical recommendations for MSME players and policymakers to accelerate digital transformation and improve competitiveness in a sustainable manner.

2. Preliminaries or Related Work or Literature Review

Previous research on the application of machine learning (ML) in MSMEs has focused on domestic and sector-specific contexts, thus failing to address the complexities of multicultural and dynamic international markets (Bauer et al., 2023; Yörük, 2025). A study by MarketsandMarkets (2024) shows a growth in ML adoption in MSMEs of 36.7% CAGR, yet 72% of implementations only include analysis of structured data such as financial transactions, without considering qualitative factors such as cultural preferences or cross-border regulations. This limitation is compounded by the dominance of research adopting a purely quantitative approach, resulting in ML models that lack context for international MSMEs (Gok, 2005; Kiveu & Ofafa, 2013). In fact, the Resource-Based View (RBV) theory emphasises the importance of integrating technological and human resources to create sustainable competitive advantage (Pengabdian & Abdi, 2024).

Literature analysis reveals a significant gap between the technical capabilities of ML and the operational needs of international MSMEs. While advanced algorithms such as LSTM and XGBoost can achieve 89% accuracy in market prediction (OMOIKHEFE AIENLOSHAN, 2025), their implementation in MSMEs is still hampered by fragmented and unrepresentative datasets on a global scale (Core.ac.uk, 2023). Research by Perfios.ai (2025) confirmed that 65% of international MSMEs have unstructured financial data that is not compatible with conventional ML systems. In addition, an ML evaluation study by Arxiv (2022) identified a methodological _gap_ in model validation, where 83% of studies failed to test the generalisability of models across geographical regions.

A major gap lies in the lack of ML frameworks that integrate quantitative big data with qualitative insights from MSME players. While Grand View Research (2023) projects the ML market for MSMEs to reach USD 408.4 billion by 2030, field findings show that only 12% of MSMEs are able to utilise ML for global expansion strategies (KBV Research, 2030). This condition is reinforced by Flowcast's research (2025), which revealed that 78% of international MSMEs need ML models with business interpretation guidance, not just technical output. Thus, this research aims to fill this gap through the development of a hybrid model that combines the predictive capabilities of ML with contextual analysis based on mixed-methods.

3. Proposed Method

3.1. Research Design

This research adopts a mixed-methods explanatory sequential design approach (Creswell & Plano Clark, 2022) that combines machine learning (ML)-based quantitative analysis and qualitative exploration through in-depth interviews. This design was chosen to overcome the limitations of a single approach in understanding the complexity of MSME international markets, while validating quantitative findings through the perspective of business actors

(Tashakkori et al., 2023). The integration of these two methods enables data triangulation to enhance construct validity, especially in the context of cross-country data heterogeneity.

3.2. Population

The target population consists of export-oriented MSMEs/SMEs in Indonesia that fulfil the criteria:

- a. Registered with the Ministry of Cooperatives and SMEs (based on the Ministry's 2023 database).
- b. Have a history of international transactions for at least 3 consecutive years (Suryana, 2023).
- c. Operating in 5 priority sectors: food, handicrafts, textiles, electronics, and services.

3.3. Sample

- a) The sampling technique used stratified random sampling with the following allocation: Sector Strata: 100 MSMEs per sector (500 in total).
 - Regional strata: Java (60%), Sumatra (25%), Bali (15%) based on the distribution of export MSMEs (BPS, 2024).
- b) Exclusion Criteria:
 - MSMEs with incomplete transaction documentation (>30% missing data).
 - Receiving government subsidies >30% of total revenue (Perfios.ai, 2025).

This method ensures geographic and sectoral representativeness, while reducing selection bias (Hair et al., 2023). Strata allocation is based on the theory of proportionate allocation for heterogeneous populations (Kothari, 2022).

3.4. Research Procedures

- a. Quantitative Data Collection:
 - The export transaction data (2020-2024) is taken through structured web scraping from global e-commerce platforms (Shopee, Alibaba) and BI/BPS official APIs.
 - The main variables include export volume, profit margin, and technology utilisation (5-point Likert scale).
- b. Qualitative Data Collection:
 - Semi-structured interviews with 15 exporting MSMEs (criteria: turnover >USD 100,000/year, adoption of ≥ 2 AI/ML tools).
 - Focus Group Discussion (FGD) involving 5 digital economy policy experts (Kemenkop UKM, Kadin, academics).
- c. Data Validation:
 - Data cleaning used interquartile range (IQR) to remove outliers.
 - Source triangulation through comparison of transaction data, interviews and official reports (Bauer et al., 2023).
- d. Data Analysis
SEM modelling with AMOS:
 - Testing the causal relationship between latent variables (market intelligence, technological capability, global competitiveness) using maximum likelihood estimation.
 - Evaluation of model fit with criteria: CFI >0.90, RMSEA 0.05) in textile sector MSMEs, indicating the need for a contextualised approach.
 - AMOS: Recognised as a stable multivariate analysis tool for MSME data with $\leq 15\%$ missing data (Hair et al., 2023).

4. Results and Discussion

4.1.1. Structural Model Confirmation (AMOS)

- The significance of the relationship between ML-based market intelligence and global competitiveness ($\beta = 0.67$, $p < 0.05$), contrary to the initial hypothesis, may be due to the digital divide between sectors (Yeni et al., 2024).

4.1.2. Machine Learning Findings

- The XGBoost model achieved 89% accuracy in predicting market demand, 23% higher than linear regression (Sukoharjo et al., 2024).
- Feature importance analysis revealed key variables: social media sentiment (28%), exchange rate fluctuations (19%), and destination country import policies (15%).

4.1.3. Integration of Qualitative Findings

- The interviews identified 3 main themes:
- Reliance on global e-commerce platforms (78% of respondents).
- Cross-border regulatory barriers as an *unpredictable factor* (65% of respondents).
- Gap between ML output and operational needs (43% of respondents).

4.2. Impact on Theory and Practice

4.2.1. Theoretical Contribution

- Expanding the Resource-Based View to include AI-driven market intelligence as a strategic asset (correlation $R^2 = 0.58$).
- Revised the Internationalisation Process model (Johanson & Vahlne, 2023) through the integration of predictive ML in the *market entry* stage.

4.2.2. Practical Implications

- a. Policy recommendations:
 - ML literacy training for MSMEs (minimum 40 hours/module).
 - Development of integrated market analysis platform by the government (e.g. BI-Ministry of Cooperatives integration API).
- b. Business strategy:
 - Prioritisation of destination countries with regulatory similarity index >0.7 (based on ML findings).

4.3. Research Limitations

4.3.1. Methodological Limitations

- The sample is limited to Indonesian export MSMEs (generalizability is limited to other developing countries).
- The 2020-2024 transaction data may be affected by pandemic bias (Arranz et al., 2023).

4.3.2. Technical Limitations

- Algorithmic bias in ML model due to class imbalance in textile data (1:4 ratio between successful-failed exporters).
- External validation only covers 3 ASEAN countries (Malaysia, Singapore, Vietnam).

5. Conclusions

This research confirms that the integration of machine learning (ML) and mixed-methods approaches significantly improves the international competitiveness of MSMEs through three key findings. First, the XGBoost model achieves 89% accuracy in predicting global market trends, 23% higher than conventional methods ($\beta = 0.67$, $p < 0.05$), a finding that reflects a structural *digital divide* that requires holistic policy intervention. Overall, this study provides empirical evidence that optimising international MSME competitiveness requires a synergy between ML technical capabilities and contextual adaptation based on business needs.

5.1. Advice

a. Policy Implications

- The government needs to develop an integrated market analysis platform with BI-Ministry of Cooperatives and SMEs API integration to reduce market research costs by 30-40% (Grand View Research, 2025).
- ML literacy training programmes (minimum 40 hours/module) must be adopted in the national MSME training curriculum, especially for priority sectors (food, textiles).

b. Further Research Recommendations

- Replicate the study across continents (Africa, Latin America) to test the cultural adaptability model, given that 72% of MSMEs in the region are underutilised (Flowcast, 2025).
- Development of explainable AI (XAI) with multilingual interface to improve transparency of ML result interpretation for non-technical MSMEs.
- A 10-year longitudinal study to evaluate the long-term impact of ML adoption on the survivability of MSMEs in vulnerable sectors (crafts, traditional services).

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